Journal of Intelligent & Fuzzy Systems 37 (2019) 3477–3487
DOI:10.3233/JIFS-179152
IOS Press

Estimation of the labor market information–an empirical study in Taiwan[1]

Ping-Yu Yang[a], Li-Chen Chou[b] and Zhan-Ao Wang[b,*]
[a]*School of Business, Nanjing University, Nanjing, Jiangsu Province, China*
[b]*School of Economics, Wenzhou Business College, Chashan University Town, Wenzhou, Zhejiang Province, China*

Abstract. Using Taiwan's Manpower Utilization Survey from 2012–2014, this paper investigates the impacts that salary variation caused by insufficient information, then evaluates the condition of information holding between the employee and the employer. The results indicate that the ignorance of employee and employer are deeper in the private sector than that in the public sector; the employees and employer ignorance with the white-collar both larger than the blue-collar. Besides, the results demonstrate insignificantly effect in both ignorance estimation in the public sector, which may reflect the labors enter to the public sector mainly through national examination and cause the insignificant estimation.

Keywords: Taiwan, employee relations, information processing

1. Introduction

The statuses and differences of salary in both the public and the private sectors are considered as the main arteries in the researches on labor economy. The public sector usually is the biggest single employer in the whole economic system. The adjustments of its salary structure not only effect itself but also the welfare and standards of salary to the employees in the private sector. There're also a number of studies on whether the wage dispersion between these two sectors will influence each other's human capital investment efficiency, production value and other issues. Previous literature on the wage dispersion between the two sectors mostly emphasized on the degree of it but seldom referred to the effects which caused by the informed degree of the employer and employee in the labor market.

Wage dispersion is familiar to most people in the labor market (Stedham and Yamamura, 2000). Hypothesizing with the human-capital and search theory, under no discriminations, employees' stock of human-capital reflect on their various salaries. In that situation, employee and employer all own the same amount of human-capital may get the same salary. If there is no information asymmetry, people can find and choose the company, likely to pay a higher salary. And the bosses will welcome the employee with the lowest wage. But they would only happen when there are no discriminations to the workers and both the two sides have sufficient information in the labor market. When it is impossible to share information, job-hunters will be not able to get a whole picture of the potential employer. The later one may also distributes very differently because of the unclear reservation wages of the offer-waiters. In short, it is insufficient information that makes the workers have the very same human capital attain the various level of wages or the workers have big differences of human capital obtain the same one.

[1]This paper was supported by the National Social Science Project in China (project no. 17JBY037), Talent Project by Qianjiang in Zhejiang province (project no. QJC1803005) and China Postdoctoral Science Foundation (Studies on the Evolution Rules and Policies of the Asia-pacific Multilateral FTA from the Perspective of Relative Gains, project no. 2017M611965).

*Corresponding author. Zhan-Ao Wang, School of Economics, Wenzhou Business College, Chashan University Town, Wenzhou, Zhejiang Province, China. E-mail: 00201055@wzbc.edu.cn.

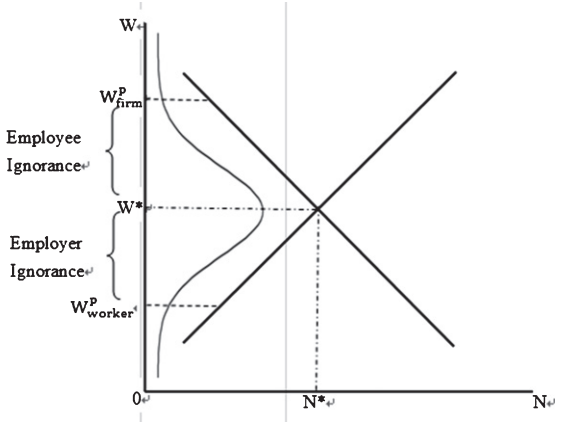

Fig. 1. The employee ignorance and the employer ignorance.

Assuming the labor market is competitive and has information symmetry, such as in the Fig. 1, abscissa presents the amount of people employed and ordinate presents the level of their salary. Because the labor isn't able to know the maximum salary the employer wants to offer(w^p_{firm}, the reservation wage of the employer) and the employer can't get what is the minimum salary the labor is willing to accept (w^p_{worker}, the reservation wage of the employee), there will reach a salary supply-demand balance $W = W^*$.

To be honest, given the information in the labor market could be insufficient and asymmetry, the employer, and the labor are more likely to form various compensation contents when fixing the salary and contract. Supposing a large sample obeys the normal distribution and the minimum salary labor is willing to accept is w^p_{worker}, the employer will not be able to know it because of the information asymmetry or insufficient. What's more, every worker in the labor market has different human capital in the reality. The employer could only judge the productive force or the ideal salary level of workers with information like educational background, age, gender and so on. If the minimum salary that the potential employee's willing to get is less than the salary supply-demand balance, there will be a gap which we can call it $W^* - w^p_{worker}$.

Previous studies defined this exceeded salary that the company owners paid as employer ignorance (Polachek and Yoon, 1987; Murphy and Strobl, 2008). Similarly, job-hunters would also lose their abilities to get the idea of the maximum salary their potential employers' willing to give due to the information asymmetry. However, if the salary, in reality, is less than the one during the information symmetry in the labor market, workers will get less because of insufficient information (the gap $w^p_{firm} - W^*$), and this phenomenon called employee ignorance. All these matters lead to a wage dispersion in the labor market and form various levels of salary. When considering salary issues in the labor market, it's appropriate and necessary to estimate and measure the information asymmetry in the labor market.

Applying the method of two-tiered earnings frontier estimation, this study mainly estimate the degree of information got between the management and the labor, with data from Manpower Utilization Survey of Taiwan during 2012 to 2014 from the Directorate General of Budget, Accounting and Statistics of Taiwan (DGBAS). The rest of the paper is organized as follows, the second part reviewed the related literatures, the third introduced the methodology, the forth introduces the data and discuss the empirical results. Concluding remarks are followed up in the final section.

2. Literature review

Wage variation between the public and the private sectors was widely discussed among literature which firstly analyzed by Smith (1976, 1981). Recently study such as Quadrini and Trigari (2007) focus on the cyclicality of employment and examine a public sector wage policy that is acyclical and procyclical. They find that public sector employment and wage policy increased employment volatility by four and two times, respectively, over the periods 1945-1970 and 1970-2003. They attribute this downward trend in employment volatility to an increasingly procyclical compensation policy adopted by the state. Chen (2007) found that the higher the worker's skill is, the lower his salary premium is in the public sector. The author drew this conclusion by analyzing the salary premium data of Taiwan's public sector from 1980 to 2006 with quantile regression. Unlike the ones in medium or high position, male workers in low position are facing more and more serious problems of salary premium nowadays. Gomes (2015) builds a dynamic stochastic general equilibrium model with search and matching frictions calibrated to U.S. data and shows that high public sector wages induce too many unemployed to apply for public sector jobs and raise unemployment.

The concept of the earnings frontier, originally used in the analysis of production efficiency (Aigner et al., 1977). It was first used in a labor economics

context by Hofler and Polachek (1985) in order to examine the extent to which young persons attain the earnings potential of their human capital investment in the process of assimilation in the labor market. The estimated gap between the earnings which are actually observed and potential earnings (also called maximum attainable earnings or frontier earnings) for a given human capital endowment, can be conceived as "earnings inefficiency". In the studies of labor issues, studies on wage variation with stochastic frontier approach may have search theory accompanied. All these works focused on the level of the gap, so the model used is always called earning frontier function.

Polachek and Yoon (1987) structured two-tiered earnings frontier estimation analyzed the information-sufficiency-degree of the management and the labor with data from dynamic tracking survey in 1981. The final results taught people the potential employees would get 28.8% more and the potential employers might pay 40% less than that when people in the labor market with information symmetry. This method could distinguish between the depth of information the supplier got and that of the demander got in the market, which provided a lot of possibilities in the research of the price or salary difference there. For example, Gaynor and Polachek (1994) found that the demander (people who go to see a doctor) know a lot less than the supplier (people who provide medical help), after studying the degree of gap between the two in department of medicine, paediatrics, gynaecology and obstetrics and forensic surgery, with the data of American health center. Polachek and Yoon(1996) made further studies of the employer and the employee ignorance in American labor market from 1969 to 1984, with long-term tracking materials, using the two-tiered earnings frontier estimation model.

Murphy and Strobl (2008) explored the differences between the reservation and real wage in Trinidad and Tobago then realized the potential employees would get 22% more and the potential employers would pay 26% less when it is in information symmetry than that in Trinidad real labor market. Using a representative survey of young persons having left full-time education in France in 1998 and interviewed in 2001 and 2005, Bazen and Waziri (2017) examines the process of their assimilation into normal employment and the extent to which job matches are inefficient in the sense that the pay in a job is below an individual's potential earnings (determined by education, other forms of training and labour market experience). Their results indicate that young workers manage to obtain on average about 82% of their potential earnings three years after leaving full-time education and earnings inefficiency had disappeared four years later.

In other related studies, Chuang (2006) discussed the effect of minimum wage on youth employment and unemployment in Taiwan; Gangopadhyay and Shankar (2015) applied the modify stochastic frontier analysis to investigate the labor mobility in the urban and peri-urban labor markets in Bangladesh. Recently, Tsionas (2012), Park et al (2015), Das and Polachek (2017) and Parmeter (2018) propose in the literature non parametric and semi-parametric approaches where no parametric assumption on the functional form of production relationship is made.

3. Methodology

The model in this study basically we followed the theory which constructed by Polachek and Yoon (1985, 1987) and Murphy and Strobl (2008). Define the demand and supply in the labor market can be expressed in below:

$$L^D = f(X^D, W) - e^D, \partial f/\partial w < 0 \qquad (1)$$

$$L^S = g(X^s, w) - e^S, \partial f/\partial w > 0 \qquad (2)$$

w indicates the wage level, while X^D and X^S means other explanatory variables besides wage, which could influence the labor demand and labor supply of that market. e^D and e^S are two nonnegative random variables and represent the effect both of the sides in the market get because of the information asymmetry. When both of e^D and e^S equal 0, the labor market is in information symmetry and both sides there could get sufficient information. When both of e^D and e^S are larger than 0, the labor market is in information asymmetry in some degree. The lager e^D or e^S get, the bigger the gap is between the two sides there. And trades might decrease while the gap grows.

When there's a balance in labor market, L^D=L^S,define the relationship equation of the excess demand as

$$H(X,w) = e^D - e^S$$

$$H(X,w) = e^D - e^S = f(X^D,W) - g(X^S,w) \qquad (3)$$

If we apply Taylor expansion to $H(X, w)$ at (x_0, w_0) and we can get the relationship equation of dependent variable:

$$W = (\partial H/\partial w)^{-1} \times \left\{ \begin{bmatrix} \partial H/\partial w)w_0 + (\partial H/\partial x_0) \\ -H(x_0, w_0) \end{bmatrix} \right\} + R \\ -(\partial H/\partial x')x + (e^D - e^S) \tag{4}$$

We take β as the remainder term of Equation (4) after Taylor expansion and transfer Equation (4) as a linear model as below:

$$w = \beta' X + u + v + \gamma \tag{5}$$

in which

$$\beta = (\partial H/\partial w)^{-1} \times \left\{ \begin{bmatrix} \partial H/\partial w)w_0 + (\partial H/\partial x')x_0 \\ -H(x_0, w_0) \end{bmatrix} \right\}. \\ , \partial H/\partial x'$$

$$v = (\partial H/\partial w)^{-1} \times e^D \leq 0,$$

$$\gamma = (\partial H/\partial w)^{-1} \times e^S \leq 0$$

B,v and z represents the coefficient of, X, the explanatory variable, the degree of insufficient information of the demander and the supplier in the labor market. Take the mathematical expectation to v and γ so that we can get $E(v) = -\mu_y < 0$ as well as $E(\gamma) = \mu_\gamma > 0$. μ_γ represents the gap between the maximum salary the employer's willing to give and the employee actually gets under the mathematical expectation, which is called employee ignorance. μ_γ represents the gap between the minimum salary the employee's willing to accept and the employer actually gives, which is call employer ignorance. We rewrite the Equation (5) as follow:

$$w = \beta' X + \varepsilon, \varepsilon = u + v + \gamma \tag{6}$$

ε contains three error terms as the error term of the regression estimation, employee and employer ignorance.

$$u_i \in (-\infty, \infty), v_i \in (-\infty, 0), \gamma_i \in (0, \infty)$$

In case of large-sample allocation, supposed u_i follows the normal distribution which has the mean of 0 and the variation of σ_u^2 v_i and γ_i are exponential distribution models of means μ_v and μ_x. Splitting these three error terms and adding marginal probability density function as:

$$g(\varepsilon) = \frac{1}{\mu_v + \mu_\gamma} \times \exp\left(\frac{\varepsilon}{\mu_v} + \frac{\sigma_u^2}{2\mu_v^2}\right) \\ \times \left\{1 - \phi\left(\frac{\varepsilon}{\mu_v} + \frac{\sigma_u}{\mu_v}\right) + \left(1 - \varphi\left(\frac{-\varepsilon}{\mu_v} + \frac{\sigma_u}{\mu_\gamma}\right)\right)\right. \\ \times \exp\left[\frac{-1}{2}\left(\frac{2\varepsilon}{\mu_u} + \sigma_u\left(\frac{1}{\mu_v} - \frac{1}{\mu_\gamma}\right)\right)\right. \\ \left.\left. \times \sigma_u\left(\frac{1}{\mu_v} + \frac{1}{\mu_\gamma}\right)\right]\right\} \tag{7}$$

ϕ is a cumulative density function which obeys the standard normal distribution. So we can estimate the employee ignorance and employer ignorance which are studied in Equation (6) and Equation (7) with maximum likelihood estimation (MLE). Equation (8) is a likelihood function while Equation (9) is a log likelihood function:

$$L(w\,|\beta, \sigma_u, \mu_v, \mu_\gamma) = \prod g(\varepsilon) = \prod g(w_i - \beta' x_i) \tag{8}$$

$$\log L = n \log\left(\frac{\theta_u \theta_v \theta_\gamma}{\theta_v + \theta_\gamma}\right) + \left[\theta_u \theta_v \sum\nolimits_i \varepsilon_i + \left(\frac{n}{2}\right)\theta_v^2\right] \\ + \sum\nolimits_i \log\left\{1 - \varphi(\theta_u \varepsilon_i + \theta_v) + [1 - \varphi(-\theta_u \varepsilon_i + \theta_\gamma)]\right. \\ \left. \exp\left[-\left(\frac{1}{2}\right)(2\theta_u \varepsilon_i + \theta_v - \theta_\gamma)(\theta_v + \theta_\gamma)\right]\right\} \tag{9}$$

The parameter θ_u, θ_v, θ_x in the equation(9) can be defined like this: $\theta_u = 1/\sigma_u$, $\theta_y = \sigma_u/\mu_y$ $\theta_x = \sigma_u/\mu_\gamma$

As mentioned above, μ_y and μ_γ represent the ignorance between the employee and employer in the labor market while θ_y and θ_x show the depth of them. Compared with Equation (9) and the traditional one-tiered earnings frontier estimation or the traditional stochastic frontier model, when evaluating the productivity, the traditional ways could only estimate the efficiency or inefficiency of the market or some specific industries but can't tell which the department or group caused it. Two-tiered earnings frontier estimation can furtherly describe the level of the deficiency of the market as well as whose ignorance is deeper and analyze the deficiency of the operation in that particular market.

Set the empirical estimation with a linear model as follows:

$$\mathrm{W_i} = \log(\mathrm{w_i}) = \beta' \mathrm{X_i} + \varepsilon_\mathrm{i}, \\ \varepsilon = \mathrm{u} + \mathrm{v} + \gamma, \mathrm{i} = 1,2, \ldots, \mathrm{n} \tag{10}$$

If we set exponential distribution and take expectation of Equation (10):

$$\mathrm{E(W_i)} = \exp(\beta' \mathrm{X_i}) \times \mathrm{E}(e_v) \times \mathrm{E}(e_\gamma) \tag{11}$$

$E(e^v)$ and $E(e^\gamma)$in Equation (11) indicate that the employee ignorance and employer ignorance could

influence the wage expectation. The economic intuition of the equation

$$E(e^{\upsilon}) = 1/(1+ \mu\ v),\ E(e^{\gamma}) = 1/(1- \mu_{\gamma})$$

as below: $E(e^{\upsilon})$ is the percentage of real wage that employees got in the potential salary level of the employers (when the market is open and there is no information asymmetry) and 1-$E(e^{\upsilon})$ is the degree or status of the employee ignorance of the worker. Similarly, $E(e^{\gamma})$ is the percentage of real wage that employers paid to the potential salary level of the employees, and $E(e^{\gamma}) - 1$ shows the degree or status of the employer ignorance.

4. Database and empirical results

This empirical data in this study all collected from Manpower Utilization Survey of Taiwan during 2012 to 2014, by DGBAS. Rules to select suitable data of the employed and the unemployed, the blue-collar and the white collar of the public sector (government) or the private sectors (employers except for government): (1) Eliminating the people with zero income or income that not counted. (2) Age of the labor is within the range between 15 and 65 years old. (3) Eliminating the labor with no work abilities, such as people want to work but haven't seek a job, people with appropriate abilities but cannot start to work because of the education, housework, and other reasons, or self-employed worker. (4) Eliminating the labor with old age (above 65 years old), disabilities, persons in active service, people under supervision or the missing persons.

The definition of employees in this paper as below: (1) People doing things for living, working after class or on vacation or after housework. (2) People on sick leave, regular holiday, casual leave, special leave (not including sick leave), getting salary but haven't start the work because of some reason, or people have work responsibilities but is not working due to some reasons. (3) People who would return to their position and getting salaries but don't work in a company. According to the definition of classification standard of professions of DGBAS, the white-collar do the work of administration, technology and routine things while the blue workers do the one of sales, farming, forestry, husbandry and fishing, mining, metal, other techniques, precision instrument, operating, packaging or physical and other types. The study got 86,230 pieces of data of labor and observation sample, with 49,536 of men and 36,694 of women in it. There were 8,946 people in the public sector, of which 6,684 were the blue-collar and 2,262 were the white-collar. There were 77,284 people in the private sectors, of which 48,430 are the blue-collar and 28,854 are the white-collar. All these estimated samples are listed in Table 1.

Table 1 listed the variables such as HRWAGE2 (the logarithm of hourly wage, wage unit: NT), SCHLING (the duration year of education), EXPER (working year experience), TENURE (the amount of years in main work places) and GOVT (dummy variable, whether the employee is in the public sector or not). The statistics indicate the average salary the male could get is higher than that of the female. The white-collar's hourly-wage and the duration of education are higher than that of the blue-collar in spite of whether the worker is in the public or the private sector. Both the white-collar and the blue-collar in public sectors could get more salary than that of the employee in the private sector. However, there could be great variations in salaries between the white-collar and the blue-collar in the private sector, which is believed to have relation with the differences of the nature of work between them. The nature of the white-collar's work is mostly human-capital-intensive, while the one of the blue-collar is mostly labor-intensive. We might believe that the duration of education of the blue-collar is less than that of the white-collar. What's more, workers in the private sector get into the labor market various different selection processes and methods, which is normally more complicated than that of the public sectors. Ages, the school people graduated from, education background, qualifications, the situation of information distribution and other factors could all have effects on the salary of a potential employee in the private sectors, which cause the bigger degree of variation in real salary than that in the public sector.

Table 2 lists the empirical results which apply Equation (9), we can find that the effects explanatory variables could do to the hourly wage of a worker are significant except the time trend (Trend). One who is more educated is likely to get a more positive influence on it. The more the work experience and the number of years in main work place the worker gets, the more his or her hourly wage will be, but they obey the rule of diminishing marginal utility. The estimation result of time trend (Trend) shows the hourly wage of the sample of both genders and only male would drop over the years. Besides, the OLS estimation of Tables 2 and 4 show that the Adj. R-

Table 1
Descriptive statistics

Variables	Total (N: 86230)			
	Mean	Variance	Minimum	Maximum
HRWAGE2	180.4321	138.7518	0.0000	9546.2344
SCHLING	1.2029	0.3342	0.0000	2.2000
EXPER	2.2317	1.2678	0.0000	5.9000
TENTURE	8.8820	8.3879	0.0000	50.5000
GOVT	0.1038	0.3049	0.0000	1.0000

	the Public Sector(Government)							
Variables	the White-Collar (N: 6684)				the Blue-Collar (N: 2262)			
	Mean	Variance	Minimum	Maximum	Mean	Variance	Minimum	Maximum
HRWAGE2	286.2191	129.4973	0.00000	3611.3311	218.3790	85.8160	0.0000	1017.4400
SCHLING	1.5093	0.2397	0.60000	2.2000	1.1760	0.2780	0.0000	1.8000
EXPER	2.0715	1.0982	0.00000	5.3000	2.5812	1.1106	0.0000	5.7000
TENTURE	11.1590	9.1644	0.08333	45.0000	11.4108	8.7534	0.0833	40.1667

	the Private Sector(Non-government)							
Variables	the White-Collar (N: 28854)				the Blue-Collar (N: 48430)			
	Mean	Variance	Minimum	Maximum	Mean	Variance	Minimum	Maximum
HRWAGE2	216.7673	170.1876	0.0000	9546.2344	142.4117	102.5710	0.0000	5966.3901
SCHLING	1.4182	0.2458	0.0000	2.2000	1.0336	0.2865	0.0000	1.8000
EXPER	1.7594	1.0780	0.0000	5.5000	2.5188	1.3118	0.0000	5.9000
TENTURE	7.6338	7.1605	0.0000	45.0000	9.1933	8.8044	0.0000	50.5000

	Genders							
Variables	Men (N: 49536)				Women (N: 36694)			
	Mean	Variance	Minimum	Maximum	Mean	Variance	Minimum	Maximum
HRWAGE2	206.5485	146.4022	0.0000	5966.3901	145.1756	118.9273	0.0000	9546.2344
SCHLING	1.1989	0.3265	0.0000	2.2000	1.2083	0.3442	0.0000	2.2000
EXPER	2.3266	1.2406	0.0000	5.9000	2.1035	1.2927	0.0000	5.9000
TENTURE	9.6031	8.7431	0.0000	50.5000	7.9086	7.7777	0.0000	46.5000
GOVT	0.0956	0.2940	0.0000	1.0000	0.1148	0.3187	0.0000	1.0000

square is not very high, which means the empirical analysis of OLS has a low degree of interpretation.

Tables 3 and 4 furtherly list the empirical results on the blue-collar and the white-collar in the public and the private sector. There are familiar outcomes in these two tables compared with Table 2, the depth of education, work experience and the amount of years of staying in main workplaces all have positive effects on the dependent variable of the white-collar both in the public and the private sector. However, the influences of the last two explanatory variables obey the rule of diminishing marginal utility. The earnings frontier estimation told us the white-collar's hourly wage drops along with time going by in the public sector, while arises with it in the private sector. In addition, the estimation results in Table 3 showed that the blue-collar in the public sector will get a negative effect in salary with work experience but insignificant, which may be caused by the fact most of the blue-collar's work is labor-intensive so that work experience could do little to influence the salary.

To estimate the level of information people get in Taiwan's labor market, Tables 2 to 4 figured the level of information symmetry of the samples, male or female, and the blue-collar and the white-collar in the public and the private sector in the market. As declared above, if the labor market is in information symmetry, then both sides in it could fully use or get the related information of the opposite side. People would get same salary when they own same nature, technique or ability in this kind of market. Otherwise, when the employer and the employee can't get a whole picture of the information in one labor market, the market is likely in information insufficient or information asymmetry. People would get different salaries although they own same nature, technique or ability.

The percentage of the real salary in the potential salary of the employee (market in information symmetry), $E(e^{v})$, and the percentage of the salary employer are willing to give in the potential salary of the employee(market in information symmetry), $E(e^{\gamma})$, are important issues to find whether the labor market was in information symmetry. Eauqtion 1-$E(e^{v})$ and $E(e^{\gamma})$-1 could help to judge whether the employee get less or the employer give more because

Table 2
Two-Tiered Earnings Frontier Estimation from 2012 to 2014

Variables	Total			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.2249[a]	87.7846	5.5434[a]	88.2049
Schooling	0.5540[a]	68.0873	0.1394[a]	33.2593
Experience	0.1203[a]	18.5170	0.0480[a]	12.2023
Experience^2	–0.0160[a]	–12.3374	–0.0159[a]	–19.3825
Tenure	0.0047[a]	5.9161	0.0048[a]	10.7953
Tenure^2	–0.0016[a]	–6.4825	–0.0015[a]	–10.4611
Trend	–0.0006	–0.0238	0.0058[a]	4.6645
N	86230		86230	
Variables	Men			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.4311[a]	104.6240	6.8521[a]	23.8182
Schooling	0.3866[a]	49.5479	0.3478[a]	33.1671
Experience	0.1775[a]	25.4519	0.1458[a]	17.9500
Experience^2	–0.0267[a]	–19.6265	–0.0245[a]	–15.3575
Tenure	0.0131[a]	16.7571	0.0152[a]	18.1057
Tenure^2	–0.00283[a]	–11.6513	–0.0036[a]	–14.1052
Trend	–0.0016	–0.6472	–0.0032	–1.1443
N	49536		49536	
Variables	Men			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.0283[a]	39.3201	4.7278[a]	12.3602
Schooling	0.7287[a]	46.4816	0.8486[a]	9.9347
Experience	0.0269[a]	2.4948	0.0786[a]	9.0175
Experience^2	0.0024	1.0618	–0.0074[a]	–5.7784
Tenure	–0.0085[a]	–5.7139	–0.0074 [b]	–2.3111
Tenure^2	–0.0019[a]	–3.8902	–0.0040[a]	–10.9810
Trend	0.0064	1.4322	0.0070[a]	2.6979
N	36694		36694	

[a]Significant at 99%; [b]Significant at 95%.

Table 3
Results on Two-Tiered Earnings Frontier Estimation in the Public Sector (from 2012 to 2014)

Variables	Public sector total sample			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.6133[a]	94.7706	2.9950	0.0879
Schooling	0.4048[a]	43.7475	0.4049[a]	19.7618
Experience	0.0700[a]	8.78238	0.0700[a]	3.9619
Experience^2	–0.0568[a]	–3.3352	–0.0569	–1.5041
Tenure	0.0979[a]	11.4045	0.0979[a]	5.1500
Tenure^2	–0.0015[a]	–5.4867	–0.0015 [b]	–2.4780
Time trend	–0.0133	–0.5169	–0.0134	–0.2352
N	8946		8946	
Variables	The white-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.5582[a]	70.2888	1.8805	0.0668
Schooling	0.4321[a]	35.1346	0.4324[a]	25.6215
Experience	0.0868[a]	8.5660	0.0869[a]	6.2507
Experience^2	–0.0052 [b]	–2.2855	–0.0052 [c]	–1.6737
Tenure	0.0072[a]	6.8139	0.0072[a]	4.9729
Tenure^2	–0.0011[a]	–3.4260	–0.0011 [b]	–2.4937
Trend	–0.0023	–0.7411	–0.0023	–0.5477
N	6684		6684	
Variables	The blue-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.9022[a]	58.6840	3.0183	0.0185
Schooling	0.2618[a]	13.3938	0.2618[a]	14.5216
Experience	–0.0242 [c]	–1.7685	–0.0242 [c]	–1.9132
Experience^2	0.0013	0.4899	0.0013	0.5301
Tenure	0.0167[a]	11.9334	0.0167[a]	12.9318
Tenure^2	–0.0026[a]	–5.6435	–0.0026[a]	–6.1147
Time trend	0.0037	0.8375	0.0037	0.9077
N	2262		2262	

[a]Significant at 99%; [b] Significant at 95%; [c] Significant at 90%.

of insufficient information. We may hardly know the reservation wage of employees or the maximum salary the employers' are willing to give most of the time. But with the method of two-tiered earnings frontier estimation, we can get the percentage of that the employee got less or the employer gave more after they receiving sufficient information. Table 2 indicates that the wage of employees' could rise 9.71% (1- $E(e^{v})$, i.e., 1-0.9029) and the employers could pay 51.29% less on average when the samples of both genders are in information symmetry. After dividing these samples to samples of the male and the female, the first one will get 13.93% (1-0.8607) more and the second one will get 13.34% (1-0.8666) more than that the information asymmetry. The employers would pay 58.15% $E(e^{\gamma}) - 1$, i.e., 1.5815-1) less to the male while 45.60% (1.4560-1) less to the female than that in information asymmetry.

Compared the ignorance of the blue-collar, the white-collar and the employer in the public and the private sectors, we could find:

(1) The ignorance of employee and employer of the white-collar is bigger than that of the blue-collar. The work of the white-collar is mostly human-capital-intensive while that of the blue-collar is always labor intensive could be the main cause.
(2) When comparing the real salary with that in a labor market with sufficient information, the white-collar could get 21.94% more and their employers could pay 27.10% less on average in the public sector. In that condition, the blue-collar could get 13.63% more and their employers could pay 17.86% less on average, but it is not significant in the public sector (see

Table 4
Results on Two-Tiered Earnings Frontier Estimation in the Private Sector (from 2012 to2014)

Variables	Private sector total sample			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.3155[a]	84.2593	16.7993[a]	25.4988
Schooling	0.4874[a]	52.7598	0.6589[a]	162.677
Experience	0.1077[a]	15.1926	0.1691[a]	48.7677
Experience^2	–0.0151[a]	–10.7250	–0.0311[a]	–40.7412
Tenure	0.0343[a]	3.9085	0.0607[a]	14.4214
Tenure^2	–0.0018[a]	–6.3934	–0.0030[a]	–21.9796
Time trend	0.0073	0.2675	0.0019	0.1622
Amount	77284		77284	
Variables	The white-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.2258[a]	54.7305	7.6643[a]	8.0671
Schooling	0.5858[a]	45.4228	0.6686[a]	14.7939
Experience	0.0904[a]	9.0203	0.1372[a]	15.4592
Experience^2	–0.0073[a]	–3.1487	–0.0146[a]	–5.2197
Tenure	0.0037[a]	2.8521	0.0068[a]	5.8666
Tenure^2	–0.0005	–1.1717	–0.0010 [b]	–2.4386
Time trend	0.0032	0.9602	0.0031	0.9435
Amount	28854		28854	
Variables	The blue-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.6968[a]	72.9938	7.4126[a]	38.6219
Schooling	0.1275[a]	8.2744	0.0587[a]	8.2600
Experience	0.1286[a]	12.8759	0.0577[a]	11.8287
Experience^2	–0.0257[a]	–13.5300	–0.0082[a]	–9.9276
Tenure	–0.0012	–0.1023	0.0028	0.4152
Tenure^2	–0.0012[a]	–3.3101	–0.0012[a]	–5.8997
Time trend	0.0022	0.5634	0.0132[a]	7.5264
Amount	48430		48430	

[a]Significant at 99%; [b] Significant at 95%.

Table 3). In the private sector, the white-collar could get 12.53% more and their employers could pay 115.24% less on average, while the blue-collar could get 11.00% more and their employers could pay 87.37% less on average (see Table 4).

(3) According to Table 3, employers could pay 49.39% less and employees could get 30.5% more than that in the information asymmetry in the public sector. This fit the result of the labor market in Trinidad estimated by Murphy and Strobl (2008), but it is not significant in measuring the ignorance of both sides in labor market in the public sector. Most of the employees entered this kind of market with examination and there are fewer differences in ability, technique or the accumulation of the human-capital-intensive of them, which might be one of the reasons of this insignificance.

(4) Compared with the condition in the information symmetry, the percentage of what the

Table 5
Results on Two-Tiered Earnings Frontier Estimation of men in the Public Sector (from 2012 to2014)

Variables	The white-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.7021[a]	63.2283	3.0078	0.0149
Schooling	0.3396[a]	24.5098	0.3396[a]	17.7168
Experience	0.1235[a]	9.2259	0.1235[a]	6.6682
Experience^2	–0.0136[a]	–4.8737	–0.0136[a]	–3.5225
Tenure	0.0065[a]	4.9347	0.0065[a]	3.5625
Tenure^2	–0.9640 [b]	–2.3840	–0.0010 [c]	–1.7210
Time trend	–0.1980	–0.0511	–0.0020	–0.0371
Variables	The blue-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.9930[a]	54.2504	1.7775	0.01279
Schooling	0.2030[a]	8.9918	0.2030[a]	8.7337
Experience	0.0157	0.9955	0.0157	0.9650
Experience^2	–0.0073 [b]	–2.3311	–0.0073 [b]	–2.2563
Tenure	0.0121[a]	7.3909	0.0121[a]	7.1598
Tenure^2	–0.0012 [b]	–2.1857	–0.0012 [b]	–2.1241
Time trend	0.0169	0.3486	0.0169	0.3385

[a]Significant at 99%; [b]Significant at 95%.

Table 6
Results on Two-Tiered Earnings Frontier Estimation of men in the Private Sector (from 2012 to2014)

Variables	The white-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.5844[a]	77.3068	10.9691	0.7991
Schooling	0.3483[a]	30.6264	0.3480[a]	21.8088
Experience	0.1454[a]	14.8738	0.1456[a]	10.6135
Experience^2	–0.0194[a]	–9.0599	–0.0195[a]	–6.4894
Tenure	0.0105[a]	8.8879	0.0105[a]	6.3302
Tenure^2	–0.0019[a]	–4.6212	–0.0019[a]	–3.2847
Time trend	0.0246	0.7780	0.0243	0.5470
Variables	The blue-collar			
	OLS		MLE	
	Coefficient	*t*-value	Coefficient	*t*-value
Constant term	1.7989[a]	81.0471	6.2662	0.9390
Schooling	0.0160	1.0841	0.0143	0.9281
Experience	0.2051[a]	20.3309	0.2064[a]	19.5745
Experience^2	–0.0382	–20.0419	–0.0384[a]	–19.3033
Tenure	0.0119[a]	10.9021	0.0118[a]	10.3904
Tenure^2	–0.0026[a]	–8.4478	–0.0028[a]	–8.0570
Time trend	–0.0013	–0.0345	–0.0043	–0.1124

[a]Significant at 99%; [b] Significant at 95%.

Table 7
Comaprison on the ignorance of employee and employer from different groups (from 2012 to 2014)

Groups	Employee ignorance		Employer ignorance		Random error		N
		t-value		t-value	σ_u	t-value	
Both genders	0.1076[a]	57.7267	0.3390[a]	852.4540	1.1831[a]	57.5979	86230
Men	0.1619[a]	17.4863	0.3677[a]	29.0909	1.7779[a]	17.3821	49536
Women	0.1540[a]	7.8058	0.3132[a]	12.8459	1.5825[a]	7.7518	36694
Employers in the public sector							
both Apartments	0.4389	0.5100	0.3307	0.2763	2.5895	0.4908	8946
the White-Collar	0.2811	0.4148	0.2132	0.2258	1.7887	0.4013	6684
the Blue-Collar	0.1578	0.0610	0.1515	0.0300	1.2023	0.0595	2262
Employers in the private sector							
both Apartments	0.9367[a]	23.0412	0.2456[a]	24.9070	3.1796[a]	24.7498	77284
the White-Collar	0.1432[a]	6.4139	0.5354[a]	25.5117	1.7036[a]	6.3954	28854
the Blue-Collar	0.1236[a]	27.8105	0.4663[a]	128.7670	1.4658[a]	27.7359	48430
Male Employers in the Public Sector							
the White-Collar	0.2344	0.0375	0.2400	0.0769	1.8458	0.0749	2985
the Blue-Collar	0.1690	0.0537	0.1282	0.0294	1.1634	0.0522	1750
Male Employers in the Private Sector							
the White-Collar	0.4342[a]	3.3477	0.6449	1.2992	3.9322[a]	3.2701	14511
the Blue-Collar	0.5400[a]	3.3623	0.4282 [b]	1.7582	3.0677[a]	3.2221	30290

[a]Significant at 99%; [b] Significant at 95%.

employers would decrease in paying is less than that the employees would increase in getting. The employees in the private sector may have more different human-capital than that in the public sector (the condition of the employees in the private sector unlike the public sector because the later ones would only face one kind of employers, the government), could cause a larger ignorance of employee than that of the employer.

The final three tables list the subgroup estimations, Tables 5 and 6 show that all the explanatory variables except time trend (Trend) would have significant influence on the hourly wage of workers. The estimated value of the ignorance coefficient is not significant in the public sector in Table 5. The ignorance of the white-collar is deeper than the blue-collar in both sectors while the ignorance of both employee and employer in the private sector is deeper than that in the public sector. When comparing the real salary with that in a labor market with sufficient information in private sector in Table 6, the white-collar could get 30.29% more and their employers could pay 181.59% less on average, while the blue-collar could get 35.06% more and their employers could pay 74.95% less on average.

With studying the ignorance of employee and employer of different groups in Table 7, we found that the both ignorance of the male are deeper than that of the female, and the ignorance of employee and employer of the white-collar is always deeper than that of the blue-collar both in public and private sectors. When focusing on the sector factors, it is clearly that the ignorance of employee and employer in the public sector is insignificant. To see the male workers', the ignorance of employee and employer in the public sector is still insignificant, while the white-collar's is deeper than that of the blue-collar in the private sector.

This research shows that there are differences between different sectors, the blue-collar and the white-collar in the labor market. The reasons are: Employers can get more information of the potential workers when they're the blue-collar than that when they're the white-collar because the first kind of group's work nature (labor-intensive) has less diversity than that of the second group. Between different sectors, the public sector recruits and employs people with a more standardized way than the private sector. Most of the workers of the public sector enter after the national examination so that their salaries will adjust through the amount of years, the work experience and qualifications. Likewise, the employees could know their own salaries exactly with these standards. But referring to the private sector, employment is more complicated than the public sector. The information that both potential employer and employee could get can vary a lot, which lead to a deeper ignorance of the both sides than that in the public sector. All in

all, the empirical results are mostly consist with our expectation.

5. Conclusion

This study tries to explore the impacts that wage dispersion which influenced by insufficient information£¬with the use of data taken from the 2012-2014 Manpower Utilization Survey of Taiwan. We found that: The employees' average payments are lower than that in a labor market with complete information. The empirical results indicate that the ignorance of employee and employer are deeper in the private sector than that in the public sector and the employees and employer ignorance with the white-collar both larger than the blue-collar. A probably reason may due to the blue-collar workers' work mainly are labor-intensive, otherwise the white-collar workers' are mainly human-capital-intensive. Therefore the employers' informed degree (the depth of information of the potential employee) in the blue-collar is larger than the other one.

The results demonstrate there is a statistical insignificant in both ignorance estimation in the public sector. We consider the labors entering to the public sector mainly through national examination and causing an insignificant estimation. When just studying the sample of the male group, we found the ignorance of employee in the private sector is deeper than that in the whole sample estimation.

This study mainly explored the degree of the information asymmetry in the labor market, with the Manpower Utilization Survey of Taiwan. With the help of these kinds of data, it is very promising and persuasive to give advice to the government on the implementation of the related labor policy. We believed it is better to make further studies with long-term tracking materials in the future.

Acknowledgment

This paper was supported by the National Social Science Project in China (project no. 17JBY037), Major Project of Humanities and Social Sciences in Colleges and Universities in Zhejiang province during the year 2017-2018 (Grant No. 2018QN089), the MOE Foundation of Humanities and Social Sciences (Grant No. 19YJCGJW011), Talent Project by Qianjiang in Zhejiang province (Grant No. QJC1803005).

References

[1] A. Abdelaziz, Ahmed, et al., A machine learning model for improving healthcare services on cloud computing environment, *Measurement* **119** (2018), 117–128.
[2] A. Aigner, C.A.K. Lovell and P. Schmidt, Formulation and estimation of stochastic frontier production function models, *Journal of Econometrics* **86** (1977), 21–37.
[3] A. Murphy and E. Strobl, Employer and employee ignorance in developing countries: The case of trinidad and tobago, *Review of Development Economics* **12** (2008), 339–353.
[4] B. Gaynor and S.W. Polachek, Measuring information in the market: an application to physician service, *Southern Economics Journal* **60** (1994), 815–831.
[5] B.U. Park, L. Simar and V. Zelenyuk, Categorical data in local maximum likelihood: Theory and applications to productivity analysis, *Journal of Productivity Analysis* **43** (2015), 199–214.
[6] C.G. Parmeter, Estimation of the two-tiered stochastic frontier model with the scaling property, *Journal of Productivity Analysis* **49** (2018), 37–43.
[7] C.L. Chen, Counterfactual decomposition of public-private sector wage differentials in Taiwan: Evidence from quantile regression, *Acdemic Economic Paper* **35** (2007), 473–520.
[8] E.G. Tsionas, Maximum likelihood estimation of stochastic frontier models by the Fourier Transform, *Journal of Econometrics* **170** (2012), 234–248.
[9] J. BatleBatle, et al., Shareability of correlations in multiqubit states: Optimization of nonlocal monogamy inequalities, *Physical Review* **A 95** (2017), 11–23.
[10] Jingmei Li, et al., Research on tridiagonal matrix solver designing based on combination of processors, *Computers & Electrical Engineering* **62** (2017), 1–16.
[11] Mohamed Elhoseny, et al., Intelligent systems based on cloud computing for healthcare services: A survey, *International Journal of Computational Intelligence Studies* **6** (2017), 157–188.
[12] P.A. Hofler and S.W. Polachek, A new approach to measuring wage ignorance in labor market, *Journal of Economics and Business* **77** (1985), 267–276.
[13] P. Gangopadhyay and S. Shankar, Labour (Im)mobility and monopsonistic exploitation of workers in the urban informal sector: Lessons from a field study, *Urban Studies* **53** (2016), 1042–1060.
[14] P. Gomes, Optimal public sector wages, *The Economic Journal* **125** (2015), 1425–1451.
[15] S. Bazen and K.M. Waziri, The Assimilation of Young Workers into the Labour Market in France: A Stochastic Earnings Frontier Approach, Working Paper.
[16] S.P. Smith, Pay differentials between federal government and private sector workers, *Industrial and Labor Relations Review* **29** (1976), 179–197.
[17] S.P. Smith, Public/Private Wage Differentials in Metropolitan Areas, in P. Mieszkowski and G. E. Peterson (eds), Public Sector Labor Markets (1981), 81–102.
[18] S.W. Polachek and B.J. Yoon, A two-tiered earnings frontier estimation of employer and employee information in the labor market, *The Review of Economics and Statistics* **69** (1987), 296–302.
[19] S.W. Polachek and B.J. Yoon, Frontier Estimation: a Three-Error Component Generalization, Working Paper.
[20] S.W. Polachek and B.J. Yoon, Panel estimates of a two-tiered earnings frontier, *Journal of Applied Econometrics* **11** (1996), 169–178.

[21] T. Das and S.W. Polachek, Estimating labor force joiners and leavers using a heterogeneity augmented two-tier stochastic frontier, *Journal of Econometrics* **199** (2017), 156–172.

[22] V. Quadrini and A. Trigari, Public employment and the business cycle, *Scandinavian Journal of Economics* **109** (2007), 723–742.

[23] Y.C. Chuang, The effect of minimum wage on youth employment and unemployment in Taiwan, *Hitotsubashi Journal of Economics* **47** (2006), 155–167.

[24] Y. Stedhamn, and J.H. Yamamura, Gender and salary: A comparative study of accountants in the US and Australia, *Asia Pacific Journal of Human Resources* **38** (2000), 104–116.