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Industry Openness, Human Capital and Wage Inequality: Evidence from Chinese Manufacturing Firms

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***Abstract*—**This paper uses a primary data from 670 Chinese manufacturing firms, together with the newly introduced regression-based inequality decomposition method, to study the effect of openness on wage inequality. We find that openness leads to a positive industry wage premium, but its contribution to firm-level wage inequality is relatively small, only 4.69%. The major contributor to wage inequality is human capital, which could explain 14.3% of wage inequality across sample firms.

***Keywords*—**Openness, human capital, wage inequality, decomposition; China.

I. Introduction

SINCE the Heckscher-Ohlin model, there have been voluminous studies investigating the effect of openness on wage inequality. While in theory the effect of trade liberalization on the reduction of wage inequality in developing countries is unambiguous, empirical studies to date have not reached a consensus [2]. A positive linkage between openness and a rise of within-country wage inequality has been observed in Galiani and Sanguinetti [3] for Argentina, Hazarika and Otero [4] for Mexico, and in Mehta and Hasan [5] for India. Yet, there was no significant association between openness and wage inequality found in Esquivel and Rodriguez-Lopez [6] for Mexico, Galiani and Sanguinetti [3] for Argentina and in Attanasio, Goldberg [7] for Colombia. The aim of this study is to investigate the effect of trade liberalization on wage inequality from China by using a primary data from 670 manufacturing firms.

This study contributes to previous literature on this issue by providing empirical evidence from China, which is rare but important given that China has experienced an unprecedented rapid rate of openness as well as a sharp rise in wage inequality over past three decades. Furthermore, this study is among very a few studies that use firm-level data to investigate the effect of trade liberalization on wage inequality. As noted by Bernard, Jensen [8], firm-level data is more suitable for such research than individual wage data that widely used in previous studies because trade is an firm activity. Most importantly, this study extended previous literature by employing the newly introduced regression-based inequality decomposition method of Fields [9] to decompose firm-level wage inequality. This methodology enables us to compute and compare contribution percentages of openness, human capital and other factors to wage inequality.

The study is organized as follows: next section describes empirical strategies and data sources, and Section III discusses empirical results, and the last section concludes with a short summary and policy implementations.

II. Methodology and Data

A. Methodology

To examine the effect of openness on industry wage inequality, this study follows a three-stage estimation framework introduced by Mehta and Hasan [5]. This method combines a two-stage estimation framework familiar from labor literature on industry wage to identify the effect of openness on industry wage premium [7] and a third stage of inequality decomposition to calculate the contribution of each factor to the wage inequality.

In this first stage, the log of firm i's wage, $\ln(w_{ij})$, is regressed on a vector of firm characteristics H_{ij} and a set of industry indicators I_{ij}, using the following equation:

$$ln(w_{ij}) = I_{ij} * wp_j + H_{ij}\beta_{ij} + \varepsilon_{ij} \quad (1)$$

The coefficient of wp_j represents the wage premium in industry j, which captures the part of wage variation that can be explained by firms' industry affiliation. H_{ij} is a set of explanatory variables, including the share of production workers, human capital, firm size, firm age, ownership form (foreign-invested, state-owned or others), and firm location (province).

In the second stage, industry wage premiums (wp_j) are regressed on industry's openness ($Open_j$) in the following form:

$$wp_j = Open_j\beta_j + \mu_j \quad (2)$$

Following Arbache, Dickerson [10], this study constructs the variable of openness by using effect rates of protection (ERP) for each industry with an exponential form, that is $open_{jt} = \exp(-ERP_{jt})$. ERP is regarded as a good measure of industry openness as it takes into account tariff levels of both intermediate and final products [2].

In the third stage, a regression-based decomposition method of Fields [9] is employed to compute the contribution percentages of industry openness, human capital and other

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factors to the inter-firm wage inequality. Using the estimation results from (1), the contribution of each factor to the firm-level wage inequality is:

$$\pi_k = \mathrm{cov}[\beta_k X_k, y]/(\sigma\hat{}2\ (y)) \quad (3)$$

where y is the dependent variable in (1), i.e. $\ln(w_i)$. X_k is a set of characteristics that determine firm wages, which includes an error item. β_k is the estimated parameters of characteristics k.

B. Data and Variables

This study uses a primary cross-sectional data set from 670 manufacturing firms in 2012. These firms covered 20 industries at two-digit level of International Standard Industrial Classification (ISIC) and employed about 3.51 million workers. All of the required data were collected from each firm's financial annual reports of 2012, which are the most recent data available. The sample includes all of manufacturing firms listed on two Chinese stock markets (Shanghai and Shenzhen) excluding those firms with uncompleted information on wage bills and labor characteristics. The reason we selected firms listed on stock markets is that independent auditors had audited those firms' financial annual reports before publishing, and thus those data are more reliable and accurate than data collected from other resources. However, we are well aware that the choice of listed firms might lead to an overestimation of coefficient because our sample firms normally have larger size and pay higher wages to their employees than those firms that did not listed on stock markets.

The dependent variable in (1) is the logarithm of firm's average annual average (W_i), which is calculated as the total wage bill divided by the total number of employments. The explanatory variable of the share of production workers (L_i) is measured as the percentage of workers working on the production line to the total employment. Human capital (R_i) is measured as the proportion of workers with a university degree and above. Additionally, firm size (S_i) is measured as the logarithm value of total assets for each firm when registered, and firm age (A_i) measures the length of time a firm has been in business. Two characteristic variables are also included: ownership form (foreign-invested, state-owned or others) and firm location (province). The descriptive statistics for the dependent variable and numeric explanatory variables are provided in Table I.

TABLE I
DESCRIPTION OF STATISTICS FOR VARIABLES

Symbol	Name and units	Mean	SD	Min	Max
W_i	Firm wage, RMB Yuan	64086	23490	9254	189432
L_i	Share of production worker, %	59.58	18.24	2.36	93.88
R_i	Human capital, %	16.35	12.04	00.14	71.02
S_i	Firm size, 1 million RMB Yuan	57.48	134.31	2.27	1750.17
A_i	Firm age, Year	14.33	4.84	2.60	47.03

To calculate the ERP for each industry, we draw on the WTO tariff database to collect recent nominal tariffs for each industry in China, and the Chinese input-output table 2010 published by the China Statistic Bureau for the data on input-output ratios. The calculation follows the method of Corden [11]. The nominal tariff levels and results of computed ERPs for 20 industries are presented in Table II.

TABLE II
NOMINAL TARIFF LEVEL AND COMPUTED ERP BY INDUSTRY, %

ISIC 2-digit Code	Sector Name	MFN	ERP
10	Food products	18.91	34.14
11	Beverages	13.09	13.34
13	Textiles	12.52	13.61
14	Wearing apparel	15.23	20.38
15	Leather and related products	11.39	11.17
17	Paper and paper products	6.10	-0.87
18	Printing and reproduction of recorded media	4.78	-0.67
19	Coke and refined petroleum products	1.46	0.90
20	Chemicals and chemical products	5.19	3.89
21	Pharmaceuticals, medicinal chemical and botanical products	4.28	NA*
22	Rubber and plastics products	9.69	-6.44
23	Other non-metallic mineral products	0.015	-0.19
24	Basic metals	4.17	3.53
25	Fabricated metal products, except machinery and equipment	8.43	-11.05
26	Computer, electronic and optical products	5.19	4.10
27	Electrical equipment	1.54	-15.00
28	Machinery and equipment i.e.	4.57	-10.93
29	Motor vehicles, trailers and semi-trailers	18.97	33.32
30	Other transport equipment	3.99	4.47
32	Other manufacturing	12.23	-2.68

Notes: *The ERP for the Manufacture of pharmaceuticals, medicinal chemical and botanical products (ISIC 21) is not available due to the data limitation on input-output ratio for this industry.

III. EMPIRICAL RESULTS

A. Estimation of Wage Equations and Wage Premium

Table III reports the first stage regression results. The R^2 for the regression excluding industry indicators and including industry indicators are 0.317 and 0.409, respectively. The difference between them implies that the industry affiliation accounted for 9% of the total variation in annual wages (log) among firms after controlling for location, human capital, worker type, firm's ownership, firm size, and firm age. Our finding is higher than the general finding using the individual wage data, which is about 4 to 7% [12]. The dissimilarity may occur because of using firm-level data and China as the case.

Nevertheless, two models present very similar coefficients for explanatory variables listed in Table III. The results suggest that human capital and firm size are positively and significantly associated with firm wages while the percentage of production workers has a significantly negative impact on firm wages. In addition to that, state-owned enterprises are found to pay higher average wages to their employees than other ownership forms of enterprises. However, firm age has no significant influence on firm wages.

TABLE III
OPENNESS AND INDUSTRY WAGES IN THE MANUFACTURING SECTOR

	Without industry indicators	With industry indicators
Constant	10.475*** (0.113)	10.496*** (0.118)
L_i	-0.186** (0.075)	-0.268*** (0.077)
R_i	1.053*** (0.113)	0.924*** (0.114)
S_i	0.056*** (0.011)	0.056*** (0.011)
A_i	-0.002 (0.002)	-0.001 (0.002)
Foreign invested	0.057 (0.045)	0.059 (0.043)
State-owned	0.097*** (0.027)	0.110*** (0.027)
Province indicators	Yes	Yes
Industry indicators	No	Yes
R^2	0.317	0.409
F-statistic	7.911	2.782
Observations	670	670

Notes: Standard errors in parentheses. *** Significant at 1% level ** Significant at 5% level* Significant at 10% level

TABLE IV
OPENNESS AND INDUSTRY WAGES IN THE MANUFACTURING SECTOR

ISIC Code	Estimated coefficients	Standard errors	Normalized coefficient
10	0.000	0.118	0.015
11	-0.001	0.089	0.005
13	-0.122*	0.071	-0.964*
14	-0.075	0.081	-0.589
15	-0.296**	0.136	-2.366**
17	-0.211**	0.104	-1.678**
18	0.021	0.103	0.185
19	0.065	0.182	0.537
20	0.037	0.062	0.315
21	-0.194***	0.065	-1.545***
22	0.147*	0.081	1.195*
23	0.040	0.075	0.338
24	0.086	0.075	0.705
25	0.065	0.073	0.534
26	0.080	0.063	0.659
27	0.065	0.063	0.540
28	0.154**	0.061	1.251**
29	-0.042	0.075	-0.321
30	0.163*	0.097	1.326*
32	-0.019	0.167	-0.141

Notes: Standard errors in parentheses. *** Significant at 1% level ** Significant at 5% level* Significant at 10% level

Based on estimation results listed in Column (2) of Table III, the estimated industry wage premiums (wp_j) are obtained and presented in Table IV. It shows a considerable dispersion across industries: the normalized wage premiums ranging from -2.37 to 1.33. Among the seven industries with statistically significant wage premiums, three industries, i.e.ISIC30, ISIC28, and ISIC2, reported positive wage premiums, and four industries, i.e. ISIC13, ISIC15, ISIC17, and ISIC21, reported negative industry wage premiums. For example, the estimated wage premium for the industry of transport equipment (ISIC30) is 0.163 at 10% level of significance, and the estimate of wage premium for textile industry (ISIC17) is -0.211 at 5% level of significance. These estimations imply that a worker with the same observable characteristics switching job from textile to transport industry would observe a rise of 37% in annual wage $(0.163 - (-0.211))$.

B. Effect of Industry Openness and Wage Premium

The scatter plots in Fig. 1 demonstrate the positive relationship between industry openness and wage premium.

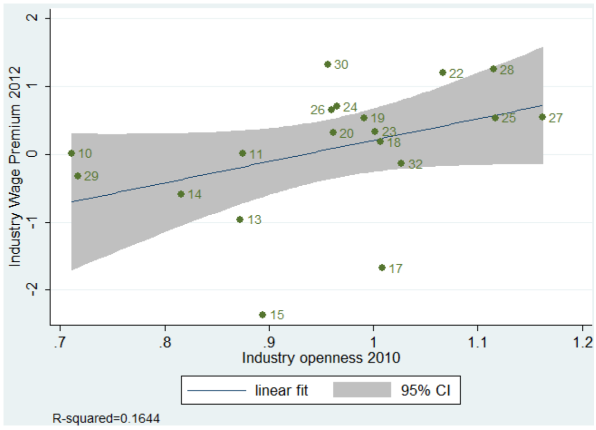

Fig. 1 Openness in 2010 and industry wage premium in 2012

The estimated results from the second stage regression are reported in Table V. Model 1 followed the OLS method and the model 2 followed the weighted least squares (WLS) method and used the inverse of the standard error of the wage premium from the first stage as weights. The estimation results are consistence with Fig. 1 and confirm a positive association between openness on industry wage premium as the coefficient of openness on the estimated industry wage premium is positive and statistically significant in both models. The magnitude of 3.3 in the WLS model indicates that a 1% increase in the industry openness leads to an increase in the industry wage premium by 3.3%. This finding is in line with Kumar and Mishra [12] for India, but contradicts Pavcnik, Blom [13] for Brazil.

TABLE V
TARIFFS AND INDUSTRY WAGE PREMIUMS: FROM CROSS-SECTION DATA

	(1) OLS model	(2) WLS model
Constant	-2.936* (1.663)	-3.023* (1.468)
Openness	3.145* (1.720)	3.308** (1.507)
R^2	0.164	0.221
Adjusted R^2	0.115	0.175
F-Statistics	3.345	4.820
Obs.	19	19

Notes: Standard errors in parentheses; *** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level

C. Decomposition of Wage Inequality

The wage inequality, measured as the Gini coefficient, is 0.19 among the 670 sample firms. It can be reflected by the corresponding Lorenz curve shown in Fig. 2, which illustrates an unequal wage distribution among those firms because the Lorenz curve depicted by the dashed line departs from the line of perfect equality (the solid line).

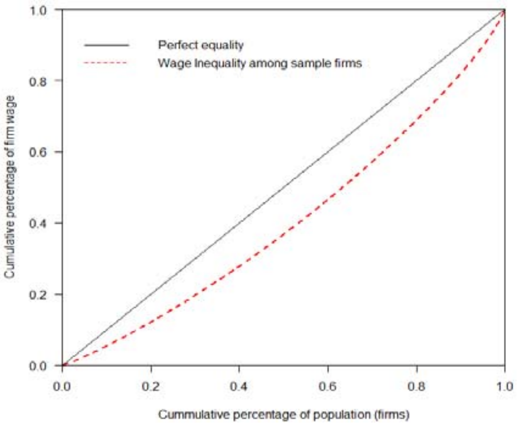

Fig. 2 Lorenz curve of wage inequality for sample firms

Based on the regression equation reported in Table III, we decomposed the firm-level wage inequality and computed the percentage contribution of each variable to the total wage inequality. The results are presented in Table VI. Except for the residual that explained 71.27% of wage inequality, the variable of human capital is the largest contributor to firm-level wage inequality, which accounted for 14.30%. The variable of industry affiliation, although being the second-most important factor, only contributed 4.69% of wage inequality. The share of productions workers is the third largest contributor with a contribution of 4.57%. Firm size and ownership form accounted for 3% and 2%, respectively. The contributions of firm location (province) and firm age were negligibly small.

TABLE VI
DECOMPOSITION OF WAGE INEQUALITY BY DETERMINANTS OF FIRM WAGES

Rank	Factors	Contribution (%)
1	Human capital	14.30
2	Industry affiliation	4.69
3	Share of production workers	4.57
4	Firm size	3.01
5	Firm ownership form	2.11
6	Province	0.05
7	Firm age	-0.01
8	Residual	71.27
9	Total	100

Notes: The decomposition is based on the Gini coefficient by using the Stata command 'ineqrbd' written by Fiorio and Jenkins [1].

IV. CONCLUSION

This study investigated impact of industry openness and wage inequality by using a primary data set from 670 Chinese manufacturing firms. Consistent with the prediction of classic trade theory, the empirical analysis has shown that trade liberalization increases firm wages as we found that firms in more opened industries tend to pay higher average wages to their employees. However, results of decomposing firm-level wage inequality show that industry affiliation is not the major contributor to wage inequality. Firm's heterogeneity in human capital is found to be the major cause for firm-level wage inequality. The contribution of human capital is about three times that of industry affiliation.

In conclusion, this study shows that openness increases wages, but only makes a moderate contributor to the firm-level wage inequality. The policy implication of these findings is that a further trade reform in the relatively closed industries will help to increase wages of low-income earners but not considerably enlarge wage inequality between firms. Moreover, providing more education opportunities for unskilled workers will enable them to earn more salaries and therefore reduce wage inequality.

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