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Jinno, Masatoshi

Nanzan University

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Masatoshi Jinno*

* Department of Economics, Nanzan University, 18 Yamazato-cho, Showa-ku, Nagoya, Aichi 466-8673, Japan.
Email: jimasato@nanzan-u.ac.jp

Abstract
This paper examines the imperfect substitutability between foreign workers and native residents in Japan. It utilizes a production function to analyze how foreign workers impact native wage rates, employing data from Japan's Basic Wage Structure Survey. The study finds significant, yet theoretically unexpected results regarding the wage rate and annual income ratios between native and foreign workers. Despite the significance of its findings, the paper acknowledges limitations and the need for further research, especially concerning classification by residency status.

Key Words: Foreign Workers, Imperfect Substitutability, Productivity

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During the preparation of this work, we used Chat GPT 4.0 for proofreading purposes.

I. Introduction

According to the International Organization for Migration (IOM, 2021), the global count of international migrants reached 281 million in 2020, marking an average annual growth rate of 2.45% since the year 2000. This growth rate is over twice the global average population growth rate of 1.18%, underscoring the growing impact of international migration in the 21st century.

Various studies have examined the impact of accepting foreign workers, focusing particularly on the wages of native residents. These studies have yielded mixed results, both positive and negative. Dustmann et al. (2016) highlight the significance of differing capital inflow responses as a reason for these varied outcomes. They also note differences in estimation methods and targets, proposing a unified estimation formula that considers an imperfect substitution relationship between native and foreign workers. They argue that foreign workers experience a "Downgrade" upon being accepted into the host country, placing them in a stratified category. Even with an assumed imperfect substitution within this category, it leads to "Misclassification." This paper argues that native and foreign workers should be considered separate production factors, a perspective also taken by Llull (2020) in analyzing GDP per capita impact. However, focusing on GDP per capita may skew the perceived impact of accepting foreign workers, depending on their productivity relative to that of the host country's workers. Thus, this paper employs a production function that accounts for the imperfect substitutability of labor provided by both native and foreign workers, as used by Llull (2020), to analyze the effect of foreign workers on native wage rates, utilizing data from Japan.

Until recently, Japan's public wage rate surveys seldom included nationality. Only recently have "Basic Wage Statistics" started to incorporate such data. Consequently, this research is the first to use public data to estimate a production function and structurally assess the impact of foreign workers.

II. Model

The production function in sector X is defined as $Y_t^X = (K_t^X)^{\delta}\left(L_t^{X_T}\right)^{(1-\delta)}$, where $\delta \in (0,1)$. Here, Y_t^X indicates the output of sector X, $K_t^{X_T}$ the sector's total capital, and $L_t^{X_T}$ the sector's

total labor force. To explore how native and foreign workers either perfectly or imperfectly substitute for each other (or complement each other), we apply a specific labor supply function:

$$L_t^{X_T} = \left[\psi\left(L_t^{X_N}\right)^{\phi} + (1-\psi)\left(L_t^{X_{IM}}\right)^{\phi}\right]^{\frac{1}{\phi}}, \quad if\ \phi \le 1, or\ \phi \neq 0 \text{ or}$$
$$L_t^{X_T} = \left(L_t^{X_N}\right)^{\psi}\left(L_t^{X_{IM}}\right)^{1-\psi}, \quad if\ \phi = 0, \tag{1}$$

where $L_t^{X_N}$ and $L_t^{X_{IM}}$ denote the labor supplied by native and foreign workers in sector X, respectively. ψ indicates the proportion allocated to the native labore force. The elasticity of substitution between these two groups is given by $\frac{1}{1-\phi}$. The relationship is perfectly substitutable when $\phi = 1$, imperfectly substitutable when $0 < \phi < 1$, and complementary when $\phi < 0$.

According to profit maximization theory, we derive the following equations:

$$(1 + r_t^X) = \delta\left(\frac{Y_t^X}{K_t^X}\right) \tag{2-a}$$

$$w_t^{X_N} = (1-\delta)\left(\frac{Y_t^X}{L_t^{X_T}}\right)\cdot\left(\frac{L_t^{X_T}}{L_t^{X_N}}\right)\cdot\left(\frac{\psi\left(L_t^{X_N}\right)^{\phi}}{\psi\left(L_t^{X_N}\right)^{\phi} + (1-\psi)\left(L_t^{X_{IM}}\right)^{\phi}}\right) \tag{2-b}$$

$$w_t^{X_{IM}} = (1-\delta)\left(\frac{Y_t^X}{L_t^{X_T}}\right)\cdot\left(\frac{L_t^{X_T}}{L_t^{X_{IM}}}\right)\cdot\left(\frac{(1-\psi)\left(L_t^{X_{IM}}\right)^{\phi}}{\psi\left(L_t^{X_{IM}}\right)^{\phi} + (1-\psi)\left(L_t^{X_{IM}}\right)^{\phi}}\right) \tag{2-c}$$

Using Equations (2-b) and (2-c), the relative wage rate in sector X is calculated as:

$$\frac{w_t^{X_N}}{w_t^{X_{IM}}} = \left(\frac{\psi}{1-\psi}\right)\left(\frac{L_t^{X_N}}{L_t^{X_N}}\right)^{\phi-1} \tag{3}$$

When equation (3) is logarithmized, it becomes the following equation:

$$\ln\left(\frac{w_t^{X_N}}{w_t^{X_{IM}}}\right) = \ln\left(\frac{\psi}{1-\psi}\right) + (\phi-1)\ln\left(\frac{L_t^{X_N}}{L_t^{X_{IM}}}\right) \tag{4}$$

In this paper, we estimate the relationship between native residents and foreign workers using Equation (4).

III. DATA

I use data from the Basic Survey on Wage Structure spanning from 2019 to 2021. Average wage rates consist of average monthly contract cash earnings. Average annual incomes are calculated by multiplying monthly contract cash earnings by 12, adding the annual bonus and any special cash earnings, and then dividing the total by the number of individuals. The dataset is restricted to individuals aged 18 to 65, who are full-time employees and male. The limitation of data usage in this manner was due to the analysis period including the COVID-19 era, which is believed to have had a more significant impact on non-regular employees, as well as women and the elderly. Foreign workers were defined as those holding residency statuses, excluding those with statuses numbered 16 to 24[1].The basic statistics of the variables are presented in Tables 1.

Sector	Sample	Average wage rate	Average annual income
D	91,354	369,011	5,530,811
		(144101)	(2537097)
E	540,151	338,481	5,121,743
		(132635)	(2362490)
F	68,664	427,623	6,490,387
		(158677)	(2463057)
G	84,016	396,581	6,044,987
		(174671)	(2949088)
H	160,491	327,908	4,709,656
		(153949)	(2400935)
I	216,115	315,988	4,718,580
		(164446)	(2855325)
J	125,156	478,972	7,585,856
		(258939)	(4870814)
K	88,550	328,859	4,913,120
		(173494)	(2918038)

Sector	Sample	Average wage rate	Average annual income
L	95,293	407,325	6,291,577
		(181247)	(3181810)
M	78,249	188,612	2,480,901
		(139685)	(1968840)
N	85,145	246,917	3,357,655
		(144645)	(2155217)
O	101,946	309,180	4,671,131
		(210583)	(3494334)
P	58,780	354,214	4,984,045
		(293360)	(3916041)
Q	60,240	326,292	4,994,057
		(119652)	(2078262)
R	203,236	294,796	4,225,880
		(130629)	(2172708)

Table 1 Basic statistics of the variables

Note: The number in parentheses represents the standard deviation (S.D.). Because the number of foreign workers in sector C becomes zero or one, sector C is excluded in this analysis.

[1] Individuals with residency status numbers 16 and 17 are categorized as 'Specified Skilled Worker (I) or (II).' Individuals with residency status numbers 18 are categorized as 'Technical Intern Trainee.' The former residency status aims to address labor shortages, whereas the latter, officially for technology transfer, also targets labor shortages. Despite salaries for these statuses being intended to match full-time employees', they tend to resemble part-time workers' pay. Thus, it is seen as inappropriate to equate them with regular foreign workers(See JILPT (2023) for detail). Individuals with residency status numbers ranging from 19 to 24 are also excluded, as their residency statuses are primarily for educational purposes, not labor.

IV. Results

The results of estimating the average wage rate ratio as the dependent variable, with the ratio of native to foreign workers within industries as the explanatory variable, are summarized in Table 2. The test results suggest that the pooled model is preferable. Although the F-value indicates that the estimation itself is meaningful, the coefficient of the employment ratio is positive and significant at the 1% level. This means that in Equation (4), $\phi - 1$ is positive, implying $\phi > 1$. This result is theoretically unexpected.

Dependent variable	ln(average wage rate)		
Analysis method	Pooled	Randam	Fix
ln(rerative number)	0.003***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)
yd2020	0.007	0.007*	0.007*
	(0.007)	(0.004)	(0.004)
yd2021	0.004	0.004	0.005
	(0.007)	(0.004)	(0.004)
Constant	0.984***	0.983***	
	(0.006)	(0.006)	
Observations	45	45	45
R2	0.223	0.262	0.291
Adjusted R2	0.166	0.208	-0.156
F Statistic	3.916**	14.541***	3.692**

Table 2.

Note： *p<0.1; **p<0.05; ***p<0.01

The Breusch-Pagan test results, showing a p-value above 0.1, do not provide significant evidence of heteroscedasticity in the residuals of the pooled model. Similarly, the F-test, with a p-value greater than 0.1, indicates that the pooled model is appropriately adaptive.

The results of estimating the average annual income ratio as the dependent variable, with the ratio of native to foreign workers within industries as the explanatory variable, are summarized in Table 3. In this estimate, we also obtain theoretically unexpected results.

Dependent variable	ln(average annual income)		
Analysis method	Pooled	Randam	Fix
ln(rerative number)	0.003***	0.002**	0.002
	(0.001)	(0.001)	(0.001)
yd2020	0.008	0.007**	0.007**
	(0.007)	(0.003)	(0.003)
yd2021	0.004	0.003	0.003
	(0.007)	(0.003)	(0.003)
Constant	0.992***	0.995***	
	(0.006)	(0.006)	
Observations	45	45	45
R2	0.22	0.208	0.212
Adjusted R2	0.163	0.15	-0.284
F Statistic	3.855**	10.754**	2.423*

Table 3.

Note： *p<0.1; **p<0.05; ***p<0.01

The Breusch-Pagan test results, showing a p-value above 0.1, do not provide significant evidence of heteroscedasticity in the residuals of the pooled model. Similarly, the F-test, with a p-value greater than 0.1, indicates that the pooled model is appropriately adaptive.

V. Conclusion

This study utilized the Basic Wage Structure Survey, which also investigates nationality, to estimate the impact of foreign worker acceptance on the wages of native residents, using the structure of the production function. However, although the estimation results were significant, they were theoretically implausible. The results of this study may be attributed to factors such as the lack of detailed classification by residency status. We intend to continue making the necessary improvements.

Preference

Dustmann, C., U. Schönberg, and J. Stuhler (2016) “The Impact of Immigration: Why Do Studies Reach Such Different Results?” Journal of Economic Perspectives, Vol. 34(4), pp. 31-56.

JILPT (2023) *Survey on the Acceptance and Utilization of Foreign Workers with Specified Skill No. 1* [Translated from Japanese.]. The Japan Institute for Labour Policy and Training. (written in Japanese).

Llull, J. (2020). “The Impact of Immigration on Productivity.” in E. Vella, J. Caballé, & J. Llull (Eds.), *Understanding Migration with Macroeconomics*, Palgrave Macmillan.