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The Effect of Offshoring on Skill Premiums: Evidence from Japanese Matched Worker-Firm Data

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Keywords: Offshoring; Skill premium; Matched worker–firm data; Japanese labor market; Wage; Annual income; Female worker; Labor demand

JEL classification: F16; J23; J24; J31; L24

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I. Introduction

When the impact of offshoring on labor markets is examined in the context of developed countries, it is usually hypothesized that the increase of offshoring has led to a shift in labor demand toward skilled workers and to a relative decrease of the wage of unskilled workers. This is because offshoring is usually observed as a movement of unskilled labor-intensive stages in business process to developing countries. Research results generally confirm that offshoring increases skill premium in sourcing countries, that is, it expands wage inequality between skilled and unskilled workers. Examples include Feenstra and Hanson (1999) for the United States (US), H. Egger and Egger (2003) for Austria, Hijzen, Görg, and Hine (2005) for the United Kingdom, Yan (2006) for Canada, Baumgarten, Geishecker, and Görg (2013) for Germany, and Hummels, Jørgensen, Munch, and Xiang (2014) for Denmark.[1] However, there is no previous research that examines the effect of offshoring on skill premium in the context of Japan, presumably because of the limitation of data availability.[2] Japan is an intriguing country in which to conduct this research, especially from the viewpoint of labor mobility; the liquidity of labor is still quite low in Japan compared with other countries, and therefore, it is assumed that the shock of offshoring in a particular firm is absorbed mostly in the internal labor market of that firm, which would produce results peculiar to Japan.[3] The aim of this study is to investigate whether offshoring of Japanese companies actually increases their employees' skill premiums, by constructing Japanese matched worker–firm data from government statistics.

Empirical examination of the offshoring effect on wages raises the difficulty of correcting the endogeneity of offshoring. It seems natural to consider that offshoring is endogenous with

[1] There are three different definitions of skilled and unskilled labor used in these studies. Feenstra and Hanson (1999) and Yan (2006) consider production workers and non-production workers as proxies for unskilled and skilled labor, respectively. H. Egger and Egger (2003) and Hijzen et al. (2005) consider the characteristics of each job or task and classify workers with jobs or tasks that require high or special qualifications as skilled labor. Baumgarten et al. (2013) and Hummels et al. (2014) use the classification of workers' educational background as a proxy for skill.

[2] Some related studies regarding international economic activities and skill premium in Japan are as follows. Although without analysis of the effect of offshoring, Sakurai (2004) estimates the effect of increased export and import in the 1980s on the relative wage of non-production to production workers in Japanese manufacturing by employing the factor content of trade approach, and shows that it raises the relative wage of non-production to production workers by 2.4% or less. Head and Ries (2002) show that additional foreign affiliate employment in low-income countries by Japanese multinationals raised high-skilled workers' share of the wage bill in 1965–1990. This result of skill upgrading is compatible with the hypothesis that increasing offshoring raises skill premium, since the increase of foreign affiliate employment of Japanese firms correlates with the increase of their offshoring, and skill upgrading increases relative labor demand for skilled labor and thereby raises skill premium. Yamashita (2008) finds a similar result, that the expansion of fragmentation trade with developing East Asian countries significantly contributed to skill upgrading in Japanese manufacturing in 1980–2000.

[3] Average job tenure of Japanese employees was 11.9 years in 2010 (from *The Basic Survey on Wage Structure*, the Ministry of Health, Labour and Welfare, Japan), which is longer than that of all countries provided in the OECD Database (*Employment by job tenure intervals*). In particular, average job tenure of Japanese male workers is 13.3 years, which is remarkably longer than that of Italian male workers (11.7 years), which is the highest of all countries available in the OECD database, which does not provide this figure for Japan.

respect to firm optimization process. Offshoring is a choice variable for firms, and thus, may be determined together with factor prices or after the determination of factor prices in each firm. In addition, other unobserved variables may simultaneously affect the level of offshoring and factor prices. This endogeneity problem has often been addressed in previous research by using lagged or aggregated levels of independent variables as instruments. Even though this could reduce the problem of reverse causality or simultaneity, independent variables and the error term may still be correlated after this treatment. Some recent studies employ two different approaches to this problem. One is to use large-scale policy change in potential offshored countries in charge of producing the intermediate goods and exporting them to offshoring countries, which is exogenous to firm performance in the offshoring country, such as Hsieh and Woo (2005) and P. Egger, Pfaffermayr, and Weber (2007).[4] The other is to use instrumental variable (IV) estimation, in which a company's offshoring is estimated by IV, such as trade costs and global trade. H. Egger and Egger (2003) is, to the best of my knowledge, the first study to adopt this approach for the analysis of offshoring, while H. Egger and Egger (2006) is another early example.[5] Since it is hard to find appropriate international examples for Japan using the former approach, I use the latter approach, that is, IV estimation, in this study.

Along with the development of trade theory to encompass the characteristics of industries and the heterogeneity of firms, as well as the expanded availability of detailed economic data for researchers, worker-level panel data came to be employed in empirical trade research mainly after the 2000s. Use of such data enables us to separate wage changes for individual workers induced by a particular type of economic activity from changes in the workforce within a firm or industry. Schank, Schnabel, and Wagner (2007) and Baumgarten (2013) estimate exporter wage premium in Germany, and Autor, Dorn, Hanson, and Song (2014) and Ebenstein, Harrison, McMillan, and Phillips (2014) analyze the effect of exposure to globalization on earnings and employment of workers in the US, all using worker-level panel data. Unfortunately, because surveys conducted by the Japanese government do not contain any worker identification information, we cannot construct worker-level panel data. Instead, I construct matched worker–firm data on which the panel variable is the firm, not the worker.

With a rich body of related previous work, this study is located especially at the end of two strands of literature: estimating offshoring effects on the labor market in sourcing countries by IV

[4] Hsieh and Woo (2005) use China's decision to open its market to foreign investors in 1980 as an exogenous factor for Hong Kong's outsourcing and suggest that outsourcing to China explains around half of the relative demand shifts toward skilled labor in the manufacturing sector in Hong Kong. In addition, P. Egger et al. (2007) use the opening of Eastern European countries during the 1990s as an exogenous factor for the Austrian labor market and their results support the view that increases in outsourcing reduce workers' probability of staying in the manufacturing sector.

[5] H. Egger and Egger (2003) show that the decrease of trade barriers after the fall of the Iron Curtain helps stimulate outsourcing activities in Austrian industries, and consequently, increases the skill premium of Austrian workers. H. Egger and Egger (2006) estimate that outsourcing in manufacturing sectors in the European Union (EU) exhibits a negative marginal effect on real value added per low-skilled worker in the EU in the short run, but this becomes positive in the long run.

estimation and using worker-level data for trade research. A study at the intersection of these two strand is Hummels, Jørgensen, Munch, and Xiang (2014), on which my study depends from a methodological point of view. Hummels et al. (2014) uses matched worker–firm data in Denmark and IV estimation to show that offshoring by Danish firms enlarges skill premium in the Danish labor market. The methodological extension in the present study is twofold. First, I consider two types of skills—field of skills and level of skills—by using two sets of dummies—female dummy and education dummies. Second, since detailed data about the international transaction of Japanese firms are not available, I test the aggregate method of constructing IV for offshoring and exports, which is applicable to other countries with limited data availability.

This study considers gender difference in the wage equation by introducing a female worker dummy and its interaction term with offshoring, since the Japanese labor market is distinguished by a large gender gap of wage distribution. Even so, it is observed that male workers generally commit themselves more fully to the firm, serve the same firm for longer, and accept longer working hours and more frequent transfers than female workers. Kambayashi, Kawaguchi, and Yokoyama (2008), Miyoshi (2008), Abe (2010), and Chiang and Ohtake (2014) show that the gender wage gap still exists in Japan after controlling for education and experience factors of the workforce. Therefore, the female worker dummy is expected to have a negative coefficient in the wage equation.

As for the interaction term of the female worker dummy and offshoring, the coefficient indicates how the increase of offshoring by firms affects the wages of their female workers. There are potentially three channels through which offshoring affects wages in the labor market: labor demand, labor supply, and the mechanism of wage determination. Among them, the effects of the second and third channels are almost negligible, since they are considered exogenous for firms' decisions on offshoring. An increase of offshoring hardly changes labor supply conditions, such as reservation wage and self-investment, nor so the system of labor market that produces, for example, statistical discrimination against female workers.[6] Therefore, I interpret the coefficient of the interaction term as the effect of the first channel, that is, offshoring affects male and female wages through the change of demand by firms for skills embodied by male and female workers. If, for example, offshoring intensively requires skills embodied abundantly by female workers, the increase

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[6] Regarding import competition, the literature suggests the possibility that it narrows the gender wage gap through the third channel. Applying the argument of employer discrimination by Becker (1957), the increasing competitive pressures from foreign firms in final goods markets makes discrimination against female workers being costly to employers, therefore employers who has a "taste for discrimination" decrease relatively their production. Black and Brainerd (2004) find that US industries which were subject to more import competition experienced greater reductions in the gender wage gap, which supports Becker (1957)'s theory. Weichselbaumer and Winter-Ebmer (2007) and Wolszczak-Derlacz (2013) also examine import and gender wage gap in a multi-country setting and find more nuanced results. This perspective does not hold, however, for the case of offshoring intermediate goods, which this paper focuses on. Rather, if increasing offshoring of a firm positively affects its revenue, it might give its employers wiggle room to wield their tastes for discrimination. In this study, I explore the possibility that firms' international transactions affect their wages through the change of their labor demand, not through the mechanism of wage determination in labor market.

of offshoring would raise the wage of female workers relatively more. It is assumed in this study that male workers relatively abundantly embody skills in "science-oriented knowledge" and administrative tasks, while female workers do so for skills in "human-oriented knowledge" and non-administrative tasks, as explained in Section II.[7]

The reminder of this paper is structured as follows. Section II explains the construction of matched worker–firm data in Japan. Section III describes two aspects of skills that this paper focuses on as well as the econometric model à la Hummels et al. (2014). Section IV presents the net effect of trade on wages. Finally, Section V concludes.

II. Data Description

Japan has neither a survey including detailed economic status of both workers and their employer companies, nor a worker identification system that enables identification of who works for which company in what time period. In order to construct a Japanese matched worker–firm dataset for this research, I use *The Basic Survey on Wage Structure* for worker data and *The Basic Survey of Japanese Business Structure and Activities* for firm data. The former is from selected establishments, that is, physically located economic units of firms, while the latter is composed of firm data. They do not include information about the establishment–firm connection, and therefore, I employ two censuses to link both datasets: *The Establishment and Enterprise Census* and *The Economic Census for Business Frame*. The worker–firm data obtained after this procedure comprise unbalanced panel data, and the panel variable is the firm, not the worker, since worker data and firm data are connected by establishments that are randomly selected every year in *The Basic Survey on Wage Structure*.

The Basic Survey on Wage Structure (hereafter, *The Wage Survey*) aims to obtain the wage structure of employees in Japan. It is currently conducted yearly by the Ministry of Health, Labour and Welfare on private establishments that have five or more regular employees and public establishments that have 10 or more regular employees. The population for this survey is about 1.4 million establishments and approximately 37 million employees nationwide every year. The sampling method consists of two-stage sampling in which establishments are the primary sampling unit while employees are the secondary sampling unit. There are about 75,000 establishments sampled and approximately 1.6 million employees sampled every year.[8] Items of this survey include each employee's monthly contractual cash earnings, annual special cash earnings, years of job tenure, age, gender, school career, and workplace information. This survey is conducted every year

[7] This definition of gender-specific skills is different from that of Juhn, Ujhelyi, and Villegas-Sanchez (2014), who assume that female workers have lower amount of "brawn" relative to male workers, and have relatively higher productivity under modern technology, which requires relatively high amount of "brain."

[8] Note that sampling design is changed in 2005, and the number of sampled employees in the private manufacturing sector, which is used in the regression in Section III, is decreased discontinuously from 425,000 in the 2004 survey to 227,000 in the 2005 survey.

in July, and the information of each item is essentially as of June of the conducted year, except for the item of annual special cash earnings, which is the value provided for each employee in the previous year.

The Basic Survey of Japanese Business Structure and Activities (hereafter, *The Business Survey*) is currently conducted yearly by the Ministry of Economy, Trade and Industry, and is aimed at acquiring basic data on business activities of Japanese private companies. The targets of this survey are companies engaged in business with both a minimum capital of 30 million JPY and 50 or more employees. The survey covers extensive industries, except agriculture, fisheries, construction, transportation, medical, healthcare, and welfare. There are around 37,000 target companies, and about 30,000 companies that submit valid responses every year. The survey is conducted on the actual results every fiscal year, and it covers such items as number of regular workers, sales, operating profit, number of subsidiaries, fixed assets, exports, and imports.

Because the unit of worker data used by *the Wage Survey* is work establishment, whereas *The Business Survey* uses a list of firm data, I use *The Establishment and Enterprise Census* as well as *The Economic Census for Business Frame* (hereafter, *The Censuses*) to link both datasets. *The Censuses* are conducted on all establishments and firms in Japan in order to compile a complete directory that serves as the master sampling framework for various statistical surveys, including *The Wage Survey*, by the Statistics Bureau, Ministry of Internal Affairs and Communications. Until 2006, *The Establishment and Enterprise Census* was conducted every 2 to 3 years, and was incorporated into *The Economic Census for Business Frame* launched in 2009.

The practice of connecting wage data and firm data works as follows (see also Figure 1). Each wage observation in *The Wage Survey* contains an identification number of the establishment at which workers are employed. Establishment identification numbers used in *The Wage Survey* are those assigned by *The Censuses* conducted a few years ago. Since establishment identification numbers change in every census, the establishment identification number for a particular establishment in *The Wage Survey* also changes every 2 to 4 years. However, we can trace back a series of identification numbers for a certain establishment, since *The Censuses* of 1999, 2001, 2004, 2006, and 2009 contain identification numbers of all establishments for both current and previous censuses. We can construct panel data of establishment identification numbers from *The Census* of 1996 to 2009, and correspondingly, from *The Wage Surveys* of 1999 to 2013.[9]

The Censuses of 2001, 2006, and 2009 also include the information about which firm each establishment belongs to. I assume that the firm–establishment relationship for *The Census* of 1996 and 1999 is the same as that in 2001, and also that the firm–establishment relationship for the 2004 census is the same as that in 2006. *The Business Survey* includes permanent identification numbers

[9] *The Establishment and Enterprise Census* for 1996 and those for earlier years do not contain establishment identification numbers used in previous censuses, and therefore, we cannot trace them before 1996 using this information. I do not use other information, such as names, addresses, and telephone numbers of establishments, to construct panel data of identification numbers and establishments, since it was beyond the capacity of my research environment.

of all firms, which do not change with respect to the survey years, but unfortunately, *The Censuses* do not change. Therefore, I connect firms in *The Censuses* with those in *The Business Survey* using two keys: firm phone number and firm name plus zip code. After this procedure, establishment identification numbers in any year are connected with permanent identification numbers of firms in *The Business Survey*, and therefore, wage observations in *The Wage Survey* in any year are connected with firm data.

I connect the data of *The Wage Survey* conducted in a certain year with the data of *The Business Survey* conducted in the previous year, from the assumption that a firm's performance in a certain fiscal year affects its workers' special cash earnings in the next calendar year, and monthly wages 2 years later. Special cash payments are a relatively flexible way for Japanese firms to distribute the results of their performances to workers compared with monthly wage payments, which require stability over time and therefore, are less sensitive to the current fluctuation of business results. For example, *The Wage Survey* conducted in 2006 contains wage information for June 2006 as well as annual special cash earnings in calendar year 2005. I assume both are affected by firms' performances in fiscal year 2004, which is recorded in *The Business Survey* conducted in 2005. Thus, *The Wage Survey* in 2006 is connected to *The Business Survey* in 2005, and represents the effect of business performance in fiscal year 2004 on special cash payments to workers in calendar year 2005 and on wage payments in June 2006. Since my panel data are composed of *The Wage Survey* from 1999 to 2013, *The Business Survey* data to match them are from 1998 to 2012.

After merging worker data and firm data, I trim this sample in several ways to make it suitable for the analysis. First, I use only worker–firm–year observations for both private establishments and firms in the manufacturing industry. This is because this study aims to estimate the wage effect of offshoring for workers in manufacturing establishments, and because most imports by firms in the services industry are not used as intermediate inputs but are purchased for direct consumption by Japanese consumers. Second, I keep observations in which firms engage in both offshoring and exports, a restriction that is necessary in order to implement IV strategy (see Section III.B). In this way, I focus on within-firm changes in the intensity of trade rather than on discrete changes from zero to positive foreign purchases. I define offshoring as intermediate imports from foreign countries, except from the Middle East. Third, observations of workers aged 60 years or older are deleted, because the age–wage profile in Japan is discontinuous at 60 years old owing to mandatory retirement systems and the national pension system. Fourth, observations of part-time workers are deleted, because this category does not include school career information, which is used as a proxy for the level of skills.

The final sample has about 0.8 million worker–firm-years and about 11,000 firm-year observations. Table 1 contains summary statistics for the data in my sample.

III. Model

III.A. Field of Skills and Level of Skills

In this study, I take two aspects of worker skills into consideration—field of skills and level of skills—and I use two sets of dummies—a female dummy and education dummies—to represent the difference of each aspect.

The female dummy is employed in order to observe how firms' trade affects their demand for different fields of skills. Here, I assume that female workers have developed relatively high skills in "human-oriented knowledge" in their school education and in non-administrative tasks in their work environment, while male workers have developed high skills intensively in "science-oriented knowledge" and in administrative tasks. These distinctive gender characteristics in the Japanese workplace are based on the following two sets of statistics.

First, while the terms "human-oriented knowledge" and "science-oriented knowledge" are not commonly used and there is no clear-cut dichotomy, they are based on the fields that Japanese high school students choose to study in college institutions for 4 years or longer, as shown in Table 2.

Table 2 reports the ratio of male or female college students who are registered with majors in each departmental field as a proportion of total male or female students, in 2000 and in 2010. Listed are the ratios for the top five areas of study with respect to the number of both male and female students registered, classified, and reported in *The School Basic Survey* by the Ministry of Education, Culture, Sports, Science and Technology. The social sciences (such as economics, law, and political science) is the most chosen area, and more than 40% of all male students choose this as their major, while that ratio is less than 30% for female students in both 2000 and 2010. Engineering (such as mechanical engineering, electrical and electronic engineering, and civil engineering) has the second largest number of students, and male students dominate this area too. On the other hand, female students dominate in the humanities (such as literature, linguistics, and history), which has the third largest number of students, in both years. In addition, the ratios of female students who choose health and welfare (such as medicine, pharmacy, and nursing) and education (such as education in individual subjects and special needs education) as majors are larger than those of male students.[10]

Here, I refer to the fields that male students tend to choose as "science-oriented knowledge," based on the assumption that both social sciences and engineering are generally aimed at understanding the structure of society and materials, while I refer to the fields that female students tend to choose as "human-oriented knowledge," since humanities, health and welfare, and education are aimed at affecting individuals' minds and bodies.[11]

[10] Gender differences in choosing a field of study are observed in many other countries, not only Japan. The OECD (2012) shows that women are still under-represented in science, technology, engineering, and mathematics, because female and male personal preferences and expectations concerning labor-market outcomes differ.

[11] These characteristics are strengthened when we include in our consideration students of other tertiary schools, such as junior colleges and higher-level vocational schools.

Second, with regard to business job hierarchy, male workers are dominant in administrative occupations. Table 3 shows that from the viewpoint of employees' status, around 10% of male workers are executives of companies or corporations, while that number is less than 5% for female workers in 2000, based on *The Labor Force Survey* of the Statistics Bureau, Ministry of Internal Affairs and Communications. Similarly, from the viewpoint of employee occupation, the ratio of workers pursuing administrative and managerial tasks is more than 5% for male workers and less than 1% for female workers in 2000. These stark gender differences are observed also in 2010.[12]

Of course, female workers have other different characteristics, such as short average tenure and a low ratio of working in the manufacturing industry or engaging in manufacturing process tasks. These factors I control in an estimation, explained shortly.

As for the level of skills, I use tertiary education dummies to observe how firms' international trade changes their demand for high skills. Because I introduce a female dummy in this research, I divide a commonly used college dummy into a 2-year college dummy and a 4-year college dummy in order to control female students' preference for choosing junior colleges as the next stage of education after graduating from high schools. Table 4 shows the ratios of students in tertiary education by school in Japan. More than 20% of female students in tertiary education studied in junior colleges in 2000, while that figures was less than 2% for male students. The ratios of students in junior colleges almost halved in 2010, but female students were still dominant. For the Japanese wage survey *The Basic Survey on Wage Structure*, school career, that is, the highest of an employee's history of school graduation, is classified into four categories: graduate of junior high school, graduate of senior high school, graduate of higher-level vocational school and junior college, and graduate of university or graduate school. In this research, employees in the third category have a value of 1 in the 2-year college dummy and those in the fourth category have a value of 1 in the 4-year college dummy. Employees with college dummies of 1 are considered to have achieved advanced study in college and to have engaged in tasks requiring skill in their workplaces.

III.B. Econometric Model

This study uses the following production function for firm j in year t, which is from the online appendix of Hummels et al. (2014), generalizing the number of worker types to any number F,

$$Y_{jt} = A_{jt} K_{jt}^{\alpha} \prod_{f=1}^{F} C_{fjt}^{\alpha_f} \ , \tag{1}$$

[12] Although the share of female workers engaging in administrative and managerial tasks is generally low in many other countries, the Japanese figures are still quite low among OECD countries. The OECD (2012) presents the share of women on the boards of listed companies by country in 2009 as an example. That figure is less than 4% in Japan, second lowest after Germany, while the OECD average is more than 10%.

where $f = 1, 2, \cdots, F$ index types of labor, $C_{fjt} = \left(L_{fjt}^{\theta_f} + O_{jt}^{\theta_f}\right)^{1/\theta_f}$, $\theta_f = \dfrac{\sigma_f - 1}{\sigma_f}$, and $\sum_{f=1}^{F} \alpha_f = 1 - \alpha$.

In equation (1), Y_{jt} is output, A_{jt} is productivity, and K_{jt} is capital. C_{fjt} is a constant elasticity of substitution composite input using type-*f* labor, L_{fjt}, and imported input, O_{jt}, and $\sigma_f > 0$ is the substitution elasticity for type-*f* labor and imported inputs. Imported inputs correspond to offshoring in this study, as in Hummels et al. (2014). I classify workers from the viewpoints of two gender groups (male and female) and three education groups (junior and senior high schools, 2-year colleges, and 4-year colleges), as explained in Subsection III.A. Therefore, there are six types of workers in this analysis, that is, $F = 6$.

Based on the procedure of Hummels et al. (2014), equation (1), and the assumption that each type of workers shows upward-sloping labor supply, the following estimating equation is obtained:

$$\ln w_{ijt} = b_{HMO} \ln O_{jt} + b_{JO} D_{Ji} \ln O_{jt} + b_{CO} D_{Ci} \ln O_{jt} + b_{FO} D_{Fi} \ln O_{jt}$$

$$+ b_{HMX} \ln X_{jt} + b_{JX} D_{Ji} \ln X_{jt} + b_{CX} D_{Ci} \ln X_{jt} + b_{FX} D_{Fi} \ln X_{jt} + \mathbf{x_{it}} \beta_1 + \mathbf{z_{it}} \beta_2 + \varphi_{INDt} + \varphi_R + \varepsilon_{ijt} \qquad (2)$$

where *i* indexes workers, w_{ijt} is the wage of worker *i* employed by firm *j* in year *t*, and X_{jt} is the value of firm *j*'s exports in year *t*. X_{jt} is included in this estimation equation in order to capture time-varying shocks to output of firm *j* in year *t*. O_{jt} and X_{jt} are both instrumented, as discussed in the next Subsection III.C. $\mathbf{x_{it}}$ is a vector of worker-level characteristics, such as years of potential work experience and years of job tenure. $\mathbf{z_{jt}}$ is a vector of firm-control variables, such as sales values, number of workers, values of fixed asset, and foreign owners' ratio of capital. In addition, φ_{INDt} and φ_R are used to absorb year-by-industry and region fixed effects. ε_{ijt} is the error term.

In equation (2), D_{Ji}, D_{Ci}, and D_{Fi} are dummy variables that equal 1 if worker *i* graduated from a junior college or a higher-level vocational school, if worker *i* graduated from a university or graduate school, and if worker *i* is female, respectively. b_{HMO} is the elasticity of the wage of male workers whose highest school graduation is from junior or senior high schools with respect to offshoring. $b_{JMO} = b_{HMO} + b_{JO}$ is the elasticity of the wage of male workers who graduated from junior colleges or higher-level vocational schools, and $b_{CMO} = b_{HMO} + b_{CO}$ is that of male workers who graduated from universities or graduate schools. $b_{HFO} = b_{HMO} + b_{FO}$, $b_{JFO} = b_{HMO} + b_{JO} + b_{FO}$, and $b_{CFO} = b_{HMO} + b_{CO} + b_{FO}$ are the corresponding elasticities of female workers' wage with respect to offshoring. For the elasticities of the wages of six worker types with respect to exports, we similarly replace *O* on subindexes of *b* with *X*.

Because equation (2) incorporates a vector of firm controls, its estimation corresponds to the direct effect of offshoring on wages, holding these firm variables constant. I follow the argument of Hummels et al. (2014) and estimate the total effect of offshoring, including the indirect effect, such as the increase of productivity and the consequential shift of the isoquant, by eliminating the firm controls from equation (2).

$$\ln w_{ijt} = b_{HMO} \ln O_{jt} + b_{JO} D_{Ji} \ln O_{jt} + b_{CO} D_{Ci} \ln O_{jt} + b_{FO} D_{Fi} \ln O_{jt}$$

$$+ b_{HMX} \ln X_{jt} + b_{JX} D_{Ji} \ln X_{jt} + b_{CX} D_{Ci} \ln X_{jt} + b_{FX} D_{Fi} \ln X_{jt} + \mathbf{x_{it}} \beta_1 + \varphi_{INDt} + \varphi_R + \varepsilon_{ijt} \qquad (3)$$

III.C. Instruments

Instruments for offshoring and exports require the characteristics that they are correlated with changes in the value of firms' offshoring and exports but are uncorrelated with changes in the firms' productivity and wage structures. I construct offshoring instruments from world export supply and export instruments from world import demand. *The Business Surveys* do not contain detailed information on firms' international transactions. All we know from the surveys are the total values of each firm's imports of intermediate goods and exports of final goods, both classified by five regions: Asia, the Middle East, Europe, North America, and the rest of the world (RoW). Therefore, I construct IV for offshoring and exports using the following aggregate method.

World export supply for firm *j* in year *t*, WES_{jt}, is calculated from the equation $WES_{jt} = \sum_r \sum_l s_{jr}^{IM} s_{rlk}^{IO} WES_{rlt}$. WES_{rlt} is the total value of goods exported from region *r* and classified as the products of industry *l*, minus its exports to Japan, in year *t*. The original data for WES_{rlt} are obtained from COMTRADE bilateral trade data at the HS6 level, and I classify them into about 60 industries. Since exports from the Middle East are mainly fossil fuels and not considered as the result of offshoring, I consider four regions in this equation: *r* = Asia, Europe, North America, and the RoW. s_{rlk}^{IO} is the share of products of industry *l* imported by Japan from region *r* and used as intermediate inputs in Japanese industry *k* to which firm *j* belongs of total *r*–*l* imports. s_{rlk}^{IO} is obtained from *The 2005 Japan–US Input–Output Table*, compiled by Japan's Ministry of Economy, Trade and Industry. In this input–output table, the world is divided into three regions: Japan, the US, and the RoW. I assume that the calculated ratios from the US to Japan apply to s_{rlk}^{IO}, where *r* = Europe and North America, and those from the RoW to Japan apply to s_{rlk}^{IO}, where *r* = Asia and the RoW. $s_{rlk}^{IO}WES_{rlt}$ is considered as export goods produced in region *r* as products of industry *l* and used in Japanese industry *k* as intermediate inputs, and $\sum_l s_{rlk}^{IO}WES_{rlt}$ is total intermediate inputs imported from region *r* by Japanese industry *k*. s_{jr}^{IM} is the share of imports from region *r* in the total value of imports for firm *j* in the year when firm *j* first appears in the panel data. s_{jr}^{IM} represents the firm-specific business relationship with each region and is assumed fairly consistent over time. $WES_{jt} = \sum_r \sum_l s_{jr}^{IM} s_{rlk}^{IO} WES_{rlt}$, the weighted sum of $\sum_l s_{rlk}^{IO}WES_{rlt}$ over four regions with s_{jr}^{IM}, has firm-year variation and is used as IV for firm *j*'s offshoring.

World import demand for firm *j* in year *t*, WID_{jt}, is used as IV for firm *j*'s exports. This is calculated from $WID_{jt} = \sum_r s_{jr}^{EX} WID_{krt}$, which is simpler than WES_{jt}. WID_{krt} is the total value of goods classified as the products of industry *k* to which firm *j* belongs and imported by region *r*, minus its imports from Japan in year *t*. The data source and industrial classification are the same as those of WES_{rlt}. I consider four regions for WID_{krt}: *r* = Asia, Europe, North America, and the Middle East, plus the RoW. s_{jr}^{EX} is the share of exports to region *r* of the total value of exports for firm *j* in the year when firm *j* first appears in the panel data.

IV. Estimation Results

Equations (2) and (3) have eight endogenous variables, offshoring and exports, and their interaction terms with the 2-year college dummy, 4-year college dummy, and female dummy. Table 5 reports the results of first-stage regressions for eight endogenous variables, each estimated with and without firm controls, clustering the standard errors at the firm-year level. These regressions use the adjusted values of offshoring, exports, world export supply, world import demand, sales, and fixed asset per capita by a Japanese gross domestic product deflator for each year.[13] Even though coefficients of world export supply are statistically insignificant in the regression equations of offshoring (columns (1) and (2)), eight instruments are jointly significant in all eight endogenous variables at the 5% level, except column (2).

Table 6 reports the estimation of worker-level wage regressions, in which I pool all workers. The dependent variable is the log scheduled hourly wage and log annual income, which is the sum of contractual cash earnings (scheduled cash earnings plus overtime allowance) and annual special cash earnings.[14] I provide fixed effect (FE) and FE-IV estimates both with and without additional firm controls.

The magnitude of the effect of offshoring and exports on wages in FE-IV estimation is generally stronger than that in FE estimation, which does not correct endogeneity of trade. Interestingly, all the estimated coefficients of offshoring and exports in FE-IV estimation are statistically insignificant, meaning there is little possibility that both offshoring and exports affect hourly wages or annual income of low-skilled male workers in Japan. The insignificant effect of offshoring on the unskilled labor wage is different from the results of previous studies, such as H. Egger and Egger (2006), Baumgarten et al. (2013), and Hummels et al. (2014).

In addition, the interaction terms between trade and workers' characteristics, such as educational background and gender, are introduced. I find that the estimate of the interaction term between offshoring and workers with tertiary education is positive, and that between offshoring and female workers is negative, while both are statistically significant in most cases. This means that offshoring increases the wage premium for higher level of skill as well as that for science-oriented knowledge and administrative tasks, which male workers embodied relatively more than female workers. These results come from two types of offshoring nature. First, offshoring substitutes imports for domestic production of low-tech goods in the Japanese context, which decreases firms' labor demand for low-skilled workers. Second, offshoring accompanies the fragmentation of production process and corresponding international reallocation of each production stage, and therefore, it requires skills of science-oriented knowledge and administrative tasks to organize and administer these internationally dispersed production stages.[15] Generally, the magnitude of

[13] Some previous research, such as Nishimura, Nakajima, and Kiyota (2005) and Hayakawa, Matsuura, Motohashi, and Obashi (2013), adopt more cautious approaches to estimate net capital stock by calculating the time series of net capital stock from those of the previous year and investment of the current year or by using industry-level ratios of estimated net capital stock to the book value of tangible assets. This study does not employ these methods and adopts a rather simple method for the adjustment, since the net capital assets estimated through these methods still seem to leave large room for improvement and the differences of estimating methods do not significantly affect the following results of wage estimation.

[14] In this study, I define annual income of a particular year as 12 times monthly contractual cash earnings in June of that year plus annual special cash earnings in the previous year. Therefore, "annual income" used in this study is not actual annual income of each employee but hypothetical annual income.

[15] In addition, I run regressions that include interaction terms of years of potential work experience with offshoring and exports, as well as interaction terms of years of job tenure with offshoring and exports, in order to examine whether trade is affected differently with respect to the accumulation of experience on wages. The

offshoring effects on skill premiums is similar to the results of previous research.

It is observed that the estimate of the interaction term between exports and workers with tertiary education is negative, and that between exports and female workers is positive, although the opposite holds in the case of offshoring.[16] When firms increase both offshoring and exports, their wage effects regarding field of skills and level of skills are partially offset. The negative coefficients of the interaction terms between exports and tertiary education are again opposite to the results of previous studies, meaning that products for sale are low-skill intensive while intrafirm administrative services are high-skill intensive in Japanese firms. The positive coefficients of interaction terms between exports and the female dummy imply that supply to foreign markets requires human-oriented knowledge and non-administrative tasks relatively more in order to understand local consumers' preferences and to liaise between headquarters and local branches.

It is noteworthy that the absolute values of elasticities of annual income with respect to interaction terms between international trade and the female dummy are smaller than those corresponding to hourly wages. For example, the coefficient of "Log offshoring x Female" in column (8) is −0.0418, the absolute value of which is smaller than that of the coefficient in column (4), −0.0888. In addition, the coefficient of "Log export x Female" in column (7) is 0.0278, which is smaller than that of coefficient in column (3), 0.0555. This means that the change of working hours and bonuses to some degree level out the uneven gendered hourly wage effects of trade.

Table 7 shows the robustness checks. I report only results of second-stage FE-IV estimation without additional firm controls. First, interaction terms of production worker dummy with offshoring and exports are added as independent variables in columns (1) and (2). This is to check whether the results in Table 6 are stable after considering the type of tasks, that is, production or non-production task.[17] *The Wage Survey* provides the information of worker type for workers in establishments classified into manufacturing sectors. Both interaction terms are insignificant, and other independent variables show similar results to Table 6. Second, columns (3) and (4) drop observations of non-regular staff, assuming that the effect is different between regular and non-regular staff. The results do not have any idiosyncratic features. Third, when I drop observations with highest and lowest 1% of annual income, the statistical significance of females' interaction terms with offshoring and exports decreases considerably in column (6). This implies that uneven gendered hourly wage effects of trade are largely leveled out by the change of working hours and bonuses for the bulk of female workers. Other results of columns (5) and (6) are similar to Table 6. Fourth, I connect the data of *The Wage Survey* and *The Business Survey* conducted in the same year. This is to examine whether firms' performances affects wages of their workers more promptly than

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results show there is no statistical significance in these interaction terms, and therefore, I do not report them in this paper.

[16] The result that an increase in exports leads to an increase in female workers' relative wage is the same as that of Juhn et al. (2014), although the hypothesis regarding the abundant skills that female workers have is different.

[17] Non-production tasks include supervisory, clerical, and technical tasks. Interactions of production worker dummy with offshoring and exports are additional endogenous variables and therefore subject to first-stage regressions.

my assumption. Offshoring, exports, and their interaction terms have similar coefficients to Table 6, and the absolute values of these coefficients in columns (7) and (8) in Table 7 are generally smaller than those of corresponding columns (4) and (8) in Table 6, respectively. This result weakly supports my assumption that it takes 1 to 2 years before workers' income reflect firms' performances.

V. Conclusions

This study estimates the effect of offshoring on workers' hourly wages and annual income in Japan by constructing Japanese matched worker–firm data, whose panel variable is the firm, from government statistics. IV estimation is employed to correct the endogeneity of offshoring. In addition to educational dummies as an index of skill levels, I use a female dummy to take into account the fields of skills from the observation that female workers have developed relatively high skills in human-oriented knowledge in their school education and in non-administrative tasks in their work environment.

It is found that the estimated scale of impact from offshoring and exports on hourly wages and annual income of male low-skilled workers is statistically insignificant in Japan. Regarding skill premiums, offshoring increases wage premium for higher level of skill and decreases that for human-oriented knowledge and non-administrative tasks. In my base results, a 1% increase in offshoring increases the skill premium by 0.03% for graduates of 2-year colleges, increases the skill premium by 0.02% for graduates of 4-year colleges, and decreases the skill premium by 0.04% for female workers with respect to annual income, considering both direct and indirect effects. Interestingly, exports have the opposite effects on these skill premiums, meaning that an increase of both offshoring and exports partially offset each other in their effect on skill premiums. In addition, it is observed that the uneven gendered effects of trade on hourly wage are leveled out to some degree by the adjustment of working hours and bonuses.

I infer from these findings that Japanese firms succeed in mitigating wage effects of international trade on their internal labor markets by offsetting the contradictory wage effects of offshoring and exports as well as by using working hours and bonuses as adjustment tools. The characteristic that internal labor markets function principally to respond to international shocks reflects the low liquidity of the Japanese labor market. To verify this inference, there are some points remaining in this study that require examination. They include an assumption that firms with low labor turnover, with labor unions organized by their own workers, or with low dependency on non-regular workers should have a high mitigation effect on the internal labor market. Verifying this assumption provides scope for further research.

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Figure 1: The construction of mathced worker–firm data

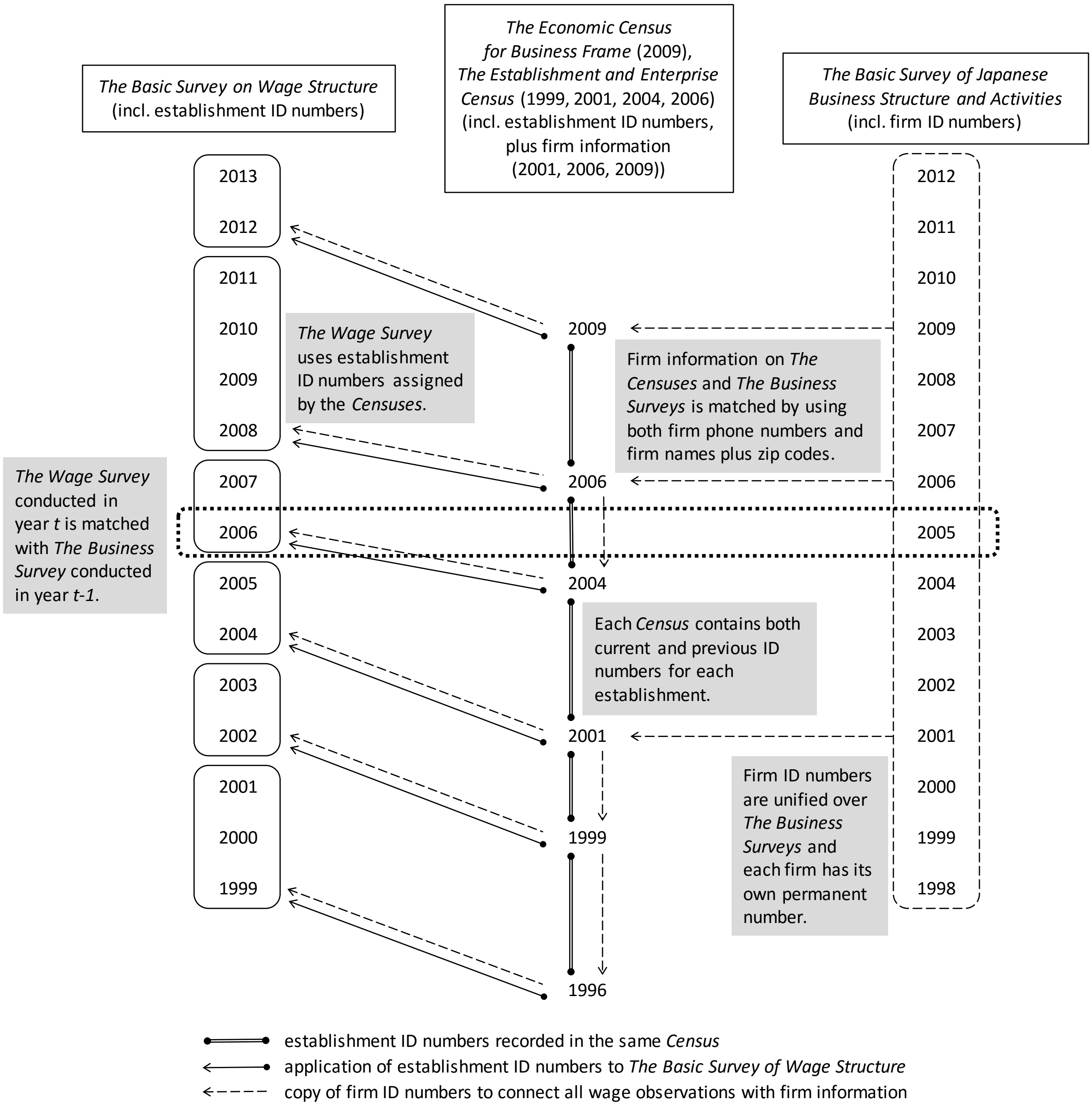

Table 1. Descriptive statistics

	Mean	Std. Dev.
Firm Firm-level data (Observations: 11,417)		
Log sales	19.403	1.634
Log employment	6.574	1.297
Log fixed asset per capita	12.038	0.863
Foreign owners' ratio of capital	6.905	17.076
Offshoring/sales	0.063	0.100
Offshoring/intermediate input	0.134	0.198
Exports/sales	0.152	0.189
Wor Worker-level data (observations: 800,809)		
Log scheduled hourly wage	2.964	0.407
Log annual income	10.872	0.398
2-year college dummy	0.084	0.278
4-year college dummy	0.334	0.471
Female dummy	0.172	0.377
Years of potential work experience	20.111	11.287
Years of job tenure	16.483	11.245

Notes : The data used for "Firm-level data" have firm-year observations, and the data used for "Worker-level data" have worker-year observations. For each variable, this table reports its mean and standard deviation across all observations.

Table 2. Ratios of undergraduate students' majors in Japan

Top five areas in which undergraduate students were registered most	2000		2010	
	Male	Female	Male	Female
1. Social sciences	**46.1%**	29.3%	**40.8%**	26.8%
2. Engineering	**27.0%**	5.1%	**24.1%**	4.0%
3. Humanities	8.7%	**30.2%**	8.8%	**24.0%**
4. Health and welfare	4.2%	**8.5%**	7.3%	**13.5%**
5. Education	3.6%	**8.9%**	4.6%	**9.2%**
(Number of students, thousand)	(1,559)	(913)	(1,481)	(1,078)

Notes : Numbers of college students by major area and by gender are reported in *The School Basic Survey* , in which colleges are categorized into 11 large areas. These 11 areas consist of the humanities, social sciences, natural science, engineering, agricultural science, health and welfare, the merchant marines, domestic science, education, art and design, and others. This table reports the ratios of male or female students with respect to the total male or female student population, studying in the top five most chosen areas, in 2000 and 2010. Bold figures show that the ratio of that gender is larger than that of the opposite gender in each area in 2000 or in 2010.

Source : *School Basic Survey 2000* and *2010* , Ministry of Education, Culture, Sports, Science and Technology.

Table 3. Ratios of employees by status, industry, and occupation in Japan

	2000		2010	
	Male	Female	Male	Female
Status:				
Executives of companies or corporations	**9.9%**	4.6%	**8.9%**	3.6%
Ordinary employees	**83.2%**	74.3%	**82.5%**	75.4%
Temporary and daily employees	6.9%	**21.0%**	8.6%	**21.0%**
Industry:				
Manufacturing	**25.0%**	18.8%	**22.5%**	12.5%
Wholesale and retail trade	15.8%	**23.0%**	14.9%	**20.5%**
Construction	**14.2%**	3.8%	**11.0%**	2.6%
Transport and postal activities	**9.9%**	3.5%	**8.6%**	2.7%
Others	35.1%	**50.9%**	43.0%	**61.6%**
Occupation:				
Administrative and managerial workers	**5.7%**	0.8%	**4.6%**	0.7%
Professional and engineering workers	12.8%	**16.0%**	14.3%	**18.5%**
Clerical and sales workers	30.6%	**46.1%**	30.9%	**44.0%**
Manufacturing process workers	**36.2%**	22.1%	**33.3%**	17.4%
Others	14.8%	**15.0%**	16.9%	**19.3%**
(Number of employees, million)	(32.16)	(21.40)	(31.33)	(23.29)

Notes : This table reports the ratios of male or female employees in each category with respect to the total male or female employees in 2000 and 2010. Bold figures show that the ratio of that gender is larger than that of the opposite gender in each category in 2000 or in 2010.

Source : *Labour Force Survey, Basic Tabulation, Yearly Average Results 2000 and 2010* , Statistics Bureau, Ministry of Internal Affairs and Communications.

Table 4. Ratios of students in tertiary education by school in Japan

	2000		2010	
	Male	Female	Male	Female
4-year or longer institutions:				
Colleges and graduate schools	**97.1%**	76.9%	**97.8%**	89.3%
Mainly 2-year institutions:				
Junior colleges	1.9%	**22.8%**	1.0%	**10.4%**
Higher-level vocational schools	**1.0%**	0.3%	**1.2%**	0.3%
(Number of students, thousand)	(1,800)	(1,290)	(1,741)	(1,327)

Notes : This table reports the ratios of male or female students registered in each school category with respect to the total male or female student population in 2000 and 2010. The course of higher-level vocational schools extends over 3 years of secondary education plus 2 years of tertiary education, and this table excludes students of secondary education. Bold figures show that the ratio of that gender is larger than that of the opposite gender in each category in 2000 or in 2010.

Source : *School Basic Survey 2000* and *2010* , Ministry of Education, Culture, Sports, Science and Technology.

Table 5. First-stage FE-IV regressions

	Log (offshoring)		x 2-year college		x 4-year college		x Female	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log WES	-0.0144	0.0174	0.0283**	0.0314**	0.115***	0.125***	0.0541***	0.0610***
	[-0.147]	[0.172]	[2.223]	[2.449]	[2.635]	[2.826]	[2.781]	[3.132]
Log WES	-0.000852	0.000268	-0.171***	-0.171***	-0.0496***	-0.0492***	-0.0387***	-0.0385***
x 2-year college	[-0.226]	[0.0703]	[-3.844]	[-3.841]	[-4.127]	[-4.096]	[-3.601]	[-3.580]
Log WES	0.00565	0.00666*	0.00324	0.00333	-0.322***	-0.322***	-0.00937**	-0.00920**
x 4-year college	[1.464]	[1.672]	[0.969]	[0.995]	[-6.895]	[-6.890]	[-2.199]	[-2.155]
Log WES	-0.00115	-0.00105	-0.0158**	-0.0158**	-0.0376***	-0.0376***	-0.158***	-0.158***
x Female	[-0.481]	[-0.427]	[-2.510]	[-2.510]	[-5.465]	[-5.472]	[-3.912]	[-3.913]
Log WID	0.00353	-0.000601	-0.0952***	-0.0959***	-0.231***	-0.237***	-0.109***	-0.112***
	[0.0331]	[-0.00548]	[-6.104]	[-6.072]	[-4.358]	[-4.375]	[-4.419]	[-4.431]
Log WID	-0.00575	-0.00699	0.546***	0.546***	0.0812***	0.0809***	0.0570***	0.0568***
x 2-year college	[-1.149]	[-1.385]	[9.959]	[9.956]	[5.030]	[5.010]	[4.152]	[4.135]
Log WID	-0.0131**	-0.0128**	-0.00565	-0.00558	0.817***	0.817***	0.0139**	0.0140**
x 4-year college	[-2.424]	[-2.285]	[-1.229]	[-1.215]	[13.22]	[13.22]	[2.384]	[2.390]
Log WID	0.00622**	0.00625**	0.0313***	0.0313***	0.0588***	0.0589***	0.588***	0.588***
x Female	[2.278]	[2.239]	[4.252]	[4.257]	[6.093]	[6.104]	[11.07]	[11.07]
Additional firm controls	Yes	No	Yes	No	Yes	No	Yes	No
Additional worker controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.323	0.297	0.565	0.565	0.626	0.626	0.569	0.569
F-statistics for instruments	1.943	1.814	18.75	18.69	27.55	27.55	24.72	24.72

	Log (exports)		x 2-year college		x 4-year college		x Female	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Log WES	-0.0576	0.00199	0.00510	0.00987	0.0563	0.0830**	0.0180	0.0290*
	[-1.063]	[0.0339]	[0.439]	[0.828]	[1.621]	[2.321]	[1.117]	[1.788]
Log WES	0.00282	0.00469	-0.0818**	-0.0816**	-0.0267**	-0.0260**	-0.0328***	-0.0325***
x 2-year college	[0.959]	[1.501]	[-1.994]	[-1.989]	[-2.236]	[-2.182]	[-3.034]	[-3.004]
Log WES	0.00144	0.00247	0.00593*	0.00600*	-0.178***	-0.178***	0.00969**	0.00987**
x 4-year college	[0.464]	[0.740]	[1.769]	[1.792]	[-3.748]	[-3.741]	[2.211]	[2.250]
Log WES	-0.000349	-0.000811	-0.0220***	-0.0221***	0.00711	0.00683	-0.113***	-0.113***
x Female	[-0.158]	[-0.331]	[-3.382]	[-3.391]	[1.006]	[0.968]	[-2.764]	[-2.766]
Log WID	0.272***	0.228***	-0.117***	-0.121***	-0.311***	-0.338***	-0.135***	-0.144***
	[3.575]	[2.630]	[-7.518]	[-7.578]	[-6.738]	[-6.949]	[-5.654]	[-5.694]
Log WID	0.000164	-0.00127	0.909***	0.909***	0.0649***	0.0644***	0.102***	0.101***
x 2-year college	[0.0478]	[-0.351]	[17.65]	[17.65]	[3.920]	[3.898]	[7.328]	[7.305]
Log WID	-0.00998**	-0.00845*	-0.000853	-0.000708	1.105***	1.106***	0.0147**	0.0149**
x 4-year college	[-2.379]	[-1.925]	[-0.176]	[-0.146]	[17.51]	[17.53]	[2.338]	[2.382]
Log WID	-0.00152	-0.000736	0.0556***	0.0557***	0.0359***	0.0363***	0.939***	0.939***
x Female	[-0.634]	[-0.278]	[8.042]	[8.054]	[3.513]	[3.557]	[16.95]	[16.95]
Additional firm controls	Yes	No	Yes	No	Yes	No	Yes	No
Additional worker controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.432	0.354	0.692	0.692	0.746	0.745	0.682	0.682
F-statistics for instruments	3.741	2.091	57.94	57.74	61.03	61.38	63.28	63.14

Notes : Table 5 presents the first-stage regressions for log offshoring, log exports, and their interactions with 2-year college dummy, 4-year college dummy, and female dummy, using world export supply (WES), world import demand (WID), and their interactions as excluded instruments. Only these excluded instruments are reported. All specifications include firm, industry–year, and prefecture fixed effects. Additional firm controls are log sales, log employment, log fixed asset per capita, and foreign owners' ratio of capital. Additional worker controls include years of potential work experience, years of job tenure, their squares, and dummies for gender and educational background. Potential experience years of work is defined as current age minus 15 years for workers whose highest history of school graduation is junior high schools, current age minus 18 years for graduates of senior high schools, current age minus 20 years for graduates of 2-year colleges, and current age minus 22 years for graduates of 4-year colleges and graduate schools. Robust t-statistics are shown in brackets. Standard errors are clustered at firm–year levels. The number of firms is 2,843 and the number of observations is 800,809 in all 16 regressions. *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Worker-level wage regressions

	Log scheduled hourly wage				Log annual income			
	FE		FE-IV		FE		FE-IV	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log offshoring (b_{HMO})	-0.00215**	-0.00208**	0.285	-0.241	-0.00299***	-0.00208**	0.296	-0.184
	[-2.094]	[-2.025]	[0.671]	[-0.786]	[-3.490]	[-2.451]	[0.773]	[-0.667]
Log offshoring	0.00168**	0.00168**	0.0192	0.0248**	0.00198***	0.00195***	0.0222**	0.0272***
x 2-year college (b_{JO})	[2.181]	[2.170]	[1.643]	[2.411]	[2.815]	[2.778]	[2.028]	[2.772]
Log offshoring	0.00838***	0.00836***	0.0361***	0.0247**	0.00670***	0.00663***	0.0300***	0.0196**
x 4-year college (b_{CO})	[9.891]	[9.869]	[3.237]	[2.297]	[9.669]	[9.540]	[3.036]	[2.013]
Log offshoring	-0.00311***	-0.00310***	-0.0958***	-0.0888***	-0.000255	-0.000229	-0.0482***	-0.0418**
x Female (b_{FO})	[-4.947]	[-4.933]	[-6.347]	[-5.944]	[-0.322]	[-0.289]	[-2.815]	[-2.414]
Log exports (b_{HMX})	-0.00209	-0.00149	0.0283	0.0243	-0.000295	0.00244**	-0.00559	-0.00453
	[-1.608]	[-1.185]	[1.192]	[0.881]	[-0.263]	[2.256]	[-0.258]	[-0.177]
Log exports	0.00200***	0.00202***	-0.00676	-0.0133**	-0.000758	-0.000746	-0.0112	-0.0171***
x 2-year college (b_{JX})	[2.758]	[2.775]	[-0.840]	[-2.119]	[-1.142]	[-1.120]	[-1.507]	[-2.896]
Log exports	0.00579***	0.00582***	-0.0126***	-0.0104**	0.00161**	0.00164**	-0.0108***	-0.00881*
x 4-year college (b_{CX})	[7.664]	[7.708]	[-2.659]	[-2.042]	[2.524]	[2.564]	[-2.605]	[-1.929]
Log exports	0.000191	0.000190	0.0555***	0.0555***	-0.00131*	-0.00134*	0.0278***	0.0277***
x Female (b_{FX})	[0.343]	[0.343]	[6.908]	[6.909]	[-1.868]	[-1.905]	[2.986]	[2.981]
Log sales	0.00225		-0.331		0.0448***		-0.261	
	[0.411]		[-0.739]		[8.631]		[-0.651]	
Log employment	0.00722		0.0803		-0.0297***		0.0460	
	[1.052]		[0.736]		[-4.765]		[0.469]	
Log fixed asset per capita	0.00259		-0.0172		-0.00819**		-0.0236	
	[0.588]		[-0.688]		[-2.149]		[-1.061]	
Foreign owners'	0.000216		0.00140		-6.43e-05		0.00120	
ratio of capital	[1.606]		[0.799]		[-0.542]		[0.755]	
Potential experience	0.0304***	0.0304***	0.0299***	0.0314***	0.0284***	0.0284***	0.0277***	0.0291***
	[82.81]	[82.80]	[24.38]	[31.65]	[73.88]	[73.77]	[24.43]	[32.52]
Potential experience^2 x 100	-0.0463***	-0.0463***	-0.0452***	-0.0475***	-0.0472***	-0.0472***	-0.0463***	-0.0484***
	[-61.38]	[-61.38]	[-22.62]	[-28.73]	[-63.20]	[-63.14]	[-25.12]	[-32.56]
Job tenure	0.0152***	0.0152***	0.0155***	0.0148***	0.0256***	0.0256***	0.0260***	0.0253***
	[43.42]	[43.33]	[25.28]	[22.58]	[64.30]	[64.16]	[42.37]	[40.08]
Job tenure^2 x 100	-0.00798***	-0.00796***	-0.00860***	-0.00796***	-0.0297***	-0.0297***	-0.0299***	-0.0293***
	[-11.19]	[-11.15]	[-10.32]	[-8.158]	[-36.71]	[-36.64]	[-33.06]	[-29.11]
R^2	0.735	0.735	0.733	0.733	0.715	0.715	0.715	0.715

Notes: Table 6 presents the results from worker-level Mincer regressions, using either log scheduled hourly wage or log annual income as dependent variables. Log offshoring, log exports, and their interactions with 2-year college dummy, 4-year college dummy, and female dummy are instrumented using world export supply (WES), world import demand (WID), and their interactions in the FE-IV columns. All specifications include firm, industry–year, and prefecture fixed effects. Dummies for gender and educational background, and their interactions with potential work experience, job tenure, and their square are also used as explanatory variables but their coefficients are not reported in this table. Robust t-statistics are in brackets. Standard errors are clustered at firm–year levels. I report 100 times the coefficient estimates for the square of potential experience and the square of job tenure years. The number of firms is 2,843 and the number of observations is 800,809 in all eight regressions. *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Robustness checks

	I. Add production worker dummy and its interactions		II. Examine only wages and income of regular staff		III. Drop highest and lowest 1% of annual income		IV. Connect wage survey and business survey conducted in the same year	
	Log scheduled hourly wage	Log annual income	Log scheduled hourly wage	Log annual income	Log scheduled hourly wage	Log annual income	Log scheduled hourly wage	Log annual income
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log offshoring (b_{HMO})	0.104	0.124	-0.0710	0.0612	-0.127	-0.108	-0.00154	-0.00121
	[0.437]	[0.582]	[-0.363]	[0.360]	[-0.559]	[-0.541]	[-0.0292]	[-0.0249]
Log offshoring	0.0122*	0.0131*	0.0189**	0.0242***	0.0209**	0.0204**	0.0215*	0.0181*
x 2-year college (b_{JO})	[1.727]	[1.871]	[2.193]	[3.065]	[2.205]	[2.320]	[1.939]	[1.686]
Log offshoring	0.0327***	0.0254***	0.0299***	0.0296***	0.0298***	0.0209**	0.0235***	0.0140**
x 4-year college (b_{CO})	[3.778]	[3.302]	[3.337]	[3.770]	[3.171]	[2.499]	[3.148]	[2.104]
Log offshoring	-0.0854***	-0.0397**	-0.0855***	-0.0490***	-0.0743***	-0.0186	-0.0744***	-0.0352**
x Female (b_{FO})	[-6.073]	[-2.524]	[-7.417]	[-3.720]	[-5.759]	[-1.276]	[-4.918]	[-2.041]
Log exports (b_{HMX})	0.0536	0.0359	0.0215	-0.00167	0.0335	0.0107	-0.0106	-0.0415
	[0.612]	[0.462]	[0.821]	[-0.0730]	[1.194]	[0.417]	[-0.293]	[-1.326]
Log exports	-0.00733*	-0.00915**	-0.0109**	-0.0167***	-0.0106*	-0.0127**	-0.00917	-0.0113**
x 2-year college (b_{JX})	[-1.691]	[-2.169]	[-2.071]	[-3.472]	[-1.901]	[-2.504]	[-1.591]	[-2.031]
Log exports	-0.0168***	-0.0110***	-0.0139***	-0.0150***	-0.0134***	-0.00958**	-0.00713	-0.00477
x 4-year college (b_{CX})	[-3.695]	[-2.764]	[-2.850]	[-3.533]	[-2.805]	[-2.246]	[-1.587]	[-1.214]
Log exports	0.0522***	0.0239***	0.0549***	0.0325***	0.0465***	0.0138*	0.0425***	0.0206**
x Female (b_{FX})	[6.679]	[2.733]	[7.870]	[4.194]	[6.545]	[1.733]	[5.352]	[2.291]
Production worker	-0.0748***	-0.0576***						
	[-11.03]	[-8.047]						
Log offshoring	0.00129	-0.000818						
x Production worker	[0.149]	[-0.0923]						
Log exports	-0.00507	-0.000497						
x Production worker	[-0.907]	[-0.0919]						
Observations	709,073		771,303		784,795		835,366	
Number of firms	2,741		2,843		2,843		2,886	
R^2	0.745	0.724	0.738	0.721	0.732	0.715	0.741	0.725

Notes: Table 7 presents the results from worker-level Mincer regressions of FE-IV, using either log scheduled hourly wage or log annual income as dependent variables. In all eight regressions, no additional firm controls are used as explanatory variables. Log offshoring, log exports, and their interactions with 2-year college dummy, 4-year college dummy, and female dummy are instrumented using world export supply (WES), world import demand (WID), and their interactions. All specifications include firm, industry–year, and prefecture fixed effects. Dummies for gender and educational background, potential work experience, job tenure, their square, and interactions of these dummy variables and year variables are also used as explanatory variables but their coefficients are not reported in this table. Robust t-statistics are in brackets. Standard errors are clustered at firm–year levels. *** p<0.01, ** p<0.05, * p<0.1.