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Offshoring and Working Hours Adjustments in a Within-firm Labor Market

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Abstract: Although a growing body of literature identifies the within-firm redistribution effects of trade, research on the adjustment processes in within-firm labor markets is scarce. This study analyzes the within-firm adjustment of working hours and wages by considering workers' educational background and gender in response to a change in offshoring. Matched worker–firm panel data in the Japanese manufacturing sector covering 1998 to 2013 are being used. The analysis leads to the following observations: First, offshoring does not significantly change monthly and annual incomes. Second, offshoring decreases working hours—that is, imported inputs are close substitutes for labor inputs. More than three-quarters of the decrease in scheduled working hours can be attributed to a decrease in working days. Third, hourly wages increase in all worker groups examined. Though the impacts of offshoring on hourly wages and incomes are contradictory, both share the same feature: offshoring expands neither skill premium nor gender gap.

JEL codes: F16, F66, J31

Keywords: Offshoring; Income; Working hours; Wages; Overtime

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1. Introduction

The effects of trade shocks experienced by firms are redistributed across groups of workers within the firm. This is considered to be an important channel through which globalization affects income inequality, based on two stylized facts, namely, that within-firm wage inequality is the same as or larger than between-firm wage inequality (Skans et al., 2009, for Sweden; Akerman et al., 2013, for Sweden; Hesse, 2015, for Germany; Barth et al., 2016, for nine states of the United States; Helpman et al., 2017, for Brazil), and that firms who engage in international trade have higher productivity, pay higher wages, and employ more skilled workers (Bernard et al., 2007, for the United States; Mayer and Ottaviano, 2008, for European countries; Wakasugi et al., 2014, for Japan). However, while a growing body in the empirical literature has identified the within-firm redistribution effects of trade, research on the adjustment process in within-firm labor markets through the change of hourly wage, working hours, and total income is still scarce.[1] This aspect is worth considering, especially in terms of the following two facts.

First, it shows how changes in workers' hourly wage and income are different as a result of working hours. Hourly wage is a key variable associated with factor price, and many related studies use it as an independent variable for estimation. However, what employers and full-time workers ultimately agree on as part of their labor contracts is not hourly wages, but contracted incomes for a certain period of time, such as a week, a half month, or a month. Therefore, the possible reduction in labor demand for workers of a particular group due to offshoring, for example, would decrease their working hours and consequently increase their hourly wage, assuming a given amount of contractual income. Working hours and hourly wage are determined simultaneously in a within-firm labor market, and are both essential for understanding the impact of trade on workers' welfare.[2]

Second and related to the first point, research on the adjustment process enables us to distinguish between the impact of trade on the across-the-board wage bill, and the impact on labor demand for each labor group within a particular firm. On the one hand, a trade shock would increase the wage bills of all worker types if it induces a Hicks-neutral technical

[1] The within-firm, or internal, labor market is defined here as an organization in which the working conditions (e.g., incomes, working hours, and tenure) are determined through the interactions of the firm's labor demand, employees' labor supply, and legal and institutional constraints surrounding them. Although a boundary is drawn between workers inside and outside of the firm concerned, some interactions between the within-firm labor market and external labor markets occur, for example, through hiring and firing employees.

[2] Examining working hours explicitly would help us to understand the results that are difficult to interpret, such as Table 5 of Hummels et al. (2014). It shows that a 1 percent increase of offshoring decreases the hourly wages of unskilled workers, including mandatory pension fund payments, by 0.022 percent (column 3) and decreases their annual labor income, not including pension fund payments, by 0.015 percent (column 5), in cases of instrumental variable estimation with firm controls in Denmark. This means that their working hours increases by 0.007 percent, if pension fund payments change commensurably to hourly wage. It is curious that hourly wage and working hours change in the opposite directions. There are various possible ways to explain this, including that offshoring reduces the number of unskilled workers by a larger number relative to their labor input, resulting in the increase of working hours for unskilled workers, or that the labor market equilibrium is located on the backward-bending section of the labor supply curve.

change in a firm. For example, Bloom, Draca, and van Reenen (2016) show that import competition from China increases technical change in European firms. On the other hand, trade shocks would reduce labor demand for certain types of workers if they are close substitutes for imported inputs. Hummels, Jørgensen, Munch, and Xiang (2014) provide a theoretical foundation of substitution between imported inputs and labor in each labor group. Considering both working hours and contracted income helps to interpret what factor causes the change in hourly wages.

Given these facts, this study enriches the argument concerning the adjustment process of trade shocks in internal labor markets by estimating the impact of such shocks on income, working hours, and hourly wage. This paper specifically deals with offshoring as a type of trade shock. Following the work of Baumgarten, Geishecker, and Görg (2013), Hummels et al. (2014), Carluccio, Fougère, and Gautier (2015), Andersson, Karpaty, and Savsin (2016, 2017), and Carluccio, Cuñat, Fadinger, and Fons-Rosen (2019), offshoring is defined as the importing of intermediate inputs from abroad. As a type of international shock, offshoring has a distinctive feature in that a large number of firms have engaged in this activity and yet their sizes vary largely, producing considerable but different impacts on within-firm redistribution in each firm. Matched worker–firm data in the Japanese manufacturing sector for 15 years from 1998 to 2013 are employed for the estimations, methodologically similar to Hummels et al. (2014) and Vahter and Masso (2019). Workers are categorized by their educational background and gender. These indicators are appropriate for worker classifications in this context because they are characteristics that are exogenous to firms' trade decisions.

The distribution effects of globalization depend on many factors including country-, time-, and group-specific factors. This case specificity may apply to within-firm redistribution as a result of the offshoring effect. As for the skill premium, previous studies uniformly report the enhancing impact of offshoring. Hummels et al. (2014) and Andersson, Karpaty, and Savsin (2016, 2017) show that an increase in imported inputs widens the income gap between skilled and unskilled workers for Denmark and for Sweden, respectively. Carluccio, Fougère, and Gautier (2015) consider four occupations in France and show that increases in offshoring enhance the hourly wages of white-collar workers and executives more than the other two occupations in the study.[3] This paper adds the contradictory evidence from Japan that offshoring to Asia does not significantly increase the skill premium of hourly wages and annual income.

Although the impact of offshoring on the gender wage gap in within-firm labor markets has not been adequately examined, some studies deal with related topics using employer–employee panel data. Bøler, Javorcik, and Ulltveit-Moe (2018) and Vahter and Masso (2019) examine exporter firms in Norway and foreign multinationals in Estonia, respectively,

[3] Closely relating to offshoring, the effect of reducing import tariffs on intermediate inputs is examined by Amiti and Cameron (2012) for Indonesia, Hahn and Choi (2017) for South Korea, and Chen, Yu, and Yu (2017) for China. They propose the opposite results; Amiti and Cameron (2012) report that it reduces the income gap between groups of skilled and unskilled workers, whereas Hahn and Choi (2017) and Chen, Yu, and Yu (2017) show that it widens the income gap.

to find that these international factors increase the within-firm gender wage gap. [4] This study deals with the issue using the case of offshoring by Japanese firms to show that offshoring does not necessarily change the gender gap of hourly wages within firms. In addition, it reveals that offshoring expands the gender gap of annual incomes, possibly due to the increase of overtime payment as well as overtime work for male workers, although statistical significance is not high enough to draw this conclusion.

The remainder of this paper is structured as follows: Section 2 explains the method of constructing the matched worker–establishment–firm panel data used in the estimation, the characteristics of the Japanese within-firm labor market, and the instrument variable for Japanese firms' offshoring to Asia. Section 3 describes the estimation equation and variables used in this study and interprets the empirical results. The estimation reveals that offshoring to Asia allows workers, regardless of educational background and gender, to reduce working days without changing contractual incomes, which consequently causes the increase in hourly wage. Section 4 concludes the study.

2. Data

2.1. Construction of the Matched Worker–Firm Panel Dataset

To construct the Japanese matched worker–firm panel dataset for this research, I utilize *The Basic Survey on Wage Structure* (hereafter, referred to as *The Wage Survey*) conducted by the Ministry of Health, Labour and Welfare for worker–establishment–year data, and *The Basic Survey of Japanese Business Structure and Activities* (hereafter, *The Business Survey*) conducted by the Ministry of Economy, Trade and Industry for firm–year data. The former data are from selected establishments (i.e., the premises of business units among firms such as branches, business offices, and plants), while the latter data are from firms. Neither dataset includes information on the establishment–firm connection and, therefore, I employ two censuses to link the datasets. These censuses are *The Establishment and Enterprise Census* and *The Economic Census for Business Frame* (hereafter, *The Censuses*) conducted by the Statistics Bureau, Ministry of Internal Affairs and Communications.[5]

The method to link wage data with firm data works as follows: Each wage observation in *The Wage Survey* contains an identification (ID) number for each establishment at which workers are employed. Establishment ID numbers

[4] Despite not using employer–employee panel data, Kodama, Javorcik, and Abe (2018) report that Japanese firms acquired by foreign firms increase the number of female employees and the share of females in their workforce. Assuming that higher labor demand causes higher wages, this result suggests that inward foreign direct investment would decrease the gender wage gap in Japan.
[5] Explanation of the four datasets constructed by the Japanese government can be found in Appendix 1.

in *The Wage Survey* were assigned by *The Censuses* conducted several years ago. Since establishment ID numbers change in every census, this number for a particular establishment in *The Wage Survey* also changes every two to four years. However, I was able to trace back a series of ID numbers for each establishment because *The Censuses* of 1999, 2001, 2004, 2006, and 2009 contain ID numbers for all establishments for both current and previous censuses. I constructed panel data on establishment ID numbers by using the five censuses from 1999 to 2009, making it possible to trace the ID numbers of each establishment in *The Wage Surveys* from 1998 to 2013.[6]

The Censuses of 2001, 2006, and 2009 also include information about the firm associated with each establishment. I assume that the firm–establishment relationship for *The Censuses* of 1996 and 1999 are the same as those in 2001 and that the firm–establishment relationship for the 2004 census is the same as the relationship in 2006. *The Business Survey* includes the permanent ID numbers for all firms, which do not change between survey years. However, *The Censuses* do not contain any firm ID numbers. Therefore, I connect firms in *The Censuses* with those in *The Business Survey* by using two pieces of information: the firms' phone numbers, and the firm names and zip codes. Following this procedure, I connect establishment ID numbers in any year to the permanent firm ID numbers in *The Business Survey*, and thus connect the wage observations in *The Wage Survey* in any year to the firm data. The obtained Japanese worker–establishment–firm–year data form an unbalanced panel, and the panel variables are the establishment and firm, not the worker, since no worker ID system has been introduced in *The Wage Survey*.

The Wage Survey is carried out in July and, therefore, the information for each item is essentially a reflection of the within-firm labor market conditions in June of the survey year, with the exception of annual special cash earnings, which record the value provided to each employee in the previous year. *The Wage Survey* in Japan is unique in the sense that it includes information not only on workers' background and incomes but also their actual working hours and days. I connect the worker data from *The Wage Survey* conducted in year t with the firm data in fiscal year t-1 from *The Business Survey* conducted in year t, with the assumption that a firm's performance in fiscal year t-1 affects workers' bonuses in year t-1 and their wages and working hours in year t.

I use observations for private manufacturing firms that directly import from foreign countries under their own names, except for firms in the petroleum industry, and the smelting and refining non-ferrous metal industries. Observations of senior management (*Bucho* in Japanese) and middle management (*Kacho*) positions are excluded from the dataset because they are taken to be on the employer side and more than 96 percent of them in the manufacturing sector report zero overtime working hours. Since working hours including overtime is the key variable in observing the adjustment process

[6] *The Establishment and Enterprise Censuses* for 1996 and earlier do not contain the establishment ID numbers used in previous censuses, and, therefore, it is not possible to trace them before 1996 by using this information. I do not use other information such as names, addresses, and telephone numbers to construct the panel data because this was beyond the capacity of the research environment.

in within-firm labor markets, they are not appropriate for the analysis. Observations considered to be unsuitable for the analysis are also deleted.[7]

The constructed panel data for this analysis cover 1998–2013 for wage and working hours data, and 1997–2012 for firm data. The panel dataset has approximately 770,000 worker–establishment–firm–year observations of approximately 8,000 establishments. Each firm is classified into one of 44 industries based on the earliest recorded observation of that firm in *The Business Survey*. The largest share of worker observations is in the "motor vehicles, parts, and accessories" industry (15.8 percent) followed by "electronic parts and devices" (6.3 percent).

2.2. Data on Wages, Working Hours, and Trade

The internal labor markets of Japanese firms are suitable for this topic, due to the following three reasons that make the effect of firms' offshoring on their incomes and working hours more observable.[8] First, the working hours and overtime hours of Japanese workers are longer than those of most other developed countries. Hence, there is more room for the adjustment of working hours in response to trade shocks experienced by Japanese workers than by those of other countries. According to Ogura (2009), working hours in Japan are similar to those in the United States and higher than those in developed European countries. Furthermore, the proportion of Japanese people working more than 49 hours per week was among the highest in developed countries in the 2000s.[9] Second, worker mobility between internal and external labor markets is still limited in Japan. Longer average job tenure of Japanese employees represents the lower liquidity of its labor market than that in other countries. [10] This feature produces two benefits for the analysis: That the effect of firm-specific trade shocks permeates through fewer other firms, and that the adjustment of labor quantity occurs mainly through

[7] A detailed explanation of the data trimming is as follows: First, for workers' status, I removed the observations of workers aged 60 years and older because the age–wage profile in Japan is discontinuous at 60 years owing to the mandatory retirement system in Japanese firms. The observations of part-time workers are also not used in the analysis because they do not provide workers' academic background information, which is used to define the group of workers later. In addition, I removed the observations of workers whose tenure year is zero because most of these workers would not have received special cash earnings (a component of annual income) in the previous year. Second, I deleted observations that meet the following conditions: Workers with fewer than 15 or more than 26 working days in a month, workers with fewer than five or more than ten average standard working hours in a day, and workers with annual special cash earnings that are more than eight times the next year's monthly wages. This is because for these workers, their working schedules are considered as not matching their employment contracts, their contracts are rather exceptional, or they take a longer leave of absence for any reason. Therefore, their observations may contain outliers for the dependent variables.

[8] The characteristics of the within-firm labor markets in Japan are summarized by, for example, Itō (1992), Ariga, Brunello, and Ohkusa (2000), and Flath (2014). Waldman (2013) surveys previous research, which explains the differences between the within-firm labor markets in the United States and Japan.

[9] In addition, OECD (1998) shows that overtime hours in Japan were longer than those in Australia, Canada, Finland, Germany, and the United Kingdom in the late 1990s.

[10] The 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 (see the variable "employment by job tenure intervals" for a comparison). In particular, the average job tenure of Japanese male workers is 13.3 years, which is remarkably longer than that of Italian male workers (11.7 years), the highest of all countries available in the OECD database, which does not provide this figure in Japan.

the changes in working hours, not the change of the number of employees.[11] Third, the enterprise union is the dominant form of labor union in Japan. Therefore, the working conditions of employees is related more closely to the performance of their firm in Japan than in other countries where craft unions prevail.

The present study focuses on two worker indicators among the many candidates: college graduates and female workers. The main reason for using these indicators is that workers' educational background and gender are almost always determined before they are hired by firms, and therefore, it is safe to say that these indicators are exogenous to firms' trade decisions. Some other indicators available in *The Wage Survey*, such as non-production workers and supervisors, are not exogenous due to job rotation driven by internal transfer and internal promotions in response to firm-specific trade shocks.[12] I categorize workers who graduated from colleges and graduate schools as college graduates and use the category to estimate the skill premium. Similarly, the category of female workers is for the estimation of the gender wage gap. As these two definitions are not mutually exclusive, there are four worker groups from the combination of the two indicators: male non-college graduates, male college graduates, female non-college graduates, female college graduates.

Table 1 shows the mean figures of key variables concerning the income, working hours, and hourly wages of the four worker groups in the constructed panel dataset. Monthly income is the sum of scheduled monthly income and overtime pay, and annual income is calculated as 12 times the monthly wage in June of that year and the annual bonuses paid in the previous year.[13] These payments are deflated by the GDP deflators of their corresponding years. Male college graduates receive the highest monthly income, bonuses, and annual income; followed by male non-college graduates, female college graduates, and female non-college graduates. Monthly working hours are the sum of scheduled working hours and overtime during the survey month of June. All four groups work almost the same number of days and scheduled hours, but male workers work more overtime hours.[14] Around 60 percent of workers record overtime work, except for a group of male non-college graduates of which 80 percent worked overtime. Hourly wage is the annual income divided by 12 times the monthly

[11] Appendix 2 reports the results of firm-level analyses that firms' offshoring to Asia does not have statistically significant effects on their number of workers.

[12] Previous research defines college graduates, non-production workers, and supervisors as skilled workers and uses them to estimate trade shocks on skill premiums. Some examples of these definitions of skilled workers from the literature on the impact of imported inputs or offshoring on the skill premium in developed countries follow. Baumgarten et al. (2013) and Hummels et al. (2014) use the classification of workers' educational background as a proxy for skill. Feenstra and Hanson (1999) and Yan (2006) consider production workers and non-production workers to be proxies for unskilled and skilled labor, respectively. Egger and Egger (2003) and Hijzen, Görg, and Hine (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.

[13] Scheduled monthly income is the before-tax amount of cash paid to employees for their scheduled working hours, based on paying conditions specified in labor contracts for the surveyed month of June. It does not include overtime pay but includes commuting and family allowances. Calculated annual income in a certain year can be interpreted as the approximate income of the first half of the corresponding year and the second half of the previous year, as Japanese firms usually pay bonuses twice a year (in July and December).

[14] Monthly working hours are considered to be underreported owing to firms' pretending to observe the Labor Standards Law and of forcing their employees to perform unpaid work. The estimation of actual working hours is beyond the scope of this study. See Kuroda (2010), for example, for the measurement and transition of Japanese working hours. Kuroda and Yamamoto (2013) investigate the determinants of Japanese workers' long working hours, with an emphasis on firms' fixed labor costs.

working hours. Hourly wages in overtime are naturally higher than hourly wages in scheduled hours in all four groups because of an overtime premium, but the difference is smaller in male college graduates, possibly because a larger share of them work according to an annual salary scheme.[15]

[Insert Table 1 Here]

2.3. IVs for Offshoring

It is intuitive to assume that firms' offshoring is endogenous with respect to the firm's optimization process because trade is a choice variable for firms and, thus, is determined together with factor prices and inputs by each firm. In addition, other unobserved variables might simultaneously affect the level of offshoring, and factor prices and inputs. Recent studies on trade mainly employ two approaches to tackle the endogeneity problem in this context. The first approach is to use a large-scale policy change exogenous to firm performance, and the other is to use an instrumental variable (IV) estimation. Since it is difficult to find appropriate international events affecting Japanese offshoring for the former approach, I use the latter approach in this study. Firms' offshoring and their interaction terms are, thus, to be instrumented. I use firms' imports from Asia as a variable of offshoring. Imports from the Middle East, Oceania, and Africa are not considered here because they largely consist of mineral resources and agricultural products, which are not appropriate measures of offshoring for Japanese manufacturing firms. Among imports from the rest of the world, those from Asia constitute the majority of intermediate imports in Japanese firms and they are a driving force of expanding offshoring.[16]

Instruments for offshoring must be correlated with changes in firms' imports from Asia but uncorrelated with changes in firms' productivity and wage structures. In this study, I employ per worker exports of Asian subsidiaries of other Japanese firms classified in the same industry (excluding exports to Japan) as an IV for Japanese firms' offshoring. Data on the overseas subsidiaries of Japanese firms are obtained from *The Survey on Overseas Business Activities* (hereafter, *The Overseas Survey*) conducted by the Ministry of Economy, Trade and Industry.[17] The IV for a particular firm in industry *i* is calculated by using *The Overseas Survey* as follows: First, find Asian subsidiaries of other Japanese firms belonging to industry *i*. Then, summate their export values to the world except to Japan. Finally, divide the total values by the sum of the number of workers employed by these Asian subsidiaries to obtain the per worker values. This variable affects firm *j*'s

[15] Time-series developments of income, working hours, and hourly wage in four worker groups are depicted in Appendix 3, Figure A1.
[16] These observations come from in Appendix 4, Figure A2, which show firms' exports of final goods and imports of intermediate goods from 1997 to 2012.
[17] I connect firms in *The Business Survey* with those in *The Overseas Survey* by using three keys: firm code, firm phone number, and firm name plus zip code.

offshoring to Asia positively because it reflects the overall tendency of overseas activities and the international transactions of the Japanese industry to which firm *j* belongs. The IV is free from endogeneity for two reasons: it uses export values of other firms' Asian subsidiaries, and these export values do not include exports to Japan.

3. Empirical Analysis

3.1. Estimation Equation

The following equation is used to estimate the effects of offshoring on income, working hours, or hourly wage:

$$\ln y_{ijt} = \beta^{off} \ln off_{jt-1} + \boldsymbol{\beta}_{\mathbf{dw}}^{\mathbf{off}} \mathbf{d}_{\mathbf{wit}} \ln off_{jt-1} + \boldsymbol{\beta}_{\mathbf{xw}} \mathbf{x}_{\mathbf{wit}} + \boldsymbol{\beta}_{\boldsymbol{\phi}} \boldsymbol{\phi} + \varepsilon_{ijt}, \quad (1)$$

where y_{ijt} is the dependent variable associated with worker *i* employed by firm *j* in year *t* (where bonuses are given in year *t*-1); off_{jt-1} represents firm *j*'s offshoring to Asia in year *t*-1; $\mathbf{d}_{\mathbf{wit}}$ is a vector of two worker dummies used as interaction terms with off_{jt-1}; $\mathbf{x}_{\mathbf{wit}}$ is a vector of the worker-level variables; $\boldsymbol{\phi}$ is a vector of the dummies that is used to absorb fixed effects for age group–year groups, female–year groups, establishment industry–year groups, and firms; and ε_{ijt} is the error term.

$\mathbf{d}_{\mathbf{wit}}$ represents two worker indicators: college graduates and female workers. A group of male non-college graduates has no dummies and, therefore, is used as the baseline. $\mathbf{x}_{\mathbf{wit}}$ includes worker-level characteristics such as years of potential work experience, years of job tenure, and their interaction terms with educational background, gender, and job position. To take into account the differences in wage profile by industry, $\mathbf{x}_{\mathbf{wit}}$ also contains the interaction term of potential work experience or job tenure with the industries of the establishment to which worker *i* belongs.[18] I use establishment as a panel variable for the fixed effect estimation. Worker is preferable to establishment as a panel variable for the matched worker–firm panel data; however, this is not viable since no worker ID system has been introduced in *The Wage Survey*, as mentioned in Section 2.1. I do not include some firm variables such as output, export, and capital in this

[18] The complete list of $\mathbf{x}_{\mathbf{wit}}$ and $\boldsymbol{\phi}$ is in Appendix 5.

equation, as I intend to observe the total results of firms' offshoring, which include a productivity effect. Table 2 summarizes the descriptive statistics of the dependent variables as well as some of the independent variables and IV.

[Insert Table 2 Here]

3.2. Preliminary Analysis for Annual Variables

The first set of estimations for preliminary analysis uses three annual values as dependent variables: annual income, annual working hours, and hourly wage. Hourly wage is obtained by dividing annual income by annual working hours; therefore, it is appropriately included in the group of annual values. Hourly wage is used as a key dependent variable in Hummels et al. (2014), Carluccio et al. (2015), and Bøler et al. (2018) within the literature on international shocks and wages. Table 3 summarizes the second-stage estimates. In columns 1–3, where college- and female-interaction terms are not used, the Kleibergen–Paap F statistic is 22.28, which is sufficiently high. The first-stage estimates are the same as those in Table 4, panel B, column 1, which show that my IV significantly explains firms' offshoring with the expected positive causality. In columns 4–6, where the interaction terms are used, the Kleibergen–Paap F statistic falls to 7.44. Although this figure is not sufficiently high, estimates are not notably different from those in columns 1–3, so I posit that possible weak identification does not produce biased results. Their first-stage estimates are the same as those in Table 4, panel B, column 3, which proves that the IVs have appropriate characteristics.

[Insert Table 3 here]

Table 3, columns 1–3 show that offshoring to Asia has distinctive effects on the three annual variables. It changes annual income non-significantly, decreases annual working hours significantly, and increases hourly wages significantly. The opposite effects of offshoring on annual working hours and hourly wages are intriguing. If we use the change of hourly wages as an indicator of the offshoring effect on firms' demand for workers and on workers' welfare, we should interpret the positive effect to mean that the increase of offshoring benefits workers through the increase of hourly wages, and that the wage increase is generated from higher demand for workers. [19] However, looking at the results on annual working hours, offshoring has a negative effect which may imply the lower demand for workers.

[19] Workers and imported inputs do not need to be complements in production to obtain the positive effect of offshoring on wages. Using the production function in the online appendix of Hummels et al. (2014), for example, offshoring increases the wages of workers whose elasticity of substitution to imported inputs is small.

This conflict of interpretation is resolved if we consider that, in labor-management negotiations, employers and employees discuss terms relating to income and working conditions (including working hours and the number of days off); but do not directly negotiate an hourly wage. Additionally, it is worth noting that, to a certain degree, employees are able to change working hours themselves by taking more or less paid and sick leave. Accordingly, income and working hours are primary variables determined in within-firm labor markets while being influenced by offshoring. Hourly wage is then calculated secondarily from observed annual income and working hours. Based on this perspective, the estimates in Table 3, column 1–3, can be explained as follows: Offshoring does not increase the annual income of employees working for firms, presumably because it does not sufficiently increase firms' productivity. However, it allows them to work less hours due to the increase of off days in firm and on their will by taking leaves, assuming that imported inputs and labor inputs are close substitutes, and consequently hourly wage increases. [20]

Columns 4–6 are the results when interaction terms of offshoring with college graduates and with female workers are used. The characteristic of the results on the base group (male non-college graduates) are the same as those in columns 1–3. In columns 4 and 5, offshoring has an additional positive effect on both annual income and annual working hours for college graduates; whereas for female workers it has an additional negative effect on these variables. I discuss the background of these opposite effects below.

3.3. Analyses for Contractual and Working Hours Variables

This subsection consists of an examination into the effect of offshoring on each component of annual income and working hours. Table 4 summarizes first- and second-stage results of the IV estimation on the impact of offshoring on two contractual variables in annual income: scheduled monthly income and bonuses. I chose these variables as contractual variables to be examined for the following reasons. Annual income is composed of scheduled monthly income, overtime pay, and bonuses. First, scheduled monthly income, the main component of annual income, is a key item in labor–management negotiations and thus is a contractual variable. [21] Second, overtime pay is the product of overtime hours and the overtime hourly wage. Since overtime hours is not predetermined in labor–management negotiations, and the overtime premium is determined by the Labor Standards Law in Japan, overtime pay is not considered to be a contractual variable in within-firm labor markets. Third, bonuses in Japanese firms are generally calculated by scheduled monthly income being

[20] Appendix 2 reports the results of firm-level analyses that a one percent increase of firms' offshoring to Asia enhances their productivity by 0.1 percent with statistical significance at the 10 percent level. This finding supports the finding in the text.
[21] Vahter and Masso (2019) also employ monthly wage as a dependent variable in their estimation of the effect of foreign firms' control, though their monthly wage includes overtime pay.

multiplied by a certain factor determined by each firm. This factor depends on the performance of each firm and is determined during the labor contract negotiations. Therefore, bonuses can also be considered as a contractual variable.

[Insert Table 4 here]

Notably in Panel A, there are no estimates for the base group with sufficiently high statistical significance in second-stage results. The reason why offshoring to Asia changes two contractual incomes of the base group workers almost non-significantly is possibly the same as that for annual income in Table 3: Japanese firms' productivity is not sufficiently improved by offshoring. In addition, although offshoring has a positive effect on scheduled monthly income for the three other groups with some statistical significance, its significance does not reach the 1 percent level. Furthermore, there are no statistically significant estimates for bonuses. [22]

However, offshoring has a remarkable, statistically significant effect on working hours for all four worker groups. Table 5 summarizes second-stage estimates for three, working hours variables: Scheduled working hours, working days, and scheduled working hours per day. Scheduled working hours is the number of hours employees actually worked from a start time to an end time in working days determined by working rules in June of the survey year. It does not include the time employees are not working because of sick leave, paid leave, or leaving the office early. Working days and scheduled working hours per day are additionally used to break down the change of scheduled working hours into extensive and intensive margins. First-stage estimates are the same as those in Table 4, panel B, columns 1 and 3.

[Insert Table 5 here]

Table 5, column 1 shows that the estimate of offshoring to Asia for scheduled working hours is −0.0436 ($t = -3.4$). In column 4 where interaction terms are used, the estimate for male non-college graduates (baseline worker group) is −0.0449 ($t = -3.5$). Table 5 also breaks down the impact on schedule working hours into the impact on working days and that on scheduled working hours per day. It is notable that the change in working days amounts to more than three quarter of that of scheduled working hours, and the estimates for working days are statistically significant at the 1 percent level, in both cases of with and without interaction terms. [23] Interestingly, most estimates for interaction terms with college graduates

[22] The estimates for scheduled working hours and for working days are similar, but that is not because these two variables are obtained from the same item in *The Wage Survey*. Rather, they are from different, independent items.
[23] The reason why all estimates for bonuses are nonsignificant is most likely that the bonuses data are the ones from the previous year of scheduled monthly income, as I explained in subsection 2.1. Therefore there is less time to convey offshoring shocks to them.

and with female workers are very small and nonsignificant. Consequently, offshoring to Asia has a similar impact on scheduled working hours and working days over all four worker groups. Summarizing the findings in Tables 3–5, offshoring allows all four groups of workers to reduce working days while it hardly changes contractual incomes, which causes the across-the-board increase of hourly wages. [24]

Annual working hours, including overtime, has already been examined in Table 3, and the difference between estimates for annual working hours and those for scheduled working hours can be attributed to overtime. Since the average scheduled monthly working hours of male non-college graduates during the analyzed period is 158.7 (as seen in Table 1) this implies that their scheduled monthly hours decreases by 7.1 hours when offshoring to Asia is doubled (158.7 × 0.0449). [25] For their annual working hours, the estimate is −0.0309 in Table 3, column 5; and their average monthly working hours including overtime is 178.4. Therefore, doubling offshoring decreases their monthly working hours by 5.5 hours. The difference between the changes of scheduled monthly hours and total monthly hours, 1.6 hours, is the increase in overtime. A possible explanation of this fact is that, due to the increase of offshoring, workers have more off days and are also able to take more days off voluntarily. As a result, some work is left unfinished and male non-college graduates must compensate for this by working more overtime on the days that they do work.

Table 6 summarizes the implied working hour changes induced by a 100 percent increase of offshoring to Asia by working group. Changes in scheduled working hours are similar over the four groups, whereas changes in monthly working hours and the resulting changes in overtime are more different to each other. Table 3, columns 4 and 5 report the positive estimates for the interaction term with college graduates, which corresponds to the larger increase of their overtime payment as well as their overtime work (for example, the increase of overtime for male college graduates, 3.0 hours, is larger than that for male non-college graduates, 1.6 hours). While this result represents the fact that intermediate inputs from Asia are unskilled-labor intensive goods and are substitutes for non-college graduates rather more so than for college graduates, some readers might think that the difference in the impact on non-college graduates and college graduates are not so large. This is possibly due to firms' attempts to mitigate the difference in trade shocks by, for example, enhancing job rotation and on-the-job training.

[24] Appendix 6, Table A2 reports four sets of robustness checks for the results of Table 5. It shows that the base results are robust across the many specifications considered.

[25] Although we are able to calculate the implied change of working conditions due to offshoring as I did in the text, the number of workers actually experiencing the change of working conditions presumably varies more in the long term even in Japan, from firms' adjustment of workforce. For example, the average value of offshoring to Asia per firm in the constructed panel dataset actually doubles from 1997 (3.1 billion JPY) to 2012 (6.1 billion JPY). If a hypothetical firm increased its offshoring by 100 percent from 1997 to 2012, male non-college graduates who were supposed to work in that firm for the whole period would expect their scheduled monthly working hours to decrease by 6.9 hours (the amount I estimate in the text). This produced a surplus of male non-college graduates, and firms were able to adjust the number of them to maintain the adequate workforce size in a long term (such as 15 years).

In contrast to the effect on college graduates, Table 3, columns 4 and 5 report negative estimates for the interaction term with female workers, which suggests that the substitution between scheduled working hours and overtime rarely occurs for female workers (for example, female non-college graduates decrease their overtime by 0.7 hours, whereas male non-college graduates increase their overtime by 1.6 hours). This lower substitutability may reflect the fact that female workers may not be able to work more overtime because they bear the burden of household work more than male workers do in Japan. Since male employees obtain more overtime payment from the increase of offshoring, whereas female employees do not, offshoring increases the gender gap of annual income, though the statistical significance of the effect is not as high as at the 1 percent level (Table 3, column 4, the estimate for the interaction term with female workers is −0.0150, with $t = -2.3$).

[Insert Table 6 here]

4. Conclusion

This study is the first attempt to analyze the impact of trade shocks on working hours in the within-firm labor market, a possible but underexamined channel through which income inequality changes. Because the within-firm labor market in each Japanese firm is less connected to other labor markets outside the firm, its data are suitable for observing the within-firm redistribution effects of trade shocks. Methodologically, I used data on the Japanese manufacturing sector and constructed a matched worker–establishment–firm dataset. Among various trade shocks, this study employed firms' offshoring to Asia, defined as their intermediate inputs imported from Asia. The data of offshoring are instrumented.

The empirical results of this study showed that an increase in imported inputs raises scheduled monthly income of male non-college graduates non-significantly, and it did not widen the monthly income gap between them and college graduates or female workers. However, offshoring decreased working hours of all worker groups, meaning that imported inputs are close substitutes for any labor inputs. More than three quarters of the decrease in scheduled working hours was caused by the decrease in working days, presumably due to the increase in off days in firms and due to employees' voluntarily electing to take more paid and sick leave. Consequently, hourly wages increased in all worker groups. Offshoring did not have a statistically significant effect on the skill premium and the gender gap of hourly wages. However, offshoring did increase male workers' overtime whereas it did not increase females', which widened the gender gap of annual income, though its statistical significance is not sufficiently high.

Depending on whether we draw conclusions based on either workers' hourly wage or their income, the impact of offshoring on workers' welfare leads to contradictory results. Focusing on hourly wage leads to the conclusion that offshoring is beneficial for employees; whereas considering income confirms the hypothesis that firms do not sufficiently distribute profits from offshoring to the employees. Despite these contradictory perspectives, we can draw the same conclusion that within-firm inequality is low in Japanese firms as a consequence of offshoring. These results may be specific to Japan since prior research based on other countries does not provide the same findings. In this sense, this study offers further evidence of the case specificity of the distribution effects of globalization. I suggest that this specificity comes partly from the adjustment processes found in within-firm labor markets.

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Table 1. Mean feagures of key variables concerning income, working hours, and hourly wage by worker group

	Male non-college graduates	Male college graduates	Female non-college graduates	Female college graduates
Income (Japanese Yen) :				
Monthly income (a = b + c)	371,849	408,335	233,701	304,581
Scheduled monthly income (b)	317,403	368,934	218,236	280,930
Overtime monthly income (c)	54,446	39,401	15,464	23,650
Bonuses (d)	1,244,240	1,362,290	789,996	1,081,533
Annual income (e = a x 12 + d)	5,706,424	6,262,315	3,594,405	4,736,501
Working days and hours :				
Monthly working days (f)	20.7	20.7	20.8	20.5
Monthly working hours (g = h + i)	178.4	176.9	169.6	170.0
Scheduled working hours (h)	158.7	160.5	160.7	158.8
Overtime working hours (i)	19.7	16.4	8.9	11.2
Working hours per day (= g / f)	8.6	8.6	8.2	8.3
Scheduled hours per day (= h / f)	7.7	7.8	7.7	7.7
Overtime per day (= i / f)	1.0	0.8	0.4	0.5
Share of obs. with positive overtime (%)	80.1	61.3	61.3	65.0
Hourly wage (Japanese Yen) :				
Hourly wage (= e / (g x 12))	2,665	2,950	1,766	2,321
Hourly wage in scheduled hours (= b / h)	2,000	2,298	1,358	1,769
Hourly wage in overtime (= c / i)	2,765	2,403	1,741	2,102
Observations	421,022	193,417	134,467	20,859

Note : Incomes and hourly wages are deflated by the GDP deflators of their corresponding years.
Source : Author.

Table 2. Descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
Worker-level dependent variables					
Annual base variables					
Log annual income	769,765	15.443	0.380	13.350	17.164
Log annual working hours	769,765	7.647	0.137	6.904	8.428
Log hourly wage	769,765	7.796	0.395	5.629	9.709
Contractual variables					
Log scheduled monthly income	769,765	12.589	0.352	8.242	14.679
Log bonuses	737,831	13.865	0.666	4.631	15.077
Working hours variables					
Log scheduled working hours	769,765	5.067	0.099	4.357	5.541
Log working days	769,765	3.025	0.095	2.708	3.258
Log scheduled working hours per day	769,765	2.042	0.053	1.609	2.303
Worker-level independent variables					
Years of job tenure	769,765	15.941	10.905	1.000	44.000
Years of potential work experience	769,765	19.812	11.315	0.000	44.000
Firm-level independent variable					
Log offshoring from Asia	13,577	19.564	2.391	13.724	27.595
Firm-level instrument variable					
Log exports of Asian subsidiaries of other firms	13,577	14.338	1.150	6.404	16.967

Notes : The worker-level data have worker-year observations and the firm-level data have firm-year observations. Incomes, wages, and trade values are deflated by GDP deflator. See the main text for the definition of variables.
Source : Author.

Table 3. Second-stage estimates for annual variables

Dep. variable:	Log annual income	Log annual working hours	Log hourly wage	Log annual income	Log annual working hours	Log hourly wage
	(1)	(2)	(3)	(4)	(5)	(6)
Log offshoring to Asia (a)	0.0176	-0.0297***	0.0474***	0.0178	-0.0309***	0.0487***
	(0.0110)	(0.0112)	(0.0150)	(0.0111)	(0.0114)	(0.0151)
x college graduates (b)				0.0058	0.0109***	-0.0051
				(0.0046)	(0.0033)	(0.0054)
x female workers (c)				-0.0150**	-0.0142***	-0.0008
				(0.0064)	(0.0034)	(0.0059)
(a) + (b)				0.0236**	-0.0200*	0.0437***
				(0.0111)	(0.0112)	(0.0152)
(a) + (c)				0.0029	-0.0451***	0.0480***
				(0.0125)	(0.0122)	(0.0165)
(a) + (b) + (c)				0.0087	-0.0342***	0.0429***
				(0.0127)	(0.0121)	(0.0165)

Notes : All specifications include establishment, establishment industry-year, age group-year, and female-year dummies, as well as other worker controls such as years of job tenure and potential work experience; the table does not report their coefficients. See Online Appendix 5 for the explanation of all variables used. Standard errors in parentheses are clustered at the establishment level. The Kleibergen-Paap F statistic and first-stage estimates for regressions 1-3 are the same as those in column 1 of Table 4, and those for regressions 4-6 are the same as those in column 3 of the table. The number of observations is 769,765 and the number of establishments is 8,261 in all columns. *** p<0.01, ** p<0.05, * p<0.1.
Source : Author.

Table 4. Estimates for contractual variables

Panel A. Second-stage estimates

Dep. variable:	Log scheduled monthly income	Log bonuses	Log scheduled monthly income	Log bonuses
	(1)	(2)	(3)	(4)
Log offshoring to Asia (a)	0.0165*	-0.0304	0.0148	-0.0302
	(0.0095)	(0.0324)	(0.0096)	(0.0328)
x college graduates (b)			0.0030	-0.0019
			(0.0048)	(0.0092)
x female workers (c)			0.0081	0.0028
			(0.0057)	(0.0101)
(a) + (b)			0.0178*	-0.0321
			(0.0100)	(0.0320)
(a) + (c)			0.0229**	-0.0274
			(0.0113)	(0.0343)
(a) + (b) + (c)			0.0259**	-0.0294
			(0.0117)	(0.0335)
Number of observations	769,765	737,816	769,765	737,816
Number of establishments	8,261	8,134	8,261	8,134
Kleibergen-Paap F statistic	22.28	22.37	7.44	7.47

Panel B. First-stage estimates

	(1)	(2)	(3)	(4)
Dep. variable: Log offshoring to Asia				
Log exports of Asian	0.1153***	0.1171***	0.1149***	0.1164***
subsidiaries of other firms	(0.0244)	(0.0248)	(0.0246)	(0.0249)
x college graduates			0.0056	0.0074
			(0.0066)	(0.0063)
x female workers			-0.0065	-0.0065
			(0.0041)	(0.0042)
R^2	0.234	0.238	0.234	0.238
F statistic of excl. instruments	2.10×10^6	5.11×10^6	120,631	6.70×10^7
Dep. variable: Log offshoring to Asia x college graduates				
Log exports of Asian			-0.0334**	-0.0288**
subsidiaries of other firms			(0.0135)	(0.0132)
x college graduates			0.2243***	0.2196***
			(0.0362)	(0.0367)
x female workers			-0.0093	-0.0094
			(0.0069)	(0.0070)
R^2			0.983	0.983
F statistic of excl. instruments			70,150	63,075
Dep. variable: Log offshoring to Asia x female workers				
Log exports of Asian			-0.0281***	-0.0290***
subsidiaries of other firms			(0.0080)	(0.0083)
x college graduates			-0.0053	-0.0073
			(0.0052)	(0.0053)
x female workers			0.2330***	0.2280***
			(0.0294)	(0.0299)
R^2			0.984	0.984
F statistic of excl. instruments			21,734	47,373

Notes: All specifications include establishment, establishment industry-year, age group-year, and female-year dummies, as well as other worker controls such as years of job tenure and potential work experience; the table does not report their coefficients. See Online Appendix 5 for the explanation of all variables used. Standard errors in parentheses are clustered at the establishment level. *** p<0.01, ** p<0.05, * p<0.1.

Source: Author.

Table 5. Second-stage estimates for working hours variables

Dep. variable:	Log scheduled working hours	Log working days	Log scheduled working hours per day	Log scheduled working hours	Log working days	Log scheduled working hours per day
	(1)	(2)	(3)	(4)	(5)	(6)
Log offshoring to Asia (a)	-0.0436***	-0.0343***	-0.0093**	-0.0449***	-0.0346***	-0.0103**
	(0.0128)	(0.0109)	(0.0046)	(0.0128)	(0.0110)	(0.0047)
x college graduates (b)				0.0042*	0.0006	0.0037***
				(0.0022)	(0.0021)	(0.0013)
x female workers (c)				0.0022	0.0010	0.0013
				(0.0018)	(0.0017)	(0.0011)
(a) + (b)				-0.0407***	-0.0340***	-0.0067
				(0.0126)	(0.0107)	(0.0045)
(a) + (c)				-0.0427***	-0.0336***	-0.0090*
				(0.0132)	(0.0113)	(0.0048)
(a) + (b) + (c)				-0.0385***	-0.0331***	-0.0054
				(0.0131)	(0.0112)	(0.0048)

Note: See the notes in Table 3.
Source: Author.

Table 6. Implied working hour changes induced by doubling offshoring

	Male non-college graduates	Male college graduates	Female non-college graduates	Female college graduates
Changes in monthly working hours	-5.5	-3.5	-7.6	-5.8
Changes in scheduled working hours	-7.1	-6.5	-6.9	-6.1
Changes in overtime working hours	1.6	3.0	-0.7	0.3

Source: Author.

Appendix 1. The explanation of the four datasets used for the panel data

The Basic Survey on Wage Structure (*The Wage Survey*) aims to provide a picture of the wage structure for employees in Japan. The Ministry of Health, Labour and Welfare conducts this survey annually, targeting private establishments with five or more regular employees and public establishments with 10 or more regular employees. The population for this survey comprises roughly 1.4 million establishments and approximately 37 million employees, nationwide. The survey uses two-stage sampling with establishments as the primary sampling unit and employees as the secondary sampling unit. About 75,000 establishments and 1.6 million employees are sampled every year. The survey items include each employee's monthly contractual cash earnings, annual special cash earnings, years of job tenure, age, gender, school career, and workplace information.

The Basic Survey of Japanese Business Structure and Activities (*The Business Survey*), conducted annually by the Ministry of Economy, Trade and Industry, acquires basic data on the business activities of private Japanese companies. The survey targets companies engaged in business with both a minimum capital of 30 million JPY, and 50 or more employees. The survey covers multiple industries; although it excludes the industries involved in agriculture, fisheries, construction, transportation, medical, healthcare, and welfare. There are approximately 37,000 companies targeted, of which roughly 30,000 submit valid responses every year. The survey covers items such as the number of regular workers, sales, operating profit, the number of subsidiaries, fixed assets, exports, and imports for the previous fiscal year.

The Establishment and Enterprise Census and *The Economic Census for Business Frame* (*The Censuses*), conducted by the Statistics Bureau, Ministry of Internal Affairs and Communications, cover all establishments and firms in Japan. They record basic information on each establishment such as name, address, telephone number, and the number of workers, and serve as the master sampling framework for statistical surveys (including *The Wage Survey*). Until 2006, *The Establishment and Enterprise Census* was conducted every two to three years. , It has since been incorporated into *The Economic Census for Business Frame* launched in 2009 and *The Economic Census for Business Activity* launched in 2012.

Appendix 2. Effect of firms' offshoring on their employment and TFP

The firm-level estimation equation for analyzing the impact of firms' offshoring to Asia on their number of workers and TFP is

$$\ln Y_{jt} = \beta^{off} \ln off_{jt} + \boldsymbol{\beta}_{\boldsymbol{\phi}} \boldsymbol{\phi} + \varepsilon_{ijt}, \quad \text{(A.1)}$$

where Y_{jt} is the firm-level dependent variable for firm j in year t; off_{jt} represents offshoring to Asia by firm j in year t; $\boldsymbol{\phi}$ is a vector of the year and firm dummies; and ε_{ijt} is the error term. Y_{jt} and off_{jt} are obtained from *the Business Survey*. The number of workers includes part-time workers. TFP is obtained from Levinsohn–Petrin estimates using the value of intermediate inputs as a proxy for productivity shocks. The IV for $\ln off_{jt}$ is the per worker exports of Asian subsidiaries of other Japanese firms classified in the same industry, excluding exports to Japan. The definition and sources of the IV are the same as in the main text.

Estimation results are summarized in Table A1. It shows that offshoring to Asia does not have a statistically significant effect on the number of workers, and that it affects TFP positively with statistical significance at the 10 percent level.

Table A1. Firm-level analyses on the number of workers and TFP

Panel A: Second-stage estimates		
Dep. variable:	Log number of workers	Log TFP
	(1)	(2)
Log offshoring to Asia	0.0800	0.1261*
	(0.0564)	(0.0700)
Observations	11,432	
Number of firms	2,236	
Kleibergen-Paap F statistic	18.12	

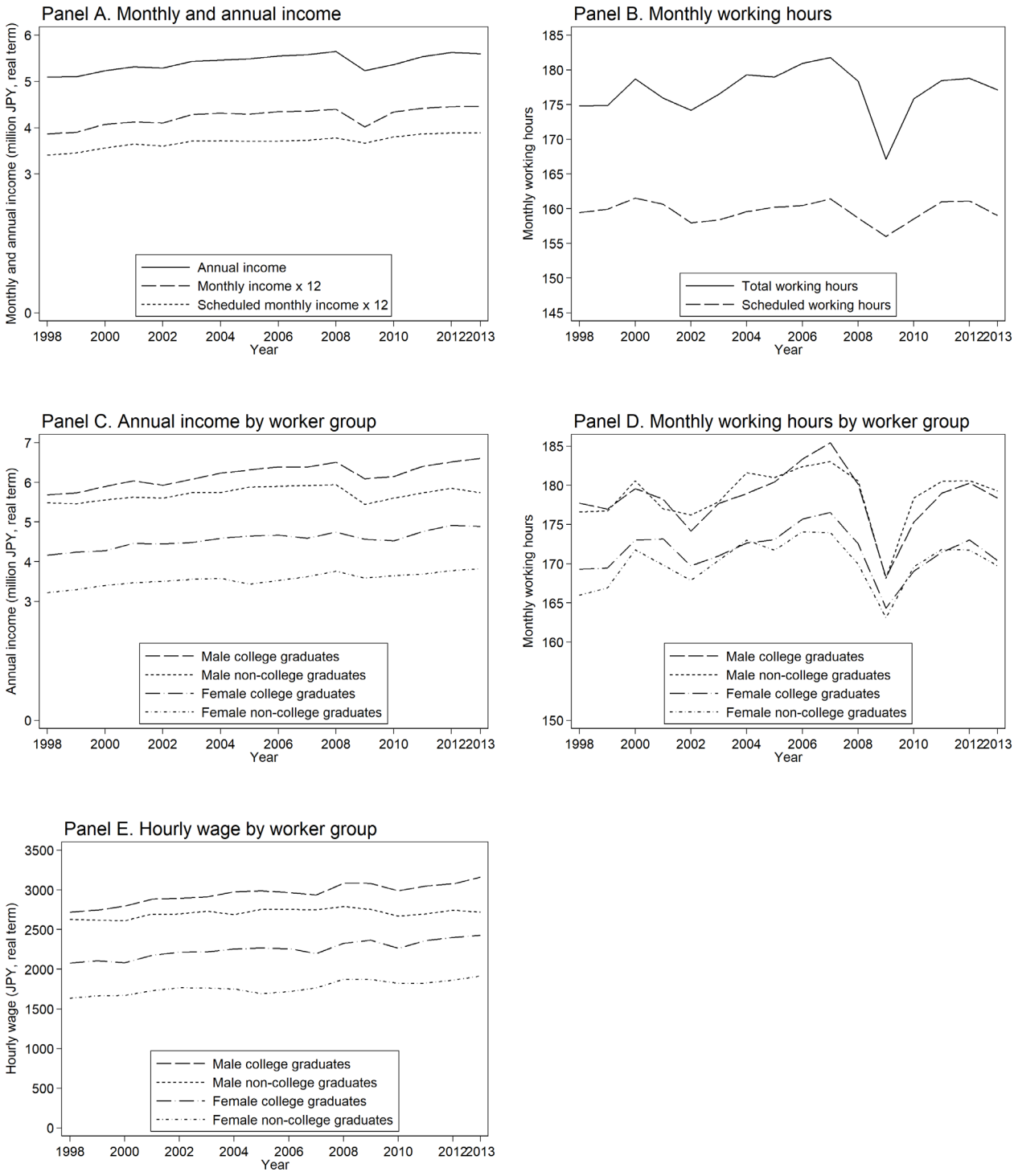
Panel B: First-stage estimate	
Dep. variable:	Log offshoring to Asia
Log exports of Asian subsidiaries of other firms, except to Japan	0.0809***
	(0.0277)
F statistic of excl. instruments	29.08

Notes: All specifications include establishment and year dummies; the table does not report their coefficients. Standard errors in parentheses are clustered at the firm level. *** p<0.01, ** p<0.05, * p<0.1.
Source: Author's calculations.

Appendix 3. Time-series data of income, working hours, and hourly wage

Figure A1 shows the time-series data on incomes, working hours, and hourly wages in the constructed panel dataset. Panel A depicts average scheduled monthly income, monthly income including overtime payment, and annual income of Japanese manufacturing workers from 1998 to 2013. Monthly and annual incomes had increased modestly until 2008, fell by around 10 percent in 2009, and then almost recovered to their pre-shock levels by 2013. The negative shock of the global financial crisis in 2009 mainly reduced overtime payments (the difference between monthly income and scheduled monthly income) and bonuses (the difference between annual and monthly incomes). Panel B reports scheduled and total working hours each year in the month of June between 1998 and 2013. Working hours show a periodic change, partly representing the change in the number of weekdays in June. In addition, the global financial crisis caused a drop in scheduled working hours and overtime (the difference between total and scheduled working hours) in 2009. Panels C, D, and E show annual income, monthly working hours, and hourly wage of four worker groups, respectively. Hourly wage in Panel E is obtained by dividing annual income in Panel C by 12, times the monthly working hours in Panel D. Annual income and hourly wages vary among the four groups. The growth of annual income and hourly wages for the group of male non-college graduates is stagnant compared to the other three groups, partly because the workforce of this group becomes younger and their tenure years becomes shorter during the period. The trend is the opposite for the other three groups.

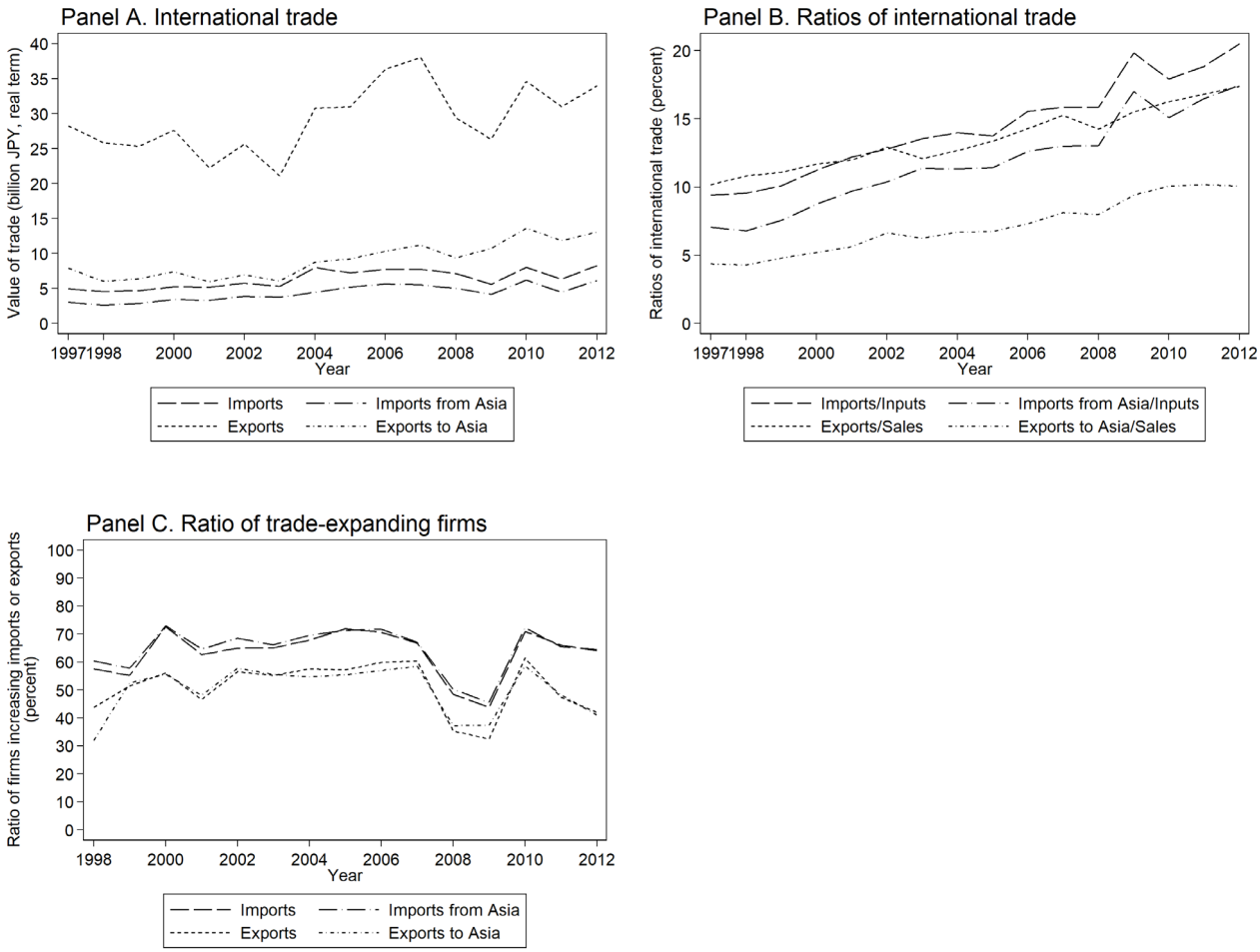
Figure A1. Time-series data of income, working hours, and hourly wage



Appendix 4. The transition of selected trade variables in the dataset

Figure A2 shows the transition of selected trade variables in the panel dataset, constructed using Japanese firms with positive imports from Asia, originally from *The Business Survey*. Panel A shows the average trade values of firms during the analysis period with regard to the following: total imports except from the Middle East, Oceania, and Africa; imports from Asia; total exports; and exports to Asia. Offshoring is defined in this paper as firms' imports, or intermediate purchases, specifically from Asia. Firms' imports from the Middle East, Oceania, and Africa are excluded in this definition of total imports in order to make the concept of total imports comparable with imports from Asia (most imports from these regions are mineral resources, which are scarce in Japan and therefore are not considered part of offshoring and substitutes for Japanese workers). Values of total imports and imports from Asia per firm have an increasing trend, although there are falls in 2009 and 2011 due to the global financial crisis, and the Tohoku earthquake and tsunami. The majority of total imports are from Asia, and the difference between total imports and imports from Asia is stable around 2 billion JPY per firm. This means that the driving force behind increasing trends of offshoring is imports from Asia. Panel B depicts the ratio of import value to total intermediate purchases and that of export value to total sales, both with respect to total trade and trade with Asian countries. Panel B clearly shows the increasing trend of all four ratios, implying that Japanese manufacturing firms have strengthened their relationship with foreign markets as both a source of intermediate inputs and a destination for their final goods. This result does not mean, of course, that all Japanese firms in the dataset experience an increase in their international transactions. Panel C reports the ratio of firms that increase their real imports and exports compared to those in the previous year, again with respect to both total trade and trade with Asian countries. Around 60–70 percent of firms, on average, increase their real transactions of imports in each year before 2007. Taken from the opposite perspective, as many as a third of the firms experienced a decrease in imports each year during this period. In this regard, my estimation result includes the effects of both the expansion and the contraction of offshoring.

Figure A2. The transition of firm-level trade variables



Appendix 5. Worker-level and fixed effect independent variables

The complete list of worker-level variables consists of three variable types. (1) Variables for the wage profile: years of potential work experience and its square, and years of job tenure and its square. (2) Dummy variables for workers' characteristics: junior high school graduate, high school graduate, higher-level vocational school or junior college graduate, college or graduate school graduate, lower management level, crew leader or equivalent, other supervisory level, specialist, non-production worker, fixed-term employment, and female. (3) Difference in wage profiles reflecting worker and industry characteristics: interaction terms with each variable in (1) and each variable in (2), and interaction terms with each variable in (1) and each dummy for the 24 aggregated industries for establishments. An establishment's industry is fixed at the industry in which that establishment first appears in *The Wage Survey* conducted after 1998. Workers' years of potential work experience is calculated by subtracting assumed age when workers graduated from school with their highest educational level from present age. Assumed age of graduation is 15 years for a junior high school graduate, 18 years for a senior high school graduate, 20 years for a higher-level vocational school or junior college graduate, and 22 years for a college graduate. *The Wage Survey* does not distinguish between workers who have graduated from graduate schools versus colleges in the questionnaire and, thus, graduate school graduates are considered to be college graduates in this calculation.

There are four types of fixed effects. The first set of dummies is used to absorb the fixed effects by age group and year. Here, I categorize workers by their age into the cohorts of 10s, 20s, 30s, 40s, and 50s in each year. This set of dummies reflects the flattening of the cohort wage profile in Japan throughout the sample period used for this research (e.g., Bognanno and Kambayashi, 2013; Hamaaki, Hori, Maeda, and Murata, 2012; Yamada and Kawaguchi, 2015). Secondly, female–year dummies are used to control for the closing trend of the wage gap between male and female workers (e.g., Abe, 2010; Hara, 2018; Kawaguchi, 2015). Thirdly, establishment industry–year dummies absorb industry-specific shocks for a particular year. Lastly, establishment dummies are used as establishment is recorded as a panel variable in this study.

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Appendix 6. Robustness test

Table A2 reports four sets of robustness checks for the results of Table 5, where the dependent variables are three working hours variables, including interaction terms. The independent variables are the same as those for Table 5. Overall, the estimates and their statistical significances are similar to the results of Table 5. This shows that the base results are robust across the many specifications considered.

Columns 1–3 are the results where log sales, log number of workers, and log fixed assets per worker are used additionally as independent variables in the regression. This set is to estimate the direct effect of offshoring. The productivity effect, or indirect effect, of offshoring is excluded by using firm control variables (Hummels et al., 2014). The absolute values of estimates are generally larger than the correspondents in Table 5, which suggests that the direct effect of offshoring is mitigated by firms through the adjustment of firm-level variables.

Columns 4–6 show the results for the observations up to 2008, before the global financial crisis in 2009. This period is considered to be a time of trade expansion without large economic turmoil, and Andersson et al. (2016, 2017) and Hummels et al. (2014) employ data from this period. Estimates are similar to those in Table 5.

Columns 7–9 present the results of the observations excluding 10 mineral-intensive industries (chemical fertilizers and inorganic chemicals; industrial organic chemicals; oil and fat products, detergents, and paints; drugs and medicines; miscellaneous chemical and allied products; plastic products; tires and inner tubes; miscellaneous rubber products; steel materials and products; and non-ferrous metal products). These industries rely greatly on mineral resources as intermediate inputs, which are scarce in Japan and, therefore, are not considered to be substitutes for Japanese workers. Although this study has already excluded the petroleum and non-ferrous metal industries, I employ this robustness check on the stricter condition on the use of mineral resources. All estimates in columns 7 and 8 are larger than the correspondents in Table 5 in terms of their absolute value. This means that we are able to observe the substitution between imported intermediate inputs and labor inputs more clearly by removing mineral-intensive industries.

Lastly, columns 10–12 show the results when non-manufacturing establishments are excluded. Since a firm generally conducts some related businesses aside from its core business, firms in the manufacturing sector often have non-manufacturing establishments in their organizations. However, employees in these non-manufacturing establishments are not directly affected by imported intermediates in their workplace, so they are removed from the study. Three estimates of offshoring on the base group are larger in absolute terms than the correspondents in Table 5. This implies that removing non-manufacturing establishments is another method to observe the substitution more clearly.

Table A2. Second-stage estimates of robustness check

Dep. variable:	Case 1: With firm controls			Case 2: Observations 1998-2008		
	Log scheduled working hours	Log working days	Log scheduled working hours per day	Log scheduled working hours	Log working days	Log scheduled working hours per day
	(1)	(2)	(3)	(4)	(5)	(6)
Log offshoring to Asia	-0.0612***	-0.0481***	-0.0131**	-0.0447***	-0.0413***	-0.0034
	(0.0194)	(0.0166)	(0.0065)	(0.0165)	(0.0157)	(0.0054)
x college graduates	0.0050**	0.0012	0.0038***	0.0027	0.0010	0.0017*
	(0.0025)	(0.0023)	(0.0013)	(0.0019)	(0.0018)	(0.0010)
x female workers	0.0021	0.0009	0.0012	0.0020	0.0011	0.0009
	(0.0019)	(0.0018)	(0.0011)	(0.0017)	(0.0016)	(0.0009)
Number of observations		769,765			571,235	
Kleibergen-Paap F statistic		5.14			6.13	

Dep. variable:	Case 3: Excl. mineral-intensive industries			Case 4: Excl. non-mnfc establishments		
	Log scheduled working hours	Log working days	Log scheduled working hours per day	Log scheduled working hours	Log working days	Log scheduled working hours per day
	(7)	(8)	(9)	(10)	(11)	(12)
Log offshoring to Asia	-0.0519***	-0.0465***	-0.0054	-0.0570***	-0.0440***	-0.0130**
	(0.0172)	(0.0156)	(0.0059)	(0.0168)	(0.0141)	(0.0056)
x college graduates	0.0072**	0.0042	0.0030**	0.0028	-0.0004	0.0032**
	(0.0030)	(0.0028)	(0.0015)	(0.0026)	(0.0024)	(0.0015)
x female workers	0.0049**	0.0033	0.0016	0.0023	0.0013	0.0010
	(0.0025)	(0.0023)	(0.0014)	(0.0021)	(0.0019)	(0.0013)
Number of observations		587,769			690,726	
Kleibergen-Paap F statistic		5.70			5.73	

Notes: See the notes in Table 4. First-stage results are similar to those in Table 4. Columns 1-3 use log sales, log number of workers, and log fixed assets per worker additionally as independent variables.
Source: Author.