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Offshoring and Wage Inequality: Theory and Evidence from Japan

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Abstract

Does offshoring widen or narrow wage inequality? To answer this question, we develop a tractable North-South model that features firm heterogeneity, foreign outsourcing, and vertical specialization. In a baseline model with exogenous firm's outsourcing decisions, we show that an increase in outsourcing raises skilled wages, lowers unskilled wages, widens wage inequality, and improves welfare. In an extended model with endogenous firm's outsourcing decisions, however, an increase in outsourcing raises or lowers skilled and unskilled wages, widens or narrows wage inequality, and improves or deteriorates welfare, depending on the initial level of outsourcing. Using Japanese data, we then show that, in contrast to most findings for the U.S., once we account for initial industry-level differences in the extent of outsourcing, it instead narrows wage inequality.

Keywords: Firm Heterogeneity; Foreign Outsourcing; Vertical Specialization; Wage Inequality
JEL Classification: F66, J31, L23

1. Introduction

Does offshoring widen or narrow wage inequality? To answer this question, we develop a tractable North-South model that features firm heterogeneity, foreign outsourcing, and vertical specialization. In a baseline model with exogenous firm's outsourcing decisions, we show that an increase in outsourcing raises skilled wages, lowers unskilled wages, widens wage inequality, and improves welfare. In an extended model with endogenous firm's outsourcing decisions, however, an increase in outsourcing *raises or lowers* skilled and unskilled wages, *widens or narrows* wage inequality, and *improves or deteriorates* welfare, depending on the *initial level* of outsourcing. Using Japanese data, we then show that, in contrast to most findings for the U.S., once we account for initial industry-level differences in the extent

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of outsourcing, it *narrows* wage inequality. Thus, our results suggest that when designing policies to promote outsourcing, it is crucial to consider which industries initially had a high or low degree of outsourcing; otherwise, such policies may lead to unintended consequences for wages, wage inequality, and welfare.

Since the 1980s, the wage gap between workers with and without a college education has increased in economies like the United States, Canada, and the United Kingdom (Doepke and Gaetani, 2024). A primary factor behind the rising college wage premium has been offshoring; for example, an earlier study of Feenstra and Hanson (1996) shows that outsourcing can account for 30.9 percent of the *rise* in U.S. wage inequality during the 1980s, driven by the increased relative demand for skilled workers. Other studies examining the relationship between offshoring and wage inequality in the U.S. typically find that increased offshoring *reduces* unskilled wages, *raises* skilled wages, and *widens* wage inequality (Kim and Hwang, 2016).[1] In particular, since the seminal work of Grossman and Rossi-Hansberg (2008) on trade in tasks, many papers have extended their theoretical framework and empirically tested its predictions.

Despite this progress, the literature has yet to reach a consensus on the relationship between offshoring and wage inequality (Hummels et al., 2014). For example, in theory, foreign outsourcing can displace domestic workers by replacing tasks previously done locally, leading to *lower* wages. At the same time, it can lower firm costs and increase productivity, enabling firms to expand output and employment and thus *raise* wages, so that the net effect remains unclear. In practice, several European countries, including Germany, Italy, and Spain, experienced a *narrowing* of wage inequality from the 1980s to the early 21st century (Doepke and Gaetani, 2024). This trend is also present in Asian countries, such as Japan.

Figure 1 shows the industry-level measure of offshoring and the college premium in Japan from 2001 to 2017. The offshoring series shows a general upward trend over the period, with occasional declines. The college premium also rises until 2009. Since 2010, however, it has followed a *downward* trend, despite no dramatic parallel decline in offshoring. Moreover, in contrast to findings from the U.S. (Kim and Hwang, 2016) and Denmark (Hummels et al., 2014)—where offshoring widens wage inequality—there are several years in the Japanese data during which they move in *opposite* directions. These patterns suggest the need to reconsider the relationship between offshoring and wage inequality.

To this end, we develop a tractable North-South model that incorporates key elements of modern international trade: foreign outsourcing, firm heterogeneity (Melitz, 2003), and vertical specialization. We analyze how outsourcing impacts the *levels* of both skilled and unskilled wages and wage inequality.[2] We first develop a baseline model with exogenous firms' outsourcing decisions to derive intuitive results. We show that an increase in outsourcing *raises* the skilled wage due to demand shifts and reallocation effects, *lowers* the

[1] See Helpman (2018) for a lucid survey. Hummels et al. (2014), using Danish matched worker-firm data, reach the same conclusion.

[2] Hummels et al. (2014) point out that the theoretical literature tends to focus only on wage inequality (*relative* wage) or demand for skilled workers, often overlooking the effects on the *levels* of both skilled and unskilled wages.

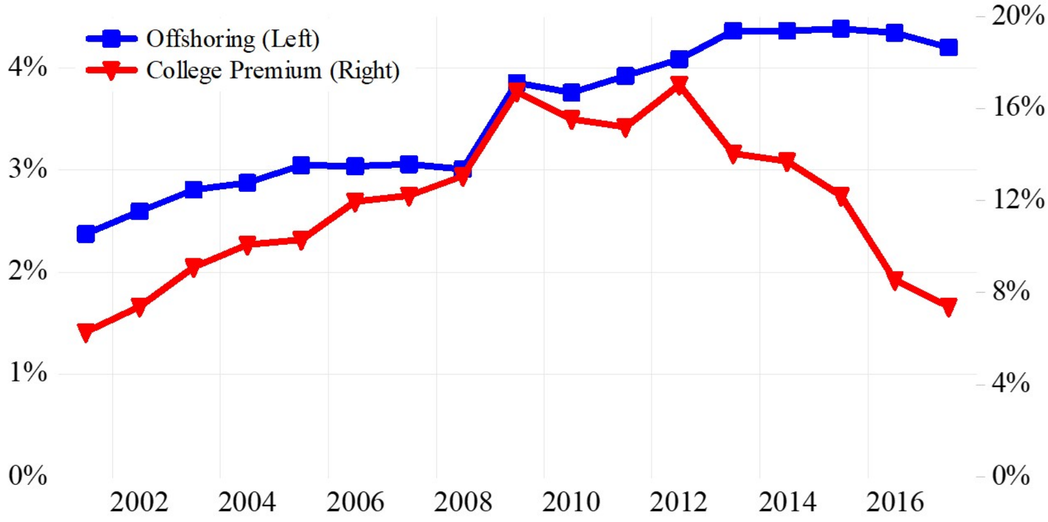

Figure 1: Offshoring and the college premium in Japan, 2001-2017. The offshoring measure is calculated as the average across 13 industries of 100% minus the share of imports from unaffiliated firms in total procurement costs. The college premium is the relative wage difference between male university graduates and male high school graduates aged 25 to 30. Source: Basic Survey of Japanese Business Structure and Activities and Basic Survey on Wage Structure.

unskilled wage due to demand shifts and the increase in skilled wages, and thus *widens* wage inequality. Though these results are consistent with the empirical findings discussed above, the mechanisms we propose are in sharp contrast to those in related studies. For example, the rise in the skilled wage due to reallocation effects emerges from the introduction of firm heterogeneity, and the fall in unskilled wages due to the rise in skilled wages stems from vertical specialization. These new channels we identify complement traditional explanations, such as shifting demand (Feenstra and Hanson, 1996).

We then extend the baseline model by endogenizing firms' outsourcing decisions. In the extended model, we show that an increase in outsourcing *raises or lowers* both skilled and unskilled wages, and *widens or narrows* wage inequality, depending on the *initial level* of outsourcing; that is, its impact varies based on the industry's initial degree of outsourcing. Despite three key elements, our model is tractable enough, allowing for fully analytical comparative statics. This makes it suitable for identifying new channels that previous studies may have overlooked, and for explaining the narrowing of wage inequality observed in some European countries and Japan.

Finally, using industry-level Japanese data from 2001 to 2017, we test the predictions of our theoretical framework. In the baseline estimation that treats industries symmetrically, an increase in outsourcing widens wage inequality—consistent with previous studies and the predictions of our baseline model. In contrast, the applied estimation that incorporates initial industry-level differences in the extent of outsourcing as suggested by our extended model shows that increased outsourcing instead *narrows* wage inequality. Thus, our findings suggest that overlooking initial industry-level differences may be one of the potential reasons why the literature has yet to reach a consensus on the relationship between offshoring and wage inequality.

There are three closely related studies. First, Egger et al. (2015) introduce firm heterogeneity into the Grossman and Rossi-Hansberg (2008) framework of trade in tasks. They show that, depending on the share of firms engaging in offshoring, an increase in offshoring may, in contrast to Melitz (2003), lead the *least* productive firms to enter the markets, unambiguously widens *income* inequality, and generally improves welfare. Their model, however, does not have vertical specialization and there is no distinction between skilled and unskilled workers, making it unsuitable for analyzing wage inequality.

Second, Acemoglu et al. (2015) present a dynamic Ricardian model of offshoring, incorporating directed technical change into the Grossman and Rossi-Hansberg (2008) framework. They show that a reduction in offshoring costs results in an inverted U-shaped effect on wage inequality; initially, it widens wage inequality, but eventually, it narrows. This occurs due to the dynamic switch from skill-biased technological change to *unskill*-biased technological change that favors unskilled workers. Similar to Egger et al. (2015), they do not consider vertical specialization and assume *homogeneous* firms, so that reallocation effects are absent.

Third, Jiang (2023) incorporates offshoring and the distinction between skilled and unskilled workers into the international real business cycle model of Ghironi and Melitz (2005). It shows that trade liberalization widens wage inequality, a reduction in outsourcing costs has an ambiguous effect on wage inequality, and higher *tariffs* deteriorate welfare. Again, it does not include vertical specialization and the welfare effects of *offshoring* are not analyzed. In contrast, we analyze the welfare implications of foreign outsourcing. Moreover, instead of falling outsourcing costs, we focus on changes in the share of intermediate goods used in final goods production.

Our paper is organized as follows. Section 2 presents our baseline model. Section 3 extends it by endogenizing firms' outsourcing decisions. Section 4 conducts empirical analysis using Japanese data. Concluding remarks appear in Section 5.

2. Baseline Model

Consider a world of two countries, the North and the South. The North is endowed with $\bar{H}$ units of skilled workers and $\bar{L}$ units of unskilled workers, and the South with $\bar{L}^*$ units of unskilled workers. Labor is immobile across countries. Exogenous wage rigidity leads to unemployment in the South. Southern variables are given an asterisk.

Firms in the North produce the final good Y by combining a Northern and a Southern intermediate good, X and X^*; that is, our model features vertical specialization and foreign outsourcing. Thus, for the skilled wage v in the North, the unskilled wage w in the North, and the unskilled wage w^* in the South, we assume $v > w > w^*$ so that the cost of production is lower in the South. We also assume that trade in X^* is costless for simplicity.

2.1. Demand

Consumer preferences take the Blanchard and Giavazzi (2003) form:

$$U = Y = \left(M^{-\frac{1}{\sigma}} \int_{\omega \in \Omega} y(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}},$$

where ω indexes varieties, Ω is the set of varieties, $\sigma > 1$ the elasticity of substitution between varieties, and M the mass of firms. Given a budget constraint $\int_{\omega \in \Omega} p(\omega) y(\omega) d\omega = \bar{E}$, the demand for each variety is:

$$y(\omega) = \left(\frac{p(\omega)}{P} \right)^{-\sigma} \frac{\bar{E}}{PM}, \tag{1}$$

where $p(\omega)$ is the price of variety ω, $\bar{E}$ denotes aggregate expenditure, and the price index is $P = \left(M^{-1} \int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}$.

2.2. Intermediate-goods firms

Northern and Southern intermediate-goods firms maximize their profits subject to a linear production technology $X = L$ and $X^* = L^*$. Perfect competition implies:

$$q = w, \quad q^* = w^*, \tag{2}$$

where q and q^* are the price of X and X^*. We choose L^* as the numéraire; so $w^* = 1 = q^*$.

2.3. Final-goods firms

Final-goods firms are heterogeneous and indexed by their firm productivity φ. The production of final goods requires skilled workers in the North and Northern and Southern intermediate goods:[3]

$$y(\varphi) = \varphi min\{\mathscr{X}, h\}, \quad \mathscr{X} = min\left\{ \frac{x}{\alpha}, \frac{x^*}{1-\alpha} \right\}, \quad \alpha \in (0,1), \tag{3}$$

where a *decrease* in α means that a larger proportion of Southern intermediate goods is used in the production of final goods. Thus, it reflects an *increase* in outsourcing.[4] Though we take firm's outsourcing decisions as given here to derive intuitive results, in Section 3, we will endogenize the share of each intermediate good used in final goods production.

[3]An example of this production process is Toyota's cell production system, where skilled workers are essential, as manufacturing is divided into independent units and each unit is operated by a small team of highly skilled workers capable of performing multiples tasks; see Isa and Tsuru (2002).

[4]This is consistent with recent trends in Japan, where an increasing amount of intermediate goods from developing countries is used in the production of finished products such as transport aircraft, machinery, and electrical equipment.

Paying fixed costs of f units of skilled labor, each firm maximizes their profits $\pi(\varphi) = p(\varphi)y(\varphi) - (qx(\varphi) + x^*(\varphi)) - v(h(\varphi) + f)$. The optimal pricing rule is:

$$p(\varphi) = \frac{q\alpha + (1-\alpha) + v}{\rho\varphi}, \quad \rho = \frac{\sigma - 1}{\sigma} \in (0,1). \tag{4}$$

Thus, firm profits equal variable profits minus the fixed cost:

$$\pi(\varphi) = \frac{r(\varphi)}{\sigma} - vf, \tag{5}$$

where $r(\varphi) = p(\varphi)y(\varphi)$ is firm revenue. Taking stock, the relative price, output, revenue, and employment of any two firms depend solely on their relative productivities:

$$\frac{p(\varphi_1)}{p(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{-1}, \quad \frac{y(\varphi_1)}{y(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma}, \quad \frac{r(\varphi_1)}{r(\varphi_2)} = \frac{h(\varphi_1)}{h(\varphi_2)} = \left(\frac{\varphi_1}{\varphi_2}\right)^{\sigma-1}. \tag{6}$$

2.4. Productivity

Following the literature, we assume a Pareto productivity distribution; a fixed distribution $g(\varphi) = k\varphi^{-1-k}$ has a continuous cumulative distribution $G(\varphi) = 1 - \varphi^{-k}$ where we normalize the lower bound of the support to one. $k > 1$ is the shape parameter; lower k means greater dispersion in φ. We require $k > \sigma - 1$ for average firm revenue to have a finite mean.

The fixed cost in (5) implies that there is a zero-profit cutoff (ZPC) productivity φ_{min} below which firms would make negative profits if they produced:

$$r(\varphi_{min}) = \sigma v f. \tag{7}$$

Weighted-average productivity $\tilde{\varphi}$ is given by:

$$\tilde{\varphi} = \left(\int_{\varphi_{min}}^{\infty} \varphi^{\sigma-1} \frac{g(\varphi)}{1 - G(\varphi_{min})} d\varphi\right)^{\frac{1}{\sigma-1}} = \left(\frac{k}{k - (\sigma - 1)}\right)^{\frac{1}{\sigma-1}} \varphi_{min}. \tag{8}$$

We assume the exogenous number of producing firms $M = [1 - G(\varphi_{min})]\,\bar{M}$ where $\bar{M}$ is the number of potential firms. Normalizing $\bar{M} = 1$ for simplicity, we get

$$M = \varphi_{min}^{-k}. \tag{9}$$

2.5. Aggregation

In equilibrium characterized by a mass M of firms and a distribution of productivity, aggregate variables can be derived as follows. First, the price index is:

$$P = \left(M^{-1} \int_{\varphi_{min}}^{\infty} p(\varphi)^{1-\sigma} M \frac{g(\varphi)}{1 - G(\varphi_{min})} d\varphi\right)^{\frac{1}{1-\sigma}} = p(\tilde{\varphi}). \tag{10}$$

Second, using $r(\tilde{\varphi}) = (\tilde{\varphi}/\varphi_{min})^{\sigma-1} r(\varphi_{min})$ from (6), (7), (8), and $r(\tilde{\varphi}) = p(\tilde{\varphi})y(\tilde{\varphi}) = \bar{E}/M$, a ZPC productivity is:

$$\varphi_{min}^{k} = \frac{k\sigma f}{k-(\sigma-1)} \frac{v}{\bar{E}}. \tag{11}$$

Note that an increase in outsourcing (a decrease in α) leads to changes in a ZPC productivity φ_{min} through its effect on the skilled wage v. Changes in φ_{min} in turn affect key endogenous variables by altering the number of final-goods firms. Thus, as we will detail in the next section, the impact of outsourcing propagates through *reallocation effects* that are unique to models incorporating firm heterogeneity.

Third, the market clearing conditions for intermediate goods in the North and the South can, using (2), (3), (4), (8), (9), $r(\varphi) = p(\varphi)y(\varphi)$, and $r(\tilde{\varphi}) = \bar{E}/M$, be expressed as:

$$X = \int_{\varphi_{min}}^{\infty} x(\varphi) M \frac{g(\varphi)}{1-G(\varphi_{min})} d\varphi = \frac{\alpha}{\alpha w + (1-\alpha) + v} \rho \bar{E},$$

$$X^{*} = \int_{\varphi_{min}}^{\infty} x^{*}(\varphi) M \frac{g(\varphi)}{1-G(\varphi_{min})} d\varphi = \frac{1-\alpha}{\alpha w + (1-\alpha) + v} \rho \bar{E}.$$

Recalling $X = L$, the labor market clearing condition for unskilled workers in the North $L = \bar{L}$ becomes:

$$\bar{L} = \frac{\alpha}{\alpha w + (1-\alpha) + v} \rho \bar{E}. \tag{12}$$

Finally, the labor market clearing condition for skilled workers in the North is, using (3), (4), (8), (9), (12), $r(\varphi) = p(\varphi)y(\varphi)$, and $r(\tilde{\varphi}) = \bar{E}/M$:

$$\bar{H} = \int_{\varphi_{min}}^{\infty} \left(h(\varphi) + f\right) M \frac{g(\varphi)}{1-G(\varphi_{min})} d\varphi = \frac{\rho \bar{E}}{q\alpha + (1-\alpha) + v} + f\varphi_{min}^{-k}. \tag{13}$$

Rearranging (13) using (11), we obtain the skilled wage:

$$v(\alpha) = \frac{k-(\sigma-1)}{k\sigma} \frac{\bar{E}}{\bar{H} - \alpha^{-1}\bar{L}}, \tag{14}$$

where we assume $\bar{H} > \alpha^{-1}\bar{L}$ for $v(\alpha) > 0$. Note that the first term in (13) represents the variable skilled labor inputs, and the second term represents the fixed component. As the latter includes φ_{min}, this implies that outsourcing affects v through reallocation effects (see (11)).

Substituting $v(\alpha)$ given in (14) into (12) yields the unskilled wage:

$$w(\alpha) = \frac{\rho \bar{E}}{\bar{L}} - \frac{1-\alpha}{\alpha} - \frac{v(\alpha)}{\alpha}, \tag{15}$$

where we assume that the following inequality holds to ensure $v > w > 1 = w^*$:[5]

$$\frac{1+v}{\alpha} < \frac{\rho \bar{E}}{\bar{L}} < \frac{1+v+\alpha(v-1)}{\alpha}.$$

As (15) shows, an increase in outsourcing affects the unskilled wage by shifting the demand for intermediate goods from the North to the South, and through changes in v. Thus, in our framework featuring firm heterogeneity, unlike previous studies, there is a crucial interaction between w and v. This result aligns with the observation of Hummels et al. (2014) that previous theoretical studies have overlooked such interactions (recall footnote 2). As we will see below, this interaction yields several new insights.

2.6. Outsourcing and wages

We now examine the impact of outsourcing on wages. Differentiating (14) and (15) with respect to α yields

$$v'(\alpha) = \underbrace{\left(\frac{-1}{\bar{H} - \alpha^{-1}\bar{L}}\right)}_{(-)} \underbrace{\left(\frac{v(\alpha)\bar{L}}{\alpha^2}\right)}_{(+)} < 0, \tag{16a}$$

$$w'(\alpha) = \underbrace{\frac{1+v(\alpha)}{\alpha^2}}_{(+)} + \underbrace{\frac{-1}{\alpha}v'(\alpha)}_{(+)} > 0, \tag{16b}$$

where prime indicates the first-order derivative. They show that an increase in outsourcing *raises* the skilled wage but *lowers* the unskilled wage, thereby *widening* the wage gap, consistent with recent studies such as Hummels et al. (2014) and Kim and Hwang (2016). We will describe the mechanisms behind this result, starting with v and then moving to w.

An increase in outsourcing leads to a decrease in the demand for Northern intermediate goods $x(\varphi)$ and an increase in the demand for Southern intermediate goods $x^*(\varphi)$. Through (4), the former leads to a fall in $p(\varphi)$ and a rise in $y(\varphi)$, while the latter leads to a rise in $p(\varphi)$ and a fall in $y(\varphi)$. As the former dominates the latter[6], the overall demand for final goods $y(\varphi)$ increases, leading to a rise in the demand for skilled labor $h(\varphi)$ and an increase in its wage v. This effect corresponds to the first term in parentheses in (16a).

At the same time, this increase in v raises the fixed costs vf, forcing the least productive firms to exit and triggering inter-firm reallocations towards more productive firms. Therefore, both φ_{min} and $\tilde{\varphi}$ increase and M decreases (see (9)). As the rise in $\tilde{\varphi}$ leads to higher firm revenue $r(\tilde{\varphi})$, given $r(\tilde{\varphi}) = k\sigma vf/(1+k-\sigma)$, it induces a *further* increase in v. This effect corresponds to the second term in parentheses in (16a) that amplifies the impact of the first term in parentheses. Thus, an increase in outsourcing *raises* the skilled wage v by shifting demand and altering the number of firms through reallocation effects.

[5]This inequality can be derived by combining the conditions for $w > 1$ and $v > w$.

[6]This is clear from the numerator of (4): as $q = w > 1$, the first term ($q\alpha$) is more responsive than the second term $(1-\alpha)$.

Next, as an increase in outsourcing means a decline in the demand for Northern intermediate goods $x(\varphi)$, the unskilled wage w falls as reflected in the first term of (16b). Additionally, as outsourcing increases the skilled wage v, via (4), it causes $p(\varphi)$ to rise. This results in the reduced demand for $y(\varphi)$ and subsequently decreases $x(\varphi)$ and the demand for unskilled labor. Thus, the unskilled wage w further falls, corresponding to the second term in (16b). Therefore, an increase in outsourcing *lowers* the unskilled wage w as these two distinct channels outweigh the upward pressure on w arising from the initial increase in the overall demand for $y(\varphi)$ that raises the demand for unskilled labor discussed above.

2.7. Welfare

Before endogenizing firm's outsourcing decisions, we examine the welfare implications of outsourcing in our baseline model. Using the utility function along with (4), (8), (11), (15), (16b), $r(\varphi) = p(\varphi)y(\varphi)$, and $r(\tilde{\varphi}) = \bar{E}/M$, we find

$$U = \left(M^{-\frac{1}{\sigma}} \int_{\varphi_{min}}^{\infty} y(\varphi)^{\frac{\sigma-1}{\sigma}} M \frac{g(\varphi)}{1 - G(\varphi_{min})} d\varphi \right)^{\frac{\sigma}{\sigma-1}} = \left[\frac{k}{k - (\sigma - 1)} \right]^{\frac{1}{\sigma-1}} \bar{L} \frac{\varphi_{min}}{\alpha},$$

so that an increase in outsourcing improves welfare:

$$\frac{1}{U}\frac{\partial U}{\partial \alpha} = \underbrace{-\frac{1}{\alpha}}_{(-)} + \underbrace{\frac{v'(\alpha)}{kv(\alpha)}}_{(-)} < 0. \tag{17}$$

This result can be explained as follows: first, an increase in outsourcing decreases the demand for $x(\varphi)$. This decrease in demand causes their prices q to fall and in turn triggers an overall increase in the demand for intermediate goods. As the demand for $y(\varphi)$ also rises, consumption increases and welfare improves. This effect is reflected in the first term of (17). Second, the initial decline in the demand for $x(\varphi)$ reduces the overall cost of acquiring these goods. This weakens the demand for $y(\varphi)$. Thus, $p(\varphi)$ falls, increasing their demand. This rise in demand also leads to an increase in the demand for $h(\varphi)$, raising v. As this increase reflects higher fixed costs, φ_{min} rises, further lowering $p(\varphi)$. This results in an increase in the demand for and consumption of final goods and improves welfare, as reflected in the second term of (17). Therefore, an increase in outsourcing *improves* welfare by shifting demand and raising average productivity $\tilde{\varphi}$.

Our findings in this section can be summarized as follows:

Proposition 1. *An increase in outsourcing: (i) raises the skilled wage due to shifting demand and reallocation effects, (ii) lowers the unskilled wage due to shifting demand and the increase in the skilled wage, (iii) widens the wage gap, and (iv) improves welfare.*

Using our simple and tractable baseline model, we have demonstrated the impact of outsourcing on skilled and unskilled wages, wage inequality, and welfare with strong intuition and in closed form. In this model, however, the most important element—firms' outsourcing decisions—is exogenous, and the derived results might be too simplified to fully explain the mixed findings on wage effects of outsourcing in the literature. Therefore, in the next section, we endogenize firms' outsourcing decisions and further explore the impact of outsourcing.

3. Extensions

We now extend our baseline model by endogenizing firms' outsourcing decisions, while keeping the other elements unchanged. This extended model generates several theoretical insights that we will empirically test in Section 4.

3.1. Endogenous outsourcing

Final-goods firms in the North now engage in a two-stage optimization process. First, they determine the quantity of intermediate goods to use to minimize their procurement costs. Following this, they set the optimal price to maximize their profits.

By solving the following cost minimization problem:

$$\min_{x(\varphi),x^*(\varphi)} qx(\varphi) + x^*(\varphi), \quad \text{s.t.} \;\; y(\varphi) = \varphi x(\varphi)^{\alpha} x^*(\varphi)^{1-\alpha},$$

we derive the demand for Northern and Southern intermediate goods:

$$x(\varphi) = \frac{\alpha}{A} q^{\alpha-1} \frac{y(\varphi)}{\varphi}, \quad x^*(\varphi) = \frac{1-\alpha}{A} q^{\alpha} \frac{y(\varphi)}{\varphi}, \quad A \equiv \alpha^{\alpha}(1-\alpha)^{1-\alpha} \in (0,1). \tag{18}$$

The firms then maximize their profit $\pi(\varphi) = p(\varphi)y(\varphi) - (qx(\varphi) + x^*(\varphi)) - v\,(h(\varphi) + f)$ subject to (1), (3), and (18). The new optimal pricing rule is:

$$p(\varphi) = \frac{A^{-1}q^{\alpha} + v}{\rho\varphi}. \tag{19}$$

Comparing the numerator of (19) with that of (4), notice that in this extended model, the term $q\alpha + (1-\alpha)$ has been replaced by $A^{-1}q^{\alpha}$. Thus, the impact of outsourcing on key endogenous variables is expected to be more pronounced through changes in the price of final goods $p(\varphi)$ than in the baseline model. In particular, when the initial demand shift induces the *decrease* in the overall demand for final goods $y(\varphi)$, the results of the baseline model are partially overturned and an increase in outsourcing may differently affect key variables such as v, w, φ_{min} and M. Below, we will provide further intuition for this possibility with the aid of a numerical example.

The derivation of v and w now requires (19), so they must be revised. First, given $X = L$, the market clearing conditions for intermediate goods in the North and the South yields:

$$X = \int_{\varphi_{min}}^{\infty} x(\varphi) M \frac{g(\varphi)}{1 - G(\varphi_{min})} d\varphi = \frac{\alpha A^{-1} q^{\alpha-1}}{A^{-1}q^{\alpha} + v} \rho \bar{E}, \tag{20}$$

$$X^* = \int_{\varphi_{min}}^{\infty} x^*(\varphi) M \frac{g(\varphi)}{1 - G(\varphi_{min})} d\varphi = \frac{(1-\alpha) q^{\alpha-1}}{q^{\alpha} + Av} \rho \bar{E}.$$

Next, from the labor market clearing condition for skilled workers in the North

$$\bar{H} = \int_{\varphi_{min}}^{\infty} (h(\varphi) + f)\, M \frac{g(\varphi)}{1 - G(\varphi_{min})} d\varphi = \frac{\rho \bar{E}}{A^{-1} q^{\alpha} + v} + fM,$$

we obtain:

$$\bar{H} = \frac{\rho \bar{E}}{A^{-1} q^{\alpha} + v} + \frac{k - (\sigma - 1)}{k\sigma} \frac{\bar{E}}{v}. \tag{21}$$

Equations (20), (21), and $L = \bar{L}$ then yield the following pair of equations:

$$v(w;\alpha) = \frac{k - (\sigma - 1)}{k\sigma} \bar{E} \left(\bar{H} - \frac{A}{\alpha} w^{1-\alpha} \bar{L} \right)^{-1}, \tag{22a}$$

$$\left(Avw^{1-\alpha} + w \right)^{-1} \alpha \rho \bar{E} = \bar{L}, \tag{22b}$$

where we assume $\bar{H} > \left(Aw^{1-\alpha} \bar{L} / \alpha \right)$ for $v > 0$.

3.2. Preliminaries

Before performing comparative statics, we examine the essential properties of the above pair of equations. First, (22a) shows that v is a function of w:

$$v(w) = \beta \left(\bar{H} - \alpha^{-1} A w^{1-\alpha} \bar{L} \right)^{-1}, \quad \beta \equiv \frac{k - (\sigma - 1)}{k\sigma} \bar{E} > 0.$$

Thus, we can confirm the following:

$$v'(w) = \bar{L} \frac{v^2}{\beta} \frac{A}{\alpha} (1 - \alpha) w^{-\alpha} > 0, \tag{23a}$$

$$v''(w) = \alpha \frac{v'(w)}{w} \left(\frac{2wv'(w)}{\alpha v} - 1 \right), \tag{23b}$$

$$\lim_{w \to 0} v(w) = \frac{\beta}{\bar{H}} > 0, \quad v(1) = \frac{\beta}{\bar{H} - \alpha^{-1} A \bar{L}} > 0, \tag{23c}$$

where primes ($''$) indicate the second-order derivative. (23a) tells that v is increasing in w. As (23b) tells, the sign of $v''(w)$ is indeterminate. For reasons that will be clear below, we assume the following holds:

$$\frac{2wv'(w)}{\alpha v} = \underbrace{\frac{\bar{L}}{\beta} \frac{1 - \alpha}{\alpha}}_{(\gtreqless 1)} \underbrace{A}_{(<1)} \underbrace{\frac{2vw^{1-\alpha}}{\alpha}}_{(>1)} < 1, \tag{24}$$

so that $v(w)$ is a decreasing function. This condition is likely to hold when the constant $\bar{L}(1 - \alpha)A/\beta\alpha$ is sufficiently less than 1. (23c) then says that, as $\alpha^{-1} A \bar{L} > 0$, $v(1)$ is larger than $\lim_{w \to 0} v(w)$.

Next, we consider the condition for a unique real solution for $w > 1$. From (22b), we define the excess demand function for the unskilled labor market:

$$\mathcal{W}(w) = \left(Avw^{1-\alpha} + w\right)^{-1} - \gamma, \quad \gamma \equiv \frac{\bar{L}}{\alpha\rho\bar{E}} > 0.$$

Then, we have

$$\mathcal{W}'(w) = -\frac{Aw^{1-\alpha}\left(v'(w) + (1-\alpha)\frac{v}{w}\right) + 1}{\left(Avw^{1-\alpha} + w\right)^2} < 0, \tag{25a}$$

$$\mathcal{W}''(w) = \frac{\overbrace{2\left(Aw^{1-\alpha}\left(v'(w) + (1-\alpha)\frac{v}{w}\right) + 1\right)^2}^{(+)}}{\underbrace{\left(Avw^{1-\alpha} + w\right)^3}_{(+)}} - \frac{\overbrace{Aw^{1-\alpha}v''(w)}^{(-)} + \overbrace{A(1-\alpha)w^{-\alpha}}^{(+)}\left(2v'(w) - \alpha\frac{v}{w}\right)}{\underbrace{\left(Avw^{1-\alpha} + w\right)^2}_{(+)}}, \tag{25b}$$

$$\mathcal{W}(1) = \frac{1 - \gamma\left(v(1)A + 1\right)}{v(1)A + 1}, \tag{25c}$$

with limits $\lim_{w\to 0}\mathcal{W}(w) = \infty$ and $\lim_{w\to\infty}\mathcal{W}(w) = -\gamma$. (25a) tells that $\mathcal{W}(w)$ is decreasing in w. Though the sign of (25b) is indeterminate, under condition (24), the numerator in the second term becomes negative, ensuring $\mathcal{W}''(w) > 0$. The sign of (25c) is also indeterminate. As the condition for the unique real solution for $w > 1$ boils down to $\mathcal{W}(1) > 0$, we assume the following inequality:

$$1 > \gamma\left(\frac{A\beta}{\bar{H} - \alpha^{-1}A\bar{L}} + 1\right).$$

This is likely to hold when γ is sufficiently small − for example, when the aggregate expenditure $\bar{E}$ is sufficiently large. From these properties and assumptions, the $\mathcal{W}(w)$ function

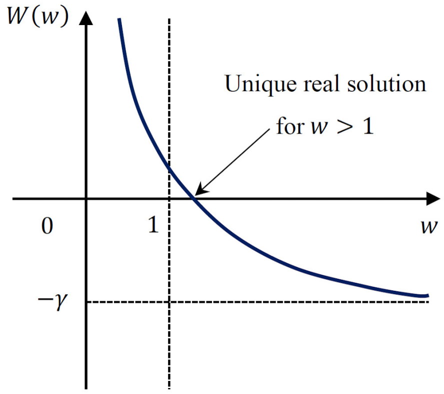

Figure 2: The existence and uniqueness of the unskilled wage $w > 1$.

can be drawn as in Figure 2.

Finally, we assume the condition for $v > w$:

$$v = \frac{\beta}{\bar{H} - \alpha^{-1} A w^{1-\alpha} \bar{L}} > w.$$

3.3. Endogenous outsourcing and wages

We now analyze the impact of outsourcing on wages in the extended model. Differentiating equations (22a) and (22b) with respect to α yields (see Appendix A for details)

$$\frac{dv(\alpha)}{d\alpha} = \underbrace{-\frac{1}{\Delta}\bar{L}\frac{v^2}{\beta}\frac{A}{\alpha}w^{1-\alpha}}_{(-)} \left(\underbrace{1 + \ln w}_{(+)} - \underbrace{\frac{1}{A}\frac{\partial A}{\partial \alpha}}_{(?)} \right) \gtreqless 0, \tag{26a}$$

$$\frac{dw(\alpha)}{d\alpha} = \underbrace{\frac{1}{\Delta}}_{(+)} \left(\underbrace{\frac{w}{\alpha}}_{(+)} + \underbrace{v w^{1-\alpha} A \left(1 + \bar{L}\frac{v}{\beta}\frac{A}{\alpha}w^{1-\alpha}\right)}_{(+)} \underbrace{\left(\left(\frac{1}{\alpha} + \ln w\right) - \frac{1}{A}\frac{\partial A}{\partial \alpha} \right)}_{(?)} \right) \gtreqless 0, \tag{26b}$$

where

$$\frac{dv(\alpha)}{d\alpha} \begin{cases} < 0 & \text{if } \alpha \in \left(0, \frac{1}{2}\right) \\ \gtreqless 0 & \text{if } \alpha \in \left(\frac{1}{2}, 1\right) \end{cases}, \quad \frac{dw(\alpha)}{d\alpha} \begin{cases} > 0 & \text{if } \alpha \in \left(0, \frac{1}{2}\right) \\ \gtreqless 0 & \text{if } \alpha \in \left(\frac{1}{2}, 1\right) \end{cases},$$

and $\Delta \equiv vA(1-\alpha)w^{-\alpha} + 1 + \frac{\bar{L}}{\alpha\beta}(vA)^2(1-\alpha)w^{1-2\alpha}$. As (26a) and (26b) indicate, in sharp contrast to the baseline model, an increase in outsourcing *raises or lowers* skilled and unskilled wages, and *widens or narrows* wage inequality. This is the consequence of firms' *endogenous* outsourcing decisions − particularly the new demand for intermediate goods (18) and the revised optimal pricing rule (19). Moreover, the wage impact of outsourcing turns out to depend critically on the *initial level* of outsourcing; when an industry's initial degree of outsourcing is low ($\alpha \in (1/2, 1)$), an increase in outsourcing raises or lowers both skilled and unskilled wages, while when an industry's initial degree of outsourcing is high ($\alpha \in (0, 1/2)$), an increase in outsourcing unambiguously lowers w and raises v, as in the baseline model.

At this point, a small numerical example will be helpful to visually represent our results, reinforce the intuition, and confirm whether there exist parameter configurations that satisfy the set of conditions and assumptions we have made so far.

3.4. Numerical example

To achieve these goals, we present a small numerical example. We set $k = 3.4$, $\sigma = 3.8$, and $f = 0.10$ based on Bernard et al. (2007). For factor endowments ($\bar{H}$ and $\bar{L}$) and $\bar{E}$, we arbitrarily choose $\bar{H} = 100$, $\bar{L} = 95$, and $\bar{E} = 1500$, solely for *illustrative* purposes. Thus, this is *not* a serious calibration.

Figure 3 displays the impact of outsourcing on unskilled wage w (a), skilled wage v (b), a ZPC productivity φ_{min} (c), the number of firms M (d), firm revenue $r(\tilde{\varphi})$ (e), welfare U (f)[7], and wage inequality v/w (g). First, lines in Figure 3 confirm that there exist parameter configurations that satisfy the conditions for $v > w > 1$. Though this condition is the result of several assumptions and might seem impossible to satisfy, Figure 3 shows that it is not too restrictive; our theoretical predictions are not confined to the narrow set of parameters.

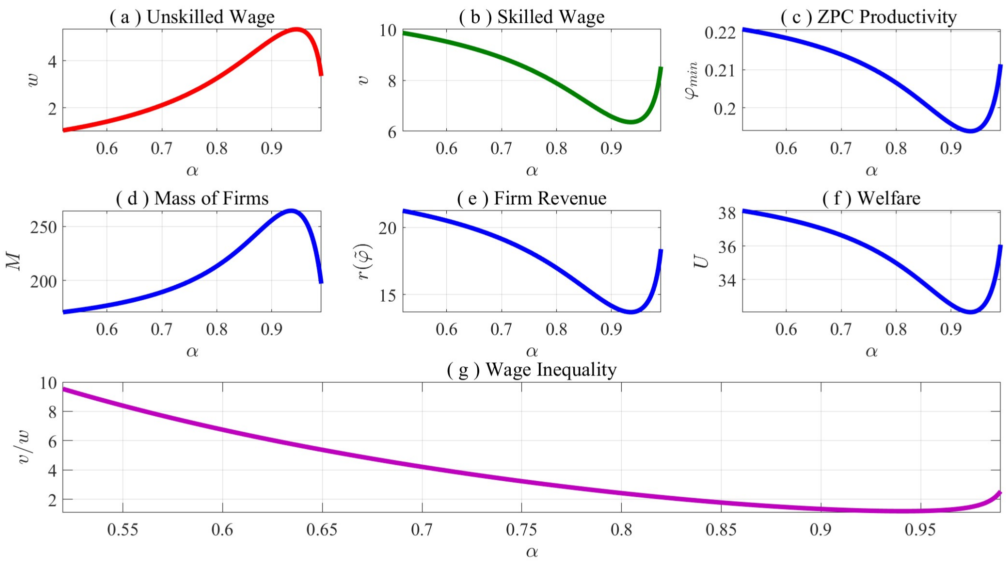

Figure 3: The impact of outsourcing on key variables.

Second, panel (a) shows that the relationship between w and the degree of outsourcing α is *inverted U-shaped*; initially, an increase in outsourcing *raises* w. After a certain point, however, this effect reverses, and further outsourcing reduces w. Panel (b) illustrates that the relationship between v and α is *U-shaped*; initially, an increase in outsourcing *lowers* v, but beyond a certain threshold, the effect reverses, and further outsourcing raises v. Thus, as panel (g) shows, the relationship between wage inequality v/w and α is also U-shaped, offering a contrast to the findings of Acemoglu et al. (2015). Consistent with our analytical predictions, this small numerical example highlights the critical role of the *initial value* of α; the impacts of outsourcing on wages and wage inequality depend significantly on initial industry-level differences in the extent of outsourcing.

The remaining panels help to explain why. When α is far from 1, the intuition mirrors that in Section 2. When α is near 1, however, due to the revised optimal pricing rule (4), an increase in outsourcing leads to a *decrease* in the overall demand for $y(\varphi)$. As a result, the demand for skilled worker and thus v falls. This reduces fixed costs vf and lowers φ_{min}

[7]See Appendix B for the results on welfare.

(panel (c)), increases M (panel (d)), and decreases $r(\tilde{\varphi})$ (panel (e)). This leads to a further decrease in v (panel (b)).

A decrease in v, via (4), lowers $p(\varphi)$, raises the demand for $y(\varphi)$ and the demand for $x(\varphi)$. This stimulates the demand for unskilled labor, and as long as this force dominates the downward pressure on w from other forces, an increase in outsourcing raises w (panel (a)). Thus, the combined effects of a falling v and rising w lead to the initial narrowing of wage inequality v/w shown in panel (g). This explains why the impact of outsourcing on wages and wage inequality differs depending on the initial value of α in the extended model.

Our findings in this section can be summarized as follows:

Proposition 2. *In the extended model, an increase in outsourcing: (i) raises or lowers skilled and unskilled wages, (ii) widens or narrows wage inequality, (iii) improves or deteriorates welfare. The impact of outsourcing depends on the initial level of outsourcing.*

Equipped with a rich set of theoretical predictions and the corresponding intuition, in Section 4, we evaluate them using Japanese data.

4. Empirical Estimation

This section empirically tests the theoretical insights developed in the previous sections using two Japanese datasets covering the period from 2001 to 2017. The offshoring data come from the *Basic Survey of Japanese Business Structure and Activities*. It covers firms with 50 or more employees and paid-up capital exceeding 30 million yen. This dataset provides industry-level information used to construct our offshoring measure (α in our theoretical framework). The data on the college premium data are from the *Basic Survey on Wage Structure*. It contains wage information across major industries. We use this dataset to calculate the wage gap between skilled and unskilled workers (v/w in our theoretical framework). We focus on the manufacturing sector.[8]

We regress wage inequality on offshoring. The wage gap is the relative difference in wages between male university graduates and male high school graduates aged 25 to 30 and illustrated in Figure 1. The offshoring measure (α_{it}) is calculated as:

$$\alpha_{it} = 1 - \kappa_{it},$$

where κ_{it} is the share of imports from unaffiliated firms in total procurement costs. The average α_{it} across 13 industries is shown in Figure 1. We index industries by i and years by t.

[8] The following industries are included: Textile; Wood, Paper, and Pulp; Publishing and Printing; Chemical; Petroleum and Coal Products; Rubber Products; Ceramics and Stone; Iron and Steel; Non-Ferrous Metals; Metal Products; General Machinery; Electrical Machinery; Transport Machinery; Food Manufacturing; and Other Manufacturing Industries.

4.1. Baseline estimation

To examine the impact of offshoring on wage inequality, we estimate the following regression:

$$ln\,(v/w)_{it} = \mu_i + \lambda_t + \vartheta\alpha_{it} + \mathbf{Z_{it}\Gamma} + \epsilon_{it}, \tag{27}$$

where $ln\,(v/w)_{it}$ is the log wage gap, μ_i are industry fixed effects, λ_t are time fixed effects, ϵ_{it} is a residual, and $\mathbf{Z}_{it}$ is a vector of control variables that includes average total factor productivity and the ratio of skilled to unskilled workers in the industry. The sign of ϑ is of our main interest.

One potential concern is endogeneity: the wage gap may be driven not only by offshoring but also by the supply and demand in the labor market. To address this, we follow Topalova (2010) and use an interaction term between the initial (2001) ratio of skilled to unskilled workers and a year dummy as an instrument.

In Table 1, we report the estimation results for (27). In the first column, after controlling for the ratio of skilled to unskilled workers, we find negative and statistically significant ϑ (at the 10% level), indicating that increased outsourcing *widens* wage inequality—consistent with previous studies and our baseline model's prediction. The second column shows a similar result after controlling for industry GDP and average productivity.

The estimates in the first two columns do not account for differences in industry size. Thus, industries with smaller workforces may be overrepresented in the results, while those with larger workforces may be underrepresented. To address this, we weight the regressions by industry employment size, using the number of workers in each industry in 2000 as weights.[9] The third and fourth columns reflect this weighted specification. We now find ϑ becomes statistically significant at the 5% level, and its magnitude increases compared to the unweighted estimates. Thus, the empirical findings from our baseline estimation are consistent with previous studies and with the prediction of our baseline model: increased outsourcing also *widens* wage inequality in Japan.

4.2. Applied estimation

A key prediction of our extended model is that the *initial* level of outsourcing matters: the impact of outsourcing on wage inequality may differ depending on whether an industry initially had a high or low degree of outsourcing. Therefore, we now estimate the following regression that applies this theoretical insight:

$$ln\,(v/w)_{it} = \mu_i + \lambda_t + \vartheta\alpha_{it} + \delta\alpha_{it}\zeta_{initial} + \mathbf{Z_{it}\Gamma} + \epsilon_{it}, \tag{28}$$

where $\zeta_{initial}$ is a dummy variable equal to 1 if, in 2001, an industry's α falls in the 75th quartile; that is, if the industry had a low degree of outsourcing at the outset. Accordingly, in (28), the coefficient of interest is δ and we report the estimation results in Table 2.

[9] In weighting, we use data from one year prior to the analysis period to avoid endogeneity concerns. The Basic Survey of Japanese Business Structure and Activities also covers the year 2000.

Table 1: Results of Baseline Estimation

	(1)	(2)	(3)	(4)
α	-1.576*	-1.573*	-2.591**	-2.317**
	(0.799)	(0.802)	(1.065)	(1.051)
Industry GDP		-0.000635		-0.000967
		(0.000667)		(0.000669)
Average TFP		0.00866		-0.0327
		(0.0772)		(0.0809)
initial_LR_YD2001	0.240**	0.240**	0.110	-0.0179
	(0.120)	(0.118)	(0.127)	(0.127)
initial_LR_YD2002	0.159	0.160	0.135	0.0216
	(0.120)	(0.118)	(0.126)	(0.125)
initial_LR_YD2003	0.335***	0.337***	0.184	0.0921
	(0.120)	(0.118)	(0.126)	(0.124)
initial_LR_YD2004	0.218*	0.219*	0.176	0.100
	(0.120)	(0.118)	(0.126)	(0.123)
initial_LR_YD2005	0.263**	0.265**	0.368***	0.307**
	(0.120)	(0.118)	(0.126)	(0.123)
initial_LR_YD2006	0.298**	0.302**	0.268**	0.216*
	(0.120)	(0.119)	(0.127)	(0.123)
initial_LR_YD2007	0.290**	0.293**	0.292**	0.250**
	(0.120)	(0.118)	(0.126)	(0.122)
initial_LR_YD2008	0.147	0.142	0.168	0.134
	(0.120)	(0.119)	(0.126)	(0.124)
initial_LR_YD2009	0.241**	0.229*	0.115	0.0909
	(0.120)	(0.119)	(0.125)	(0.122)
initial_LR_YD2010	0.104	0.0960	-0.0787	-0.0955
	(0.120)	(0.118)	(0.125)	(0.122)
initial_LR_YD2011	0.184	0.180	0.00302	-0.00393
	(0.120)	(0.118)	(0.125)	(0.122)
initial_LR_YD2012	0.153	0.151	-0.114	-0.113
	(0.120)	(0.118)	(0.125)	(0.122)
initial_LR_YD2013	0.154	0.160	-0.0594	-0.0605
	(0.120)	(0.118)	(0.125)	(0.121)
initial_LR_YD2014	0.0101	0.0157	-0.0856	-0.0857
	(0.120)	(0.118)	(0.125)	(0.121)
initial_LR_YD2015	0.146	0.146	-0.0808	-0.0795
	(0.120)	(0.118)	(0.125)	(0.121)
initial_LR_YD2016	0.118	0.117	0.0349	0.0346
	(0.120)	(0.118)	(0.126)	(0.121)
Year FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
Constant	2.469***	2.531***	3.521***	3.462***
	(0.782)	(0.828)	(1.032)	(1.040)
Observations	221	221	221	221
R^2	0.374	0.402	0.498	0.538
Number of industries	13	13	13	13

Notes: Standard errors in parentheses. α is the offshoring measure, and `initial_LR_YD` denotes the interaction terms between the initial (2001) ratio of skilled to unskilled workers and a year dummy. Estimates in the third and fourth columns account for weights based on industry employment size.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table 2: Results of Applied Estimation

	(1)	(2)
α	-2.383**	-2.271**
	(1.066)	(1.058)
$\zeta_{initial}$	2.471*	0.716
	(1.465)	(1.510)
Industry GDP		-0.000934
		(0.000674)
Average TFP		-0.0325
		(0.0811)
initial_LR_YD2001	0.0942	-0.0169
	(0.126)	(0.127)
initial_LR_YD2002	0.120	0.0219
	(0.125)	(0.125)
initial_LR_YD2003	0.171	0.0922
	(0.125)	(0.124)
initial_LR_YD2004	0.162	0.0992
	(0.126)	(0.124)
initial_LR_YD2005	0.353***	0.306**
	(0.126)	(0.123)
initial_LR_YD2006	0.255**	0.214*
	(0.126)	(0.123)
initial_LR_YD2007	0.281**	0.249**
	(0.125)	(0.122)
initial_LR_YD2008	0.155	0.132
	(0.126)	(0.124)
initial_LR_YD2009	0.110	0.0907
	(0.125)	(0.123)
initial_LR_YD2010	-0.0889	-0.0975
	(0.125)	(0.122)
initial_LR_YD2011	0.00245	-0.00361
	(0.125)	(0.122)
initial_LR_YD2012	-0.115	-0.113
	(0.125)	(0.121)
initial_LR_YD2013	-0.0614	-0.0609
	(0.125)	(0.121)
initial_LR_YD2014	-0.0850	-0.0855
	(0.125)	(0.121)
initial_LR_YD2015	-0.0807	-0.0794
	(0.125)	(0.121)
initial_LR_YD2016	0.0311	0.0335
	(0.125)	(0.122)
Year FE	YES	YES
Industry FE	YES	YES
Constant	2.542**	3.185***
	(1.180)	(1.195)
Observations	221	221
R^2	0.506	0.539
Number of industries	13	13

Notes: Standard errors in parentheses. α is the offshoring measure, $\zeta_{initial}$ is a dummy variable equal to 1 if, in 2001, an industry's α falls in the 75th quartile, and `initial_LR_YD` denotes the interaction terms between the initial (2001) ratio of skilled to unskilled workers and a year dummy. Estimates account for weights based on industry employment size.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

In the first column, we find *positive* and statistically significant δ (at the 10% level). This result suggests that, in industries with initially low levels of outsourcing, an increase in outsourcing *narrows* wage inequality. In the second column where we control for industry GDP and average productivity, though the coefficient becomes insignificant, it remains positive. Thus, *missing initial industry-level differences in outsourcing may be one potential reason why the literature has yet to reach a consensus on the relationship between offshoring and wage inequality.*

Our findings in this section can be summarized as follows:

Proposition 3. *In the baseline estimation that treats industries symmetrically, an increase in outsourcing widens wage inequality, consistent with previous studies and our baseline model. In contrast, in the applied estimation that takes initial industry-level differences in the extent of outsourcing into account, increased outsourcing narrows wage inequality.*

Therefore, although our empirical analysis is based on Japanese data, our results might apply to a broader set of countries; for example, taking initial industry-level differences in outsourcing into account could *overturn* previous findings in the U.S. and Denmark, where offshoring is generally found to *widen*, not *narrow*, wage inequality. This insight is worth testing for the literature to move toward a consensus.

5. Concluding Remarks

Does offshoring widen or narrow wage inequality? To answer this question, we have developed a tractable North-South model featuring firm heterogeneity, foreign outsourcing, and vertical specialization. In the baseline model with exogenous firms' outsourcing decisions, we have shown that an increase in outsourcing raises skilled wages through shifting demand and reallocation effects, lowers unskilled wages due to shifting demand and rising skilled wages, widens wage inequality, and improves welfare. In the extended model with endogenous firms' outsourcing decisions, however, an increase in outsourcing *raises or lowers* skilled and unskilled wages, *widens or narrows* wage inequality, and *improves or deteriorates* welfare, depending critically on the *initial level* of outsourcing in each industry.

Using Japanese data, we then provide empirical evidence that, in contrast to most findings from the U.S., once we account for *initial industry-level differences* in the degree of outsourcing, it instead *narrows* wage inequality. Therefore, our results suggest that when designing policies to promote outsourcing, it is crucial to carefully consider which industries started with high or low levels of outsourcing; otherwise, such policies may lead to unintended consequences for wages and wage inequality.

Appendix A. Stability

This Appendix proves the stability of the system consisting of (22a) and (22b). Differentiating with respect to α, we can express them in the matrix form:

$$\begin{pmatrix} J_{11} & J_{12} \\ J_{21} & J_{22} \end{pmatrix} \begin{pmatrix} dv \\ dw \end{pmatrix} = \begin{pmatrix} S_1 \\ S_2 \end{pmatrix} d\alpha,$$

where $J_{11} = -1$, $J_{12} = \bar{L}\frac{v^2}{\beta}\frac{A}{\alpha}(1-\alpha)w^{-\alpha} > 0$, $J_{21} = -w^{1-\alpha}A < 0$, $J_{22} = -\left((1-\alpha)Avw^{-\alpha} + 1\right) < 0$, and

$$S_1 = \underbrace{\bar{L}\frac{v^2}{\beta}\frac{A}{\alpha}w^{1-\alpha}}_{(+)}\left(\underbrace{\ln w + \frac{1}{\alpha}}_{(+)} - \underbrace{\frac{1}{A}\frac{\partial A}{\partial \alpha}}_{(?)}\right) \gtreqless 0, \;\; S_2 = -\left[\underbrace{\frac{w}{\alpha} + Avw^{1-\alpha}\left(\frac{1}{\alpha} + \ln w\right)}_{(+)} - \underbrace{vw^{1-\alpha}\frac{\partial A}{\partial \alpha}}_{(?)}\right] \gtreqless 0.$$

As the trace and determinant of the Jacobian matrix are $TrJ = J_{11} + J_{22} < 0$ and $DetJ \equiv \Delta = J_{11}J_{22} - J_{12}J_{21} > 0$, the system is stable.

Appendix B. Welfare

This Appendix analyzes welfare in the extended model. It is given by:

$$U = \left(\frac{k}{k-(\sigma-1)}\right)^{\frac{1}{\sigma-1}} \bar{L}\frac{A}{\alpha}w^{1-\alpha}\varphi_{min},$$

so that

$$\frac{1}{U}\frac{dU}{d\alpha} = \underbrace{-\left(\frac{1}{\alpha} + \ln w\right)}_{(-)} + \underbrace{\ln\frac{\alpha}{1-\alpha}}_{(?)} + \underbrace{\frac{1-\alpha}{w}w'(\alpha)}_{(?)} + \underbrace{\frac{1}{kv}v'(\alpha)}_{(?)} \gtreqless 0.$$

That is, an increase in outsourcing may deteriorate welfare. Note that the last term arises from the reallocation effect.

Conflict of Interest

The authors have declared no conflict of interest.

Data Availability Statement

The research data are not publicly available and therefore are not shared.

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