Research on Firms' International Activity and Labor Share

BY

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Contents

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Chapter 1 Introduction

1. Research background and purpose

The 1990s and 2000s were eras of expansion in trade and foreign direct investment (FDI) worldwide and of the fragmentation of the production process due to the development of information and communication technology. This period observed tariff reduction and improvement in the investment environment because of bilateral or plurilateral free trade agreements. According to the World Bank's "World Integrated Trade Solution" database, the value of global trade expanded 11.2 times from 1,347.8 billion USD in 1990 to 15,162.2 billion USD in 2010, and the amount of FDI flow increased 6.7 times from 204.9 billion USD in 1990 to 1,365.1 billion USD in 2010. This expansion in trade and FDI, along with the widespread offshoring, reflects the diffusion of the cross-border fragmentation of production processes aiming for optimization, resulting in firms procuring their intermediaries, as exemplified by a famous case study of iPod in Dedrick, Kramer, and Linden (2010).

While the degree of interdependence in the world economy deepened during this period, the primary players were private firms. Therefore, in the field of international economics, the international activities of firms have been the focus of many researchers.

National- or industrial-level data have typically been used to conduct empirical research on international economics. However, in the middle 1990s, researchers had access to firm- or business-level micro data in public statistics in some countries. After the study of Bernard and Jensen (1995), the use of data from firms or business establishments in international economics research has increased exponentially. The first popular research was conducted to elucidate the distribution and characteristics of international firms that export or undertake FDI.[1] Traditional trade theories assume that firms within an industry are homogeneous; however, empirical studies using firm-level data have rejected this hypothesis. As revealed by Mayer and Ottaviano (2007) and Wakasugi et al. (2008), extremely limited number of firms engage in international activities, whereas many other firms do not directly engage in international activities. Moreover, on average, few international firms are more productive and have larger employee and sales than non-international firms. Melitz (2003) proposed a trade theory on the heterogeneity of firms, which is now widely used as a standard trade theory worldwide.

In the 2000s international economists focused on the causal relationship between firms' international activities and productivity and have presented two hypotheses: The "self-selection" hypothesis, which states that a highly productive firm starts to export,

[1] The early studies include Bernard and Jensen (1995 and 1999), Bernard and Wagner (2001) and Wagner (1995).

and the “learning by exporting” hypothesis, which states that the productivity of a firm improves by exports. Numerous researchers have examined these two hypotheses. As summarized in the study of Wagner (2007), the self-selection hypothesis has been confirmed in many studies, whereas not all studies have observed the significant effect of learning by exporting on firms.

Furthermore, in the 2010s, the scope of the analysis expanded to the relationship between the international activities of firms and variables other than productivity:. In particular, variables related to labor input, such as labor share and wages, has been the focus of international economists in the boom of anti-globalism claims that are gaining political support in various countries, including the United Stated and United Kingdom. In Japan, the claims of protectionists have not received wide support, and studies on these claims are limited. However, the recent trend of protectionism in other countries suggests that liberal policies will fail if they do not have public support. Therefore, based on Japan’s trade policy, the quantitative analysis of how the international activities of firms affect workers is necessary. Thus, this dissertation analyzes the impact of the international activities of Japanese firms on employees in the manufacturing sector, which is highly affected by globalization.

2. Structure of the dissertation

This doctoral dissertation is structured as follows:

(1) Chapter 2 A Microeconomic Analysis of the Declining Labor Share in Japan

This chapter analyzes the impact of the international activities of firms in the Japanese manufacturing sector on the labor share. A long-term downward trend in labor share has been prominent since the 1990s, particularly in developed countries (International Labour Organization and Organization for Economic Cooperation and Development, 2015). Since a labor share is a ratio of a firm's value added to payment for its employees, its downward trend (i.e., an increasing capital share) indicates a widening income inequality between households depending on wages for income (particularly middle- and low-income households) and those with capital income. Therefore, many studies on macroeconomic levels have examined the determinants of the trend. Some of the studies report economic globalization as a factor contributing to the long-term downward trend in the labor share. For example, Hijzen and Swaim (2010) emphasized the impact of expanding labor-intensive processes overseas, and Abraham et al. (2009) emphasized the impact of importing labor-intensive goods from low-income countries.

Although a labor share is determined at the micro level of firms, studies primarily from Europe started using firm-level data for analysis, for example: Bockerman and Maliranta (2012) and Perugini et al. (2017). In Japan, few studies have conducted the empirical analysis of the labor share.

In this chapter, the panel data on the manufacturing sector from the "Basic Survey of Japanese Business Structure and Activities" (the JBSA survey) implemented by the Ministry of Economy, Trade, and Industry (METI) were used to analyze the effect of the international activities of firms, such as the expansion of overseas activity (both exports and imports) and other factors affecting their labor share.

Regarding the determinants of the labor share of a firm, Bentolila and Saint-Paul (2003) and Fukao and Perugini (2021) have made theoretical considerations based on a production function and revealed that a labor share is a function of a capital–output ratio. Based on the theory, the proposed labor share function was estimated; the significant effect of the dummy variables indicating the effect of firms' export and overseas subsidiaries on the labor share were not observed. However, the ratio of exports to sales and that of overseas subsidiaries to domestic employees reduce the labor share. The results suggest that when the scale of a firm's exports and international activities exceed a certain threshold, the mechanism of comparative advantage, offshoring or imperfect competition works to lower the labor share.

(2) Chapter 3. Wage Premium of Exporting Plants in Japan: An Analysis of Matched Employer–Employee Data

According to the analysis results in Chapter 2, exporting firms have less labor share than non-export firms. However, since Bernard and Jensen (1995) many empirical studies found that the average wage of exporting firms is statistically significantly higher than that of non-exporting firms in both developed and developing countries. The difference in average wages is termed the "wage premium of exporting firms" and has been observed in Japan as well; this finding seems to be inconsistent with the low labor share of exporting firms.

Lawrence (1995) highlighted that measuring the export premium of wages with firm- or establishment-level panel data may lead to a positive bias because it fails to consider the characteristics of employees. Thus, Schank et al. (2007) estimated the wage function by using German employer–employee panel data, which is a combination of micro data on firms and employees to control the attributes of firms and employees and found that the wage premium of exporting firms does not increase in the years after firms start exporting. Although similar research has been rarely conducted in Japan, Tanaka (2015) and Endoh (2016) estimated wage premium by using Japanese employer–employee data. However, Tanaka (2015) targeted only regular male employees and Endoh

(2016) targeted only firms conducting offshoring business and export.

In this chapter, the 2012 employer–employee cross-section data are obtained by combining the micro data on Japanese manufacturing plants from the Economic Census for Business Activity (ECBA) implemented by the Ministry of Internal Affairs and Communications (MIC) and METI and on employees from the “Basic Survey on Wage Structure” (BSWS) conducted by the Ministry of Health, Labor, and Wealth (MHLW). The Mincer-type wage function was then estimated to validate the wage premium of exporting firms after controlling the characteristics of manufacturing plants and employees.

Because of verification, the coefficients of the export variables are statistically and significantly positive, but the portion of the wage premium correlated with exports is very limited, only less than 10% of the wage premium according to Blinder－Oaxaca decomposition. It has also been confirmed that a certain portion of the observable wage premium of export is ascribed to plants’ skilled labor intensity. These findings are consistent with the low labor share of exporting firms.

(3) Chapter 4.　Japan’s Participation in Global Value Chains: Splitting the IO Table into Production for Export and Domestic Sale

The results of Chapter 2 suggest that the presence of skilled labor appears to have a significant influence on the determination of labor share. However, the finding that exports have no positive effect on the labor share in the estimation implies that Japan's exports may not require skilled labor. To verify this possibility, this chapter analyzes the degree of factor content including skilled labor in Japanese exports and domestic sale. Public data do not show the number of skilled and unskilled workers employed by firms. Therefore, in this chapter, a new approach, the split international input–-output table proposed in Koopmans et al. (2012, 2014) and Ahmad et al. (2013), is used to distinguish the differences in the demand of exporting and non-exporting sectors for skilled labor. In particular, the outputs of 16 industries belonging to the Japanese manufacturing sector in the Organization for Economic Cooperation and Development (OECD) intercountry input–output (ICIO) table are split into output for export or domestic sales. Then, using the employer–employee data constructed in Chapter 3, the factor input created through international demand is calculated. By using the split ICIO table, trade in value-added (TiVA) indicators were computed to examine the participation of Japanese manufacturing plants in global value chains; the results were compared with the OECD–WTO TiVA indicators. The comparison revealed that the estimated forward linkage indicators, such as the ratio of domestically created value added to exports, are less than the original TiVA indicators, thereby revealing that a part of the domestic value added leaks when plant heterogeneity within industries is considered. This result is attributed to high cross-border production fragmentation, large presence of Japanese multinational companies in global manufacturing, and high volume of intrafirm trade in Japan's manufacturing sector.

We then calculate Japanese factor inputs embodied in foreign final demand using our split ICIO table and compare the skilled labor intensity of exports and domestic sale. We observed that the share of exports was relatively higher for university graduates than for regular and non-regular workers. This means that exports are both more capital intensive and skilled-labor intensive than domestic sale. Therefore, rather than the hypothesis that Japan's exports are not skilled labor intensive, we can infer that exporters tend to decrease total labor demand and replace their demand for unskilled labor with demand for skilled labor.

Chapter 2 A Microeconomic Analysis of the Declining Labor Share in Japan

1. **Introduction**

The empirical evidence of the latest decades has challenged what researchers previously regarded as one of the stylized facts of modern economic growth, that is, the constancy of factors' shares of income (Kaldor 1961). The decline in the labor share, which started during the 1970s in most developed countries, has stimulated extensive research efforts to provide possible explanations and adequate policy responses. Research has identified the drivers of such dynamics as factors related to the production function (technological change and inputs' elasticity of substitution), the consequences of increased globalization of markets for firms' structure and organization, and institutional factors affecting the relative bargaining power of capital and labor. Despite the purely microeconomic nature of the potential drivers of the labor share, empirical research has so far focused mainly on the aggregate (country or sector) level.

In the 2000s, research focusing on heterogeneous changes in labor share among firms appeared. Kyyra and Maliranta (2008) decomposed Finnish plant-level data (from

1974 to 2001) and found that the labor share was virtually constant within firms, while its aggregate decline was related to a compositional shift from high- to low-labor-share plants. Bockerman and Maliranta (2012) obtained similar outcomes for Finland by aggregating establishment-level data at the industry level. Using the same approach of decomposing of firms or establishments, Autor et al. (2020) and Kehrig and Vincent (2021) revealed the reallocation of labor share among U.S. firms and establishments. Autor et al. (2020) also indicated that the reallocation of labor share among firms is based on the rise of "superstar" firms. [2] Kehrig and Vincent (2021) insist that reallocation is due to firms or establishments with low labor share. Recent research in the 2010s goes one step further and seeks to elucidate the determinants of firms' labor share. Analyzing a sample of Polish firms for the period 1995–2008, Growiec (2012) concluded that sector-specific factors, such as changes in the ownership structure and human capital accumulation, explain a large fraction of the observed downward trend in the labor share. Sieghenthaler and Stucki (2015) examined a sample of Swiss firms between 2001 and 2010 and identified the share of workers using information and communication technologies (ICT) as the main factor behind the declining labor share. Hwang and Lee (2015) explored the drivers of the labor share of firms in the Republic of Korea during

[2] In Autor et al. (2020) "superstar firms" refer to firms with high productivity.

the period 2005–2011 and found that, in addition to factors related to production technology and market power, employees' bargaining power and the corporate labor strategy are pivotal in explaining heterogeneity in the labor share. Dall'Aglio, Magnani, and Marchini (2015) analyzed the medium- and short-run dynamics of the labor share in Italian firms from 2004 to 2007. They found that the capital–output ratio plays a key role in both the short and the medium run; in addition, an increase in the markup over production costs and the implementation of technological progress have positive effects on the labor share in the short run and negative effects in the medium run. Berkovitz, Ma, and Nishioka (2017) studied the evolution of the labor share over the period 1998–2007 for a sample of Chinese firms and associated the decline primarily with institutional factors, namely market reforms in the state sector and product market deregulation; in addition, they found that the increasing importance of large "superstar" firms, which have relevant market power and a small labor share, is an important explanation for the decline, as the earlier version of Autor et al. (2020) insisted. [3] Their results further showed that more exposure to international competition reduces the labor share in the short run, likely favoring the bargaining power of entrepreneurs relative to employees and leading to wage

[3] In the earlier paper, the same authors (Berkovitz, Ma, and Nishioka 2015) determined the drivers of the decline in the labor share in the manufacturing sector to be the increasing market power and capital intensity of Chinese firms and the decreasing political pressure on state-owned firms.

moderation. Finally, using a sample of firms from six EU countries, Perugini, Vecchi and Venturini (2017) showed that the labor share decreases for firms engaged in internationalization processes, but this effect is not related to differences in the composition of the labor force, technological factors, or firms' market power. Although such studies aimed at determining the drivers of micro-level labor share recently began to be conducted, no conclusive results have yet been reached.

This chapter contributes to this literature relying on data for Japanese manufacturing firms for the period 2001–2012. This is the first microeconomic-level analysis for this country, for which empirical evidence on the labor share movements is quite limited (see Takeuchi 2005; Wakita 2006; Agnese and Sala 2011; Fukao and Perugini 2021). While studying the microeconomic drivers of the labor share, we focus on a comprehensive set of aspects related to technology, factors' intensity, internationalization patterns, and the composition of the workforce. We also exploit the sectoral detail of our data to allow for sector-specific employment features and product and labor market institutional settings.

We organize the chapter as follows. In the next section (2), we provide a bird's eye view of the relevant literature on the drivers of the labor share. Section 3 describes the empirical modeling approach and methods. In section 4, we illustrate the dataset and provide some preliminary descriptive evidence, while, in Section 5, we present the results of our estimations. Section 6 summarizes and concludes.

2. Literature background

The literature provides various explanations for the decline in the labor share that, despite often being conceptually separated, are in fact closely related to each other. In this section, we summarize the factors that drive the labor share mentioned in previous studies.

2.1 The drivers of the labor share: technological change, factor contents and imperfect market

Factors' productivity and, in the presence of market frictions, their relative bargaining power ultimately determine the distribution of income that the production process generates. This implies that all possible drivers of the income share accruing to workers (or, complementarily, to capital and profits) are mutually related. Technological change, for example, has been increasingly capital augmenting, and this has resulted in more capital-intensive production processes; this could explain, along with greater substitutability of labor with capital, the decrease in the labor share (Bentolila and Saint-Paul 2003; Lawless and Whelan 2011). The macroeconomic evidence emphasizes that capital deepening is the main factor driving the decline in the labor share, provided that the elasticity of substitution between capital and labor is larger than one (Karabarbounis and Neiman 2014; Piketty 2014; Piketty and Zucman 2014).

We can extend this baseline conceptual structure in various directions. First, not all studies have agreed on the level of the elasticity of substitution, with some of them arguing that capital and labor are gross complements rather than substitutes (Antràs 2004). More importantly, the framework gains much in explanatory power when taking labor heterogeneity into account. It is indeed possible to include high- and low-skilled workers separately in the production function (a general CES type to guarantee flexibility in the elasticity of substitution) and for their elasticity of substitution to differ (Arpaia et al. 2009; Elsby, et al. 2013). In this way, it is possible to model and empirically estimate the consequences of skill-biased technological change in terms of both skilled/unskilled relative demand and prices.

Second, many studies have found that technological change, which the introduction of ICT induces, explains a remarkable proportion of the aggregate or sector-level labor share decline (e.g., European Commission 2007; Lawless and Whelan 2011). However, as much as ICT is likely to replace low- and medium-skilled labor, it might also be complementary to high-skilled labor (Acemoglu and Autor 2011). Hence, the overall effect of skill-biased technological change on the labor share depends on the interplay between different types of labor complementarity/substitutability levels and their relative skill premium. Karabarbounis and Neiman (2014) documented that the change in the relative prices of ICT compared to other assets, along with possible complementarities between ICT and high-skilled labor, explains a large fraction of the variation in the labor share. Also related to the ICT/skills debate is the potential impact of organizational change, which tends to be biased toward high-skilled labor (Caroli and Van Reenen 2001; Piva et al. 2005).

More recently, research has devoted attention to another side of capital heterogeneity, distinguishing the impact on the labor share of tangible and intangible capital assets. Koh, Santaeulàlia-Llopis, and Zheng (2016) found that the declining trend of the labor share in the US is entirely due to the increase in the capital intensity of intellectual property products (IPPs); O'Mahony et al. (2018) showed more mixed results, with some types of intangible capital (those complementary to ICT and innovative capital) increasing the labor share and others (economic competencies) decreasing it.

Relaxing the assumption of perfectly competitive (product and input) markets opens the door for additional potential drivers of the labor share. In an imperfect market, price markups and workers' bargaining power vis-à-vis employers vary from firm to firm. This phenomenon results in firm heterogeneity in terms of labor share. The decomposition approach represented by Autor et al. (2017, 2020) and Kehrig and Vincent (2021) focuses on the heterogeneity. A firm's market power (measured by its price markup) determines the size of the rent and the extent to which emerging rents accrue toward capital or labor becomes crucial to explaining the dynamics in the factor share of income (Blanchard and Giavazzi 2003). If price markups are larger than wage markups, researchers expect a lower degree of competition to decrease the labor share (Azmat at al. 2012). Kehrig and Vincent (2021) stressed the role of price markups.[4] Barkai (2016) and Autor et al. (2017, 2020) provided evidence of a negative correlation between market concentration and labor share in the US.[5] The extent of this phenomenon also depends on workers' bargaining power, which in turn stems from the general macroeconomic conditions and institutional settings (European Commission 2007; Bental and Demougin 2010). In fact, the decline in collective labor organizations (union density, collective bargaining systems) and labor market regulation (employment protection, minimum wage provisions) that

[4] Decomposing the labor share of the US manufacturing sector into value added per worker and wage, Kehrig and Vincent (2021) indicated that the former is the dominant factor in the decline of the US manufacturing labor share. Furthermore, they found that the low-labor-share establishments (those in the lowest quintile of the labor share distribution), benefitting from high revenue labor productivity and high price premiums, led the decline of the labor share.

[5] Using the US enterprise data, Autor et al. (2020) decomposed the change in the aggregate labor share into four components; (1) the within-firm component of surviving establishments, (2) the component of a reallocation between surviving establishments, (3) the component of entrants and (4) the component of exiters. Their results indicated that the reallocation among survivors was the main component of the fall of the labor share from 1982 to 2012. They also revealed that sectors with a high concentration of sales tend to have large reallocation effect and high growth rate of productivity and markup. Their findings imply that the main driver of the declining labor share in the US is a rise in firms with high price mark-up and low labor share ("superstar" firms).

have characterized virtually all OECD countries in recent decades may have contributed to the decreasing trend in the labor share (see Bentolila and Saint-Paul 2003; OECD 2011).

2.2 Globalization as a driver of labor share

The forces related to globalization add complexity to all sources of labor share changes. According to the Heckscher–Ohlin (HO) model, researchers expect trade to drive specialization in production sectors that reflect countries' comparative advantage, resulting from relative factor endowments. Therefore, developed countries specialize in capital-intensive industries, and this drives the labor share downward, provided that the elasticity of substitution is lower than one (i.e., capital and labor are gross complements) (European Commission 2007). In recent years, the shift of production factors is not limited to domestic; rather, it often moves across national borders in the form of offshoring. In developed countries with abundant capital, labor-intensive production processes are transferred to developing countries with abundant labor, which reduces the domestic labor share. In addition to importing labor-intensive goods, which are inferior in comparison to capital goods, imports will lower the labor share due to the expansion of vertical intra-industry trade (Ishido et al. 2003) stemming from offshoring. Elsby et al. (2013) emphasized the effect of reducing the labor share due to competition with imports in the United States. [6]

The "*new" new trade* theory emphasizes the importance of firm heterogeneity (in terms of productivity) as a key driver of the probability of entering, surviving, and producing profits in international markets in the presence of fixed general and trade-linked costs, which originate economies of scale (Melitz 2003). Competitive pressure due to exposure to international trade is an important stimulus for productivity-enhancing micro-restructuring (creative destruction) within industries (e.g., Bernard et al. 2007; Lileeva 2008; Bockerman and Maliranta 2012). In the firm heterogeneity model proposed by Bernard et al. (2007) with two industries, trade liberalization increases the proportion of firms that start to export among entrants, compared to that of a disadvantaged industry. Thus, in the case of developed countries with abundant capital, the theory predicts that exporters tend to be comparatively capital-intensive and have lower labor shares.

Additionally, in imperfectly competitive labor markets, globalization forces tend to adversely affect the bargaining position of labor, a relatively less mobile factor of production compared to capital. Reduced barriers to trade accentuate the asymmetries

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[6] The study of Elsby et al. (2013) is an early study analyzing the factors behind the decline of the US labor share in the 2000s using industry-level data. After discussing that the decline in the labor share since the 1990s was due to the decline in payroll for workers within the same industry, they analyzed the effects of (1) the substitution with capital, (2) the decline in unionization, and (3) the increase in the import penetration rate on the change in labor share by estimating an ordinary least square (OLS) model with cross-industry data. They found that only the increase in the import penetration had a significant negative effect.

between groups that can cross international borders (owners of capital and a small number of highly skilled workers) and those that cannot (the great majority of workers; Rodrik 1997; Slaughter 2000). The fixed costs of relocating are much higher for workers (particularly unskilled workers) than for capital. Their bargaining position will consequently deteriorate because of an increase in firms' outside options (IMF 2007). The threat of relocating the production process (or part of it) through FDI, outsourcing segments of the productive chain abroad or importing intermediate inputs, is therefore likely to compress wages and lead to a decline in the labor share. In addition, when domestic firms in developed, high-wage countries decide to produce abroad or to offshore the most unskilled-labor-intensive segments to respond to labor cost pressures, the labor demand for low-skilled workers decreases (see, for example, Crinò 2012) and the wage elasticity grows. In fact, unskilled workers are more easily replaceable with the services of other people across national boundaries. Both factors drive the labor share downward, as various empirical studies on developed countries have shown (Harrison 2002; Guscina 2006; Jaumotte and Tytell 2007; Jayadev 2007). Hutchinson and Persyn (2012) also provided a theoretical framework in which foreign competition limits the scope of union wage demand. Obviously, researchers expect the opposite (or no effects of internationalization/offshoring) in low-wage countries, in which workers would likely benefit from the division of labor across countries (Bassanini and Manfredi 2012). Guerriero and Sen (2012) provided empirical evidence concerning the opposite effect of trade openness on labor share for OECD (negative) and non-OECD (positive) countries; when they distinguished between developed and developing countries, they found that, in both cases, the effect of openness is positive but much weaker for the advanced economies.

Even more relevant to our analysis of Japan is the fact that intra-industry trade between developed countries has become prevalent. This has resulted from a shift toward the production of horizontally differentiated goods, which normally leads firms to benefit from market power and to gain an increase in their markups and profits.

Based on previous research thus far, in the case of Japan, exporting firms seem to have a low labor share. However, labor heterogeneity should be considered. Modern versions of the HO model distinguish between low-skilled and high-skilled labor, with the first normally being a substitute for and the second being a complement to capital (Wood 1994). This complicates the predictions of the model in terms of labor share developments as the overall effect now depends on the relative elasticity of substitution of the different types of labor with respect to capital. If higher productivity is driven by higher capital intensity aimed at reducing labor costs, international firms will tend to have a smaller labor share. However, if capital and skilled labor are complements, the final effect on the labor share will depend on the relative change in the workforce composition based on skills within the firm.

3. Empirical model and estimation strategy

Our empirical model is based on the framework that Bentolila and Saint Paul (2003) proposed; they showed that, in the presence of two factors of production (K and L), and under the assumptions of constant returns to scale, capital- and labor-augmenting technological progress, and competitive markets, a unique function *g* exists that explains the labor share in firm *i* (LS^i), based on the capital–output ratio ($K_i = k_i/y_i$) and on changes in the capital-augmenting technological progress (A_iK_i). This relationship—the so-called SK relationship $[LS^i = g(A_iK_i)]$—is stable as long as the marginal product of labor is equal to the real wage. The nature of our data (see section 4) allows us to distinguish different types of non-labor inputs that might have different levels of substitutability with labor: tangible capital (k_T), intangible assets (expenditures on R&D and advertisement—e_{INT}), and ICT assets (expenditure on e_{ICT}). As Fukao and Perugini (2021) showed, under certain assumptions, it is possible to extend the Bentolila–Saint Paul model to more than two inputs (labor and capital) by assuming that the production activity of each firm consists of different processes (in our case, a tangible capital-intensive process, an intangible asset-intensive process, and an ICT asset-intensive process), all with constant elasticities of substitution between non-labor input and labor and with unitary elasticity of substitution between them. Under such circumstances, it is possible to express the labor share as a function of tangible capital intensity (on output), intangible capital intensity, and ICT asset intensity, with changes in technological progress shifting this extended SK schedule. Any factor able to create a gap between the marginal product of labor and the real wage (as those explained in section 2) moves the economy *off* the SK schedule.

Following Bentolila and Saint-Paul (2003) and Fukao and Perugini (2021), we assume a multiplicative form of the extended labor share function:[7]

$$LS^{ijt} = g(K_T^{ijt}, E_{INT}^{ijt}, E_{ICT}^{ijt}, C^{ijt})h(Z^{ijt}) \qquad (1)$$

where superscripts *i, j*, and *t* denote firms, sectors, and years, respectively, and the function $g(.)$ describes the labor share determinants strictly derived from the production function (the SK schedule). K_T^{ijt} corresponds to $\frac{k_T^{ijt}}{y^{ijt}}$; E_{INT}^{ijt} corresponds to

[7] Bentolila and Saint-Paul (2003) shows that labor share is a monotonic decreasing function of (i) capital augmenting technology level, (ii) Hicks neutral technology level, and (iii) capita-output ratio from a normal CES production function.

Following Bentolila and Saint-Paul (2003), Fukao and Perugini (2018) develops a labor share function with multiple capital and multiple labor.

In Appendix 1, we show the ratio of multiple capitals to output and capital augmenting technological indices are the labor share determinants strictly derived from the production function, based on Bentolila and Saint-Paul (2003).

$\frac{e^{ijt}_{INT}}{y^{ijt}}$; and E^{ijt}_{ICT} corresponds to $\frac{e^{ijt}_{ICT}}{y^{ijt}}$. Due to the data availability, we use annual amount of real expenditure for intangible and ICT assets to approximate the relevant stock of firms. C^{ijt} is a measure of technological change that summarizes the effects of all types of technological change that are not labor augmenting (A_T, A_{INT}, A_{ICT}). The separate exponential function $h(.)$ is instead meant to account for the other potential factors (Z^{ijt}) that shift the economy *off* the SK schedule. They include internationalization patterns, employment characteristics, and product and labor market institutional factors that are able to shape the relative bargaining power of labor and capital.

Assuming that both $g(.)$ and $h(.)$ are also multiplicative and by taking logs, we can express the labor share as:

$$\ln LS^{ijt} = \gamma \ln LS^{ijt-1} + \beta_0 \ln(C^{ijt}) + \beta_1 \ln(K^{ijt}_T) + \beta_2 \ln(E^{ijt}_{INT}) + \beta_3 \ln(E^{ijt}_{ICT}) + \gamma \ln(Z^{ijt}) + \alpha^i + \lambda^{jt} + \varepsilon^{ijt} \quad (2)$$

where α^i are firm fixed effects, λ^{jt} is a set of sector/year dummies, and ε^{ijt} is a residual error term.

Modeling the drivers of the labor share poses some identification issues. A relevant one relates to omitted variable bias, which, despite the advantages that firm-specific intercepts guarantee in our case, might persist due to the fact that the labor share might be characterized by high within-firm inertia and therefore be time persistent. The inclusion of the lagged dependent variable among the regressors in equation (2) is the standard approach to address this issue. However, the presence among the right-hand side variables of the lagged $\ln LS^{ijt-1}$, which is correlated with the composite error ($\alpha^i + \varepsilon^{ijt}$), leads to inconsistent parameter estimates when we account for firms' heterogeneity by means of conventional fixed- or random-effect estimators (Baltagi, 2001). To address this issue, we opt for the GMM estimator that Arellano and Bond (1991) proposed, which they specifically designed for situations with panels of a relatively short time dimension and many individual units, fixed individual effects implying unobserved heterogeneity, and right-hand variables that are not strictly endogenous (i.e., correlated with the past and possibly the current realization of the error).

4. Data and summary statistics

We use firm-level panel data from the "Basic Survey of Japanese Business Structure and Activities" (hereinafter "the JBSA survey"), conducted annually by METI. The JBSA survey covers all firms with at least 50 employees or 30 million yen of paid-in capital in the Japanese manufacturing, mining, and most of the service sectors. We limit our sample here to manufacturing and to the period 2001–2012, since many important variables, such as exports and imports, are not available for previous years. The questionnaire of the JBSA survey covers firms' broad activities and characteristics, such as sales, number of employees, tangible assets and intangible investment, and international activities (see Appendix 2 for the full list of variables that we use).

Table 2-1: Summary Statistics

variables	observations	mean	std	min.	max.
LS	147,725	0.663	0.165	0	1
TFP	147,067	1.002	0.378	0.392	95.930
Kτ	147,725	0.258	0.341	0	60.283
E INT	147,725	0.013	0.029	0	2.324
E ICT	147,565	0.005	0.038	0	7.825
PAT (d)	147,725	0.307	0.461	0	1
REG	147,601	0.877	0.173	0	1
EXP (d)	147,725	0.318	0.466	0	1
IMP (d)	147,725	0.289	0.453	0	1
FDI (d)	147,725	0.072	0.259	0	1
FOREIGN (d)	147,725	0.092	0.289	0	1
EXP_s	147,725	0.044	0.122	0	1
IMP_s	147,565	0.031	0.099	0	2.963
FOREIGN_s	147,725	0.002	0.016	0	1
SIZE	147,725	396.766	1607.890	50	80840
SME (d)	147,725	0.766	0.423	0	1
PARENT (d)	147,725	0.337	0.473	0	1
FIRMAGE	147,086	43.254	18.697	0	657

Note: Author's calculation on the Basic Survey of Japanese Business Structure and Activities.

Table 2-1 presents the descriptive statistics of the variables used in our analysis. The size of the unbalanced panel of firms (pooled, all years) was 147,725. We defined the labor share (variable *LS*).as the total payroll to workers over value added. [8] The

[8] The JBSA survey asked sample enterprises to report total payroll to workers (including bonuses and retirement allowance) up to 2006. Since 2007, this questionnaire was split into welfare expense (including retirement allowance) and total payroll to workers (including bonuses).

While the labor shares up to 2006 and those after 2007 are discontinuous, we use the following definition of labor share adopted by the JBSA survey.

Labor share

= total payroll to workers (including bonus and retirement allowance) / Value added (2001~2006)

= total payroll to workers (including bonuses) / Value added (2007~2012)

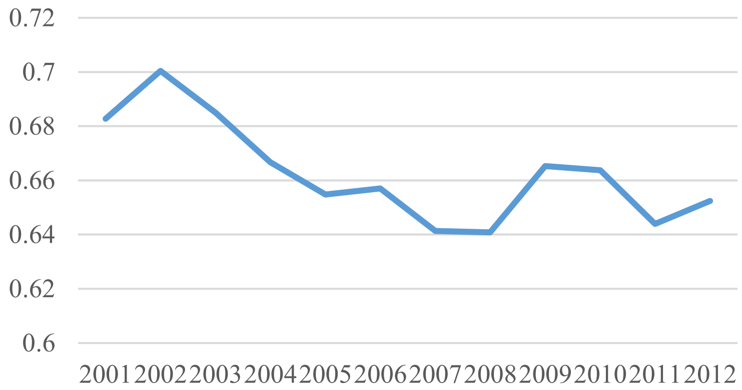
Due to the slit of welfare expense, the definition of value added was also changed as follows.

Value added

= operating profit + total wages + rental expenses + depreciation expenses + taxes and public charges (2001~2006)

= operating profit + depreciation expenses + total payroll + welfare expenses + real estate and movables property rental + taxes and public imposition (2007~2012) average labor share during the period is 66.3%, which is consistent with the existing empirical evidence (see Fukao and Perugini 2021). It shows a clear declining trend over the period considered (Figure 2-1). In particular, while the labor share fluctuated around 70% at the beginning of the 2000s, it declined in the following years to about 64%. A new declining trend in 2011 and 2012 followed the countercyclical increase observable in 2009 and 2010.

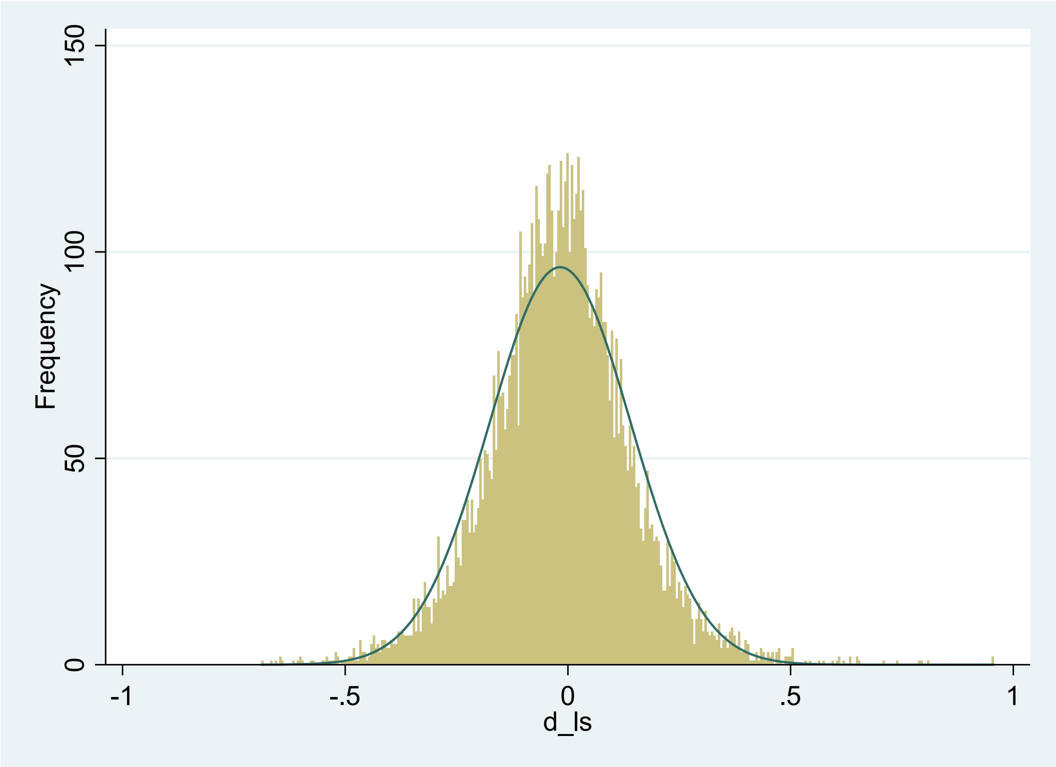
Figure 2-1: Average Labor Share of Japanese Manufacturing Firms, by Year



Note: Author's calculation on the Basic Survey of Japanese Business Structure and Activities.

In order to observe if the labor share of many firms is declining as well as the overall trend, Figure 2-2 plots the changes in the labor share of firms from 2001 to 2012. We found that the distribution follows a normal distribution centered on zero, and only about half of the firms have a decline in the labor share. This result shows the importance to scrutinize the circumstances of each company by using micro data.

Figure 2-2: Distribution of change in labor share, 2001-2012



Note: 1 Author's calculation on the Basic Survey of Japanese Business Structure and Activities.

2 This figure shows the distribution of difference of firms' labor share from 2001 to 2012, that is, $d\ LS^{ij,2012} = LS^{ij,2012} - LS^{ij,2001}$

3 The total number of firms, which exist from 2001 to 2012, is 7,676.

4 The mean and standard deviation of $d\ LS^{ij,2012}$ are -0.01737 and 0.1590, respectively.

We estimated total factor productivity (TFP) following the method proposed by Olley and Pakes (1996) and normalized it by subtracting the sector average of TFP in 2000.[9] As explained in the previous section we alternatively used the annual amount of real expenditure for intangible and ICT assets to calculate real expenditure for the intangible asset–real sales ratio E INT and real ICT cost–real sales cost ratio E ICT due

[9] For the details of the calculation, see Appendix 3. We also estimated the model using the non-normalized TFP and the normalized TFP based on the sector average of the TFP in 1995. The results are consistent with those presented in Table 2-2.

to a lack of stock information on these assets in the JBSA survey.[10] The set of technology-related indicators shows that R&D-intensive firms do not have a dominant share. The R&D expenditure to sales ratio is 0.9%, growing to 1.3% if we add expenses of other intangible assets (advertisement) (variable e_{INT}).[11] Approximately one-third of firms develop their own patents, while the share of regular employees in total employees is close to 90%.

The variables related to internationalization indicate that firms engaged in international business are limited in number. The share of exporting and importing firms is about 32% and 29%, respectively. Firms with FDI are even fewer (7%), while firms partially or completely owned by foreign firms amount to 9% of the total. Regarding firm size, the average number of employees is close to 400, but the proportion of small and medium enterprises (firms with 300 or fewer employees) amounts to 76.6%. About 34% of firms are subsidiaries of other firms

As discussed in Section 2, many preceding studies have found that the institutional features of both the final product market and the labor market affect labor

[10] For the detail of the calculation of E INT and E ICT, see Appendix 4.

[11] The form of the JBSA survey was revised to report rights of business, patent, trademark, utility model, design, land lease, superficies, trademark, mining, fishing and software as intangible fixed asset in 2007. However, we do not use the variable because of a lack of information from 2001 to 2006.

In the field of business administration, research and development expenses and advertising expenses are often used as a proxy for intangible assets (for example see Kawakami and Asaba, 2013). We follow this method for intangible assets as well as ICT assets.

share. Unfortunately, however, information on workforce characteristics is quite limited, and the JBSA survey does not cover some crucial aspects (such as its composition by gender, age, education/skills, and wage levels). As the second-best choice, we exploited the detailed sector breakdown of the JBSA survey (41 subsectors of manufacturing) and estimate equation (2) as a robustness check, using sector-level data on workforce characteristics, which we constructed using the Japan Industrial Productivity Database (JIP Database) provided by the Research Institute of Economy, Trade, and Industry (RIETI).[12] These sectoral measures, meant to account for the institutional environment in which firms operate, are, with reference to the product market conditions: (i) the markup rate (log of sales/total cost of each sector); and (ii) an import penetration indicator, as a proxy for the level of competition or complementarity due to imported goods. For the labor market, we include: (i) the share of high-skilled workers (in terms of working hours), (ii) the trade union density (the number of union members among the total number of employees), (iii) the share of female workers, and (iv) a measure of seniority of employment. All of the indicators describe the important characteristics of the product and labor markets in Japan (Fukao and Perugini 2021).

[12] See Appendix 2 for their definition and Appendix 5 for descriptive statistics.

5. Econometric results

5.1. Benchmark estimations

Table 2-2 reports the benchmark result of the estimation of equation (2). All of the models include sector, year, and prefecture dummies. We present here the results of a standard fixed-effect (FE) and the Arellano–Bond (AB) GMM estimator. To observe the independent effect of intangible asset and ICT from that of tangible fixed assets, both estimation methods were conducted with and without $E\ INT$ and $E\ ICT$. Columns [1] and [2] report the FE estimation without and with $E\ INT$ and $E\ ICT$, respectively. Columns [3] and [4] are the estimation result without $E\ INT$ and $E\ ICT$, by one-step GMM and two-step GMM estimations, respectively.[13] Columns [5] and [6] are the result of one-step and two-step GMM estimation with $E\ INT$ and $E\ ICT$. The results of Arellano-Bond test of second-order serial correlation in all GMM estimations does not reject the null hypothesis; there is no second-order serial correlation in the first-order difference of the error term. Moreover, the results of the Sargan test of all GMM estimations does not reject the null hypothesis at 5% significance; all instrumental variables and error terms

[13] GMM estimation has two methods: one-step estimation which uses the generalized least squares method under the assumption of homoscedasticity on the product of the error term matrix and the instrumental variable matrix, and two-step estimation without imposing homoscedasticity The result of two-step estimation is more general because of fewer assumptions but has downward bias (Arellano and Bond, 1991). Thus, in this chapter we compare the results of both methods.
Arellano and Bond (1991) also show that the results of both methods are asymptotically equal if the error terms are independent and identically distributed.

are uncorrelated and error terms are homoscedastic. Thus, we can consider the results of GMM estimations to be reasonable.

Table 2-2 Drivers of the Labor Share at the Firm Level in Japan (2001–2012)
Internationalization Pattern of Firms Described by Means of the Set of Dummy Variables

	[1]	[2]	[3]	[4]	[5]	[6]
Estimation Method	FE	FE	AB (one step)	AB (two step)	AB (one step)	AB (two step)
TFP (ln)	-0.3373 ***	-0.3332 ***	-0.2811 ***	-0.2835 ***	-0.2844 ***	-0.2861 ***
	[-58.74]	[-57.88]	[-3.94]	[-2.69]	[-3.98]	[-2.72]
K(ln)	0.1841 ***	0.1779 ***	0.6540 ***	0.6478 ***	0.6424 ***	0.6367 ***
	[21.66]	[20.86]	[15.49]	[10.15]	[14.95]	[9.85]
E INT (ln)		0.4986 ***			0.6166 ***	0.6109 ***
		[12.01]			[7.48]	[4.30]
E ICT (ln)		0.1284 **			0.1489 *	0.1484
		[2.19]			[1.96]	[1.36]
PAT (d)	-0.0008	-0.0015	-0.0028	-0.0026	-0.0035	-0.0033
	[-0.38]	[-0.69]	[-0.77]	[-0.64]	[-0.97]	[-0.81]
REG (ln)	0.0855 ***	0.0849 ***	0.2072 ***	0.2017 **	0.1994 ***	0.1947 *
	[8.39]	[8.30]	[2.87]	[1.99]	[2.79]	[1.94]
EXP (d)	0.0023	0.0017	-0.0034	-0.0032	-0.0037	-0.0036
	[0.95]	[0.68]	[-0.75]	[-0.60]	[-0.82]	[-0.67]
IMP (d)	0.0032	0.0033	-0.0012	-0.0008	-0.0013	-0.0009
	[1.51]	[1.51]	[-0.35]	[-0.19]	[-0.36]	[-0.21]
FDI (d)	-0.0016	-0.0018	-0.0142 **	-0.0132	-0.0141 **	-0.0132
	[-0.53]	[-0.62]	[-2.06]	[-1.42]	[-2.00]	[-1.42]
FOREIGN (d)	-0.0043	-0.0049	-0.0063	-0.0067	-0.0069	-0.0073
	[-0.97]	[-1.09]	[-0.74]	[-0.79]	[-0.81]	[-0.86]
SIZE (ln)	0.0186 ***	0.0179 ***	0.5000 *	0.4828	0.4777 *	0.4634
	[5.70]	[5.50]	[1.76]	[1.19]	[1.67]	[1.14]
SME (d)	-0.0081 **	-0.008 **	0.1276 *	0.1225	0.1213 *	0.1171
	[-2.25]	[-2.23]	[1.73]	[1.17]	[1.65]	[1.11]
PARENT (d)	-0.0071 **	-0.0065 **	-0.0011	-0.0019	-0.0002	-0.0011
	[-2.19]	[-2.00]	[-0.16]	[-0.22]	[-0.04]	[-0.13]
LS(t-1) (ln)	0.2884 ***	0.2883 ***	0.4261 **	0.4037	0.4388 **	0.4151
	[103.31]	[103.28]	[2.20]	[1.36]	[2.25]	[1.39]
CONST	-0.5365 ***	-0.5328 ***				
	[-3.09]	[-3.07]				
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummies	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond (1)			-3.67 (0.000)	-2.30 (0.021)	-3.70 (0.000)	-2.32 (0.020)
Arellano-Bond (2)			1.16 (0.245)	0.67 (0.502)	1.23 (0.219)	0.71 (0.476)
Sargan			5.52 (0.063)	5.52 (0.063)	5.43 (0.066)	5.43 (0.066)
R-squared	0.1652	0.1664				
N	127,184	127,057	102,946	102,946	102,829	102,829

Note 1 Author's calculation.
2 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.
3 "FE" denotes fixed-effect model. "AB" denotes Arellano Bond GMM estimation.
4 "ln" denotes the variable is logarithmic.
5 "d" denotes the variable is a dummy variable.
6 "Arellano-Bond (1) and (2)", denotes the Arellano-Bond test of first and second order serial correlation. Parentheses indicates p-value.
7 "Sargan" denotes the Sargan test of over-identification restriction. Parentheses indicates p-value.

A comparison of the results based on the FE and AB GMM estimation methods shows that the signs and significance levels of TFP, real tangible fixed asset–real sales ratio, $K\tau$, regular employees–total employees ratio, Reg are stable. In both the FE and AB GMM estimations, we add the one-year lag of the labor share to the explanatory variables. The significantly positive coefficient is consistent with expectations and confirms a remarkable feature of persistence of the levels of labor share over time.

Firms with high TFP have a smaller labor share, a result that is in line with the evidence that many previous studies have produced. Although the growth of TFP, a portion of growth in output not explained by growth in inputs, seems to be neutral for factor share, the negative coefficient implies that technological progress entails capital deepening as Karabarbounis and Neiman (2014) indicated. On the other hand, the coefficients of tangible capital intensity and intangible assets' intensity are positive and significant, meaning that these factors of production are complementary to skilled labor. The comparison of columns [3]–[6] indicates that intangible assets intensity has an effect that is independent of that of tangible fixed assets. The coefficient of ICT capital intensity is also positive, although the statistical significance is not as strong.

As far as tangible capital is concerned, this result could be part of the explanation for the decline in the labor share in Japan as the capital intensity has been declining in the country throughout the 2000s.[14] The positive signs of intangible and ICT assets are likely due to the fact that the firms in the sample employ a large majority of labor on a permanent and full-time basis and that regular workers in Japan are typically associated with high formal or informal (experience) skills. Therefore, it is plausible that the result is connected to the dynamics of high-skilled labor that firms demand. If capital, intangible, and ICT assets are close complements to high-skilled workers, the expectation is that the labor share will increase with their accumulation.

A larger proportion of regular workers is associated with a larger labor share; this is likely due to regular workers' wages being higher than those of non-regular workers on average.

Regarding the effect of international activity, the labor share of firms with foreign subsidiaries tends to be lower. Surprisingly, and differing from previous research, the variables related to international trade have an insignificant coefficient. However, based solely on this result, we cannot conclude that exports and imports do not affect the labor share at all; the internationalization variables in Table 2-2 are dummy indicators. This means that we consider firms as companies operating abroad independent of the share of domestic and overseas activity.

[14] In the data that we used, the average capital–labor ratio gradually increased in the late 1990s and reached its peak in 2002. After several years of relative stability, it declined steadily after 2008.

In Table 2-3, we use continuous indicators rather than dummy variables as proxies for firms' internationalization patterns. Because the results of the Arellano-bond test and Sargan test of all GMM estimations do not reject the null hypothesis as in Table 2-2, we focus on the result of GMM estimation. The results indicate that export intensity decreases labor share. Columns [11] and [12] show that the labor share decreases by 0.1 % due to an increase in the export-sales ratio of 1%. The different significance of export in Tables 2-2 and 2-3 implies that the impact of exports, stemming from the mechanism of comparative advantage and/or imperfect competition, which is discussed in Section 2.2, appears only when firms' exporting activity is fairly active among their sales activity.

The coefficient of the foreign investment intensity of GMM estimations is stably negative, meaning that firms' operation of foreign subsidiaries lowers their labor share by focusing on skilled labor operations in Japan, regardless of the scale of operation. In contrast to the effect of export and FDI intensity, firms' import intensity has no effect on their labor share.

Table 2-3: Labor Share at the Firm Level in Japan (2001–2012)

Internationalization Pattern of Firms According to the Continuous Variables

	[7]	[8]	[9]	[10]	[11]	[12]
Estimation Method	FE	FE	AB (one step)	AB (two step)	AB (one step)	AB (two step)
TFP (ln)	-0.3377 ***	-0.3336 ***	-0.2906 ***	-0.2812 ***	-0.2935 ***	-0.2929 ***
	[-58.80]	[-57.93]	[-4.48]	[-2.96]	[-4.53]	[-3.07]
Kτ(ln)	0.1843 ***	0.1780 ***	0.6491 ***	0.6498 ***	0.6376 ***	0.6333 ***
	[21.68]	[20.88]	[16.48]	[10.90]	[15.92]	[10.46]
E INT (ln)		0.5009 ***			0.6241 ***	0.6165 ***
		[12.07]			[7.78]	[4.42]
E ICT (ln)		0.1291 **			0.1479 *	0.1476
		[2.21]			[1.93]	[1.36]
PAT (d)	-0.0005	-0.0012	-0.0028	-0.0026	-0.0035	-0.0033
	[-0.23]	[-0.56]	[-0.76]	[-0.64]	[-0.96]	[-0.79]
REG (ln)	0.0866 ***	0.0859 ***	0.2049 ***	0.2106 **	0.1973 ***	0.1943 **
	[8.49]	[8.40]	[2.99]	[2.22]	[2.91]	[2.06]
EXP_s (ln)	-0.0809 ***	-0.0820 ***	-0.1023 ***	-0.1021 ***	-0.1034 ***	-0.1024 ***
	[-6.21]	[-6.30]	[-4.48]	[-3.16]	[-4.52]	[-3.17]
IMP_s (ln)	0.0412 ***	0.0405 ***	-0.0189	-0.0153	-0.0201	-0.0172
	[3.16]	[3.11]	[-0.80]	[-0.45]	[-0.85]	[-0.50]
FDI_s (ln)	-0.1212 ***	-0.1199 **	-0.9520 **	-0.9795 *	-0.9249 **	-0.9033 *
	[-2.59]	[-2.56]	[-2.52]	[-1.80]	[-2.44]	[-1.65]
FOREIGN (d)	-0.0038 **	-0.0043	-0.0067	-0.0074	-0.0073	-0.0077
	[-0.84]	[-0.96]	[-0.78]	[-0.86]	[-0.85]	[-0.90]
SIZE (ln)	0.0202 **	0.0195 ***	0.4854 *	0.5141	0.4638 *	0.4571
	[6.19]	[5.97]	[1.81]	[1.37]	[1.73]	[1.20]
SME (d)	-0.0081 **	-0.0081 **	0.1205 *	0.1273	0.1146 *	0.1123
	[-2.26]	[-2.24]	[1.77]	[1.33]	[1.68]	[1.16]
PARENT (d)	-0.0072 **	-0.0065 **	-0.0004	-0.0016	0.0004	-0.0005
	[-2.20]	[-2.01]	[-0.07]	[-0.19]	[0.06]	[-0.06]
LS(t-1) (ln)	0.2881 ***	0.2880 ***	0.4408 **	0.3907	0.4530 **	0.4242
	[103.22]	[103.18]	[2.41]	[1.41]	[2.45]	[1.50]
CONST	-0.5412 ***	-0.5374 ***				
	[-3.12]	[-3.10]				
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummies	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond (1)			-3.93 (0.000)	-2.42 (0.016)	-3.95 (0.000)	-2.47 (0.013)
Arellano-Bond (2)			1.33 (0.184)	0.69 (0.491)	1.40 (0.163)	0.80 (0.425)
Sargan			5.13 (0.077)	5.13 (0.077)	5.05 (0.080)	5.05 (0.080)
R-squared	0.1656	0.1673				
N	127,183	127,057	102,945	102,945	102,829	102,829

Note 1 Author's calculation.

2 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

3 "FE" denotes fixed-effect model. "AB" denotes Arellano Bond GMM estimation.

4 "ln" denotes the variable is logarithmic.

5 "d" denotes the variable is a dummy variable.

6 "Arellano-Bond (1) and (2)", denotes the Arellano-Bond test of first and second order serial correlation. Parentheses indicates p-value.

7 "Sargan" denotes the Sargan test of over-identification restriction. Parentheses indicates p-value.

Regarding the other explanatory variables, the coefficients of firms' TFP, tangible fixed asset–real sales ratio, and real expenditure for intangible asset–real sales ratio have the same sign as that in Table 2-2, and the level is quite similar, implying the stable significance of the variables on labor share. [15]

5.2. Robustness check: estimation with sector-level variables

As we told in section 4, we run the estimates using the one-step and two-step GMM method with the inclusion of sector-level variables as a robustness check. Since sector-level variables are part of the set of independent variables, we do not include sector dummies in the model. Continuous variables on firms' international activity are used in the estimation.

Table 2-4 indicates the estimation result by one-step GMM estimation while the result of two-step estimation is shown in Table 2-5. Because the results are very similar, we focus on Table 2-4. All columns of Table 2-4 show that, consistent with previous works, the coefficient of the markup variable (in logs) is significant and negative, suggesting that stronger competitive pressure within a sector has the effect of increasing

[15] In Tables 2-2 and 2-3, three variables related to capital, $K\tau$, $E\ \ INT$ and $E\ \ ICT$ are used. However, $K\tau$ is a stock variable while the latter two are flow variables. To confirm that the difference of the dimension of the variables may generate a difference in the estimation results, we implemented the estimation with a flow variable: real new acquisition of tangible fixed asset - real sales ratio, $E\ \ K$, rather than $K\tau$. As shown in Appendix 6, the results differ only minimally from Table 2-2 and Table 2-3.

the labor share. In comparison to the results in Tables 2-2 and 2-3, the coefficient of TFP is considerably different, likely due to some omitted variable bias. The effect does not disappear if we saturate the model with other sector-level variables (see columns [14]–[18]). In columns [14]–[18], we add the trade union organization rate as an explanatory variable, and its coefficient is almost insignificant. This may be due to the low levels and variability of the indicator.[16]

The share of high-skilled workers also does not show significance in our estimation. One possible explanation for this result is that other explanatory variables, such as expenditures on intangibles and ICT, innovation, and internationalization activity, already account for the importance of high-skilled labor at the firm level.

[16] According to the information that the MHLW (December 2017) provided, the estimated trade union organization rate amounted to 17.1% in 2017.

Table 2-4: Labor Share at the Firm Level in Japan (2001–2012) and Institutional Variables (at sector level)

	[13]	[14]	[15]	[16]	[17]	[18]
Estimation Method	AB (one step)	AB (one step)	AB (one step)	AB (one step)	AB (one step)	AB (one step)
TFP (ln)	-0.2105 ***	-0.1313 *	-0.2384 ***	-0.2276 ***	-0.2403 ***	-0.2313 ***
	[-2.73]	[-1.71]	[-3.02]	[-3.21]	[-3.00]	[-2.89]
Kт(ln)	0.5972 ***	0.6564 ***	0.5773 ***	0.5978 ***	0.5922 ***	0.6089 ***
	[9.79]	[10.63]	[9.44]	[10.64]	[9.72]	[9.95]
E INT (ln)	0.5939 ***	0.5210 ***	0.6186 ***	0.6141 ***	0.6028 ***	0.5975 ***
	[4.32]	[3.84]	[4.44]	[4.58]	[4.39]	[4.36]
E ICT (ln)	0.1293	0.1286	0.1295	0.1327	0.1333	0.1362
	[1.34]	[1.33]	[1.34]	[1.35]	[1.35]	[1.35]
PAT (d)	-0.0037	-0.0040	-0.0036	-0.0034	-0.0034	-0.0035
	[-0.87]	[-0.96]	[-0.86]	[-0.80]	[-0.80]	[-0.84]
REG (ln)	0.1758 *	0.2807 ***	0.1391	0.1590 *	0.1576	0.1798 *
	[1.77]	[2.84]	[1.37]	[1.76]	[1.56]	[1.78]
EXP_s (ln)	-0.1018 ***	-0.1114 ***	-0.0984 ***	-0.1002 ***	-0.0994 ***	-0.1025 ***
	[-3.08]	[-3.36]	[-2.97]	[-3.05]	[-3.01]	[-3.11]
IMP_s (ln)	-0.0249	-0.0146	-0.0283	-0.0263	-0.0249	-0.0225
	[-0.70]	[-0.41]	[-0.80]	[-0.75]	[-0.71]	[-0.64]
FDI_s (ln)	-0.7887	-1.3908 **	-0.5774	-0.6878	-0.6843	-0.8195
	[-1.37]	[-2.41]	[-0.98]	[-1.30]	[-1.17]	[-1.40]
FOREIGN (d)	-0.0070	-0.0095	-0.006	-0.0064	-0.0061	-0.0069
	[-0.80]	[-1.10]	[-0.68]	[-0.73]	[-0.70]	[-0.78]
SIZE (ln)	0.3939	0.8221 **	0.2445	0.3236	0.3188	0.4120
	[0.99]	[2.07]	[0.60]	[0.89]	[0.79]	[1.02]
SME (d)	0.0934	0.2019 **	0.0555	0.0762	0.0751	0.0985
	[0.92]	[2.00]	[0.53]	[0.83]	[0.73]	[0.96]
PARENT (d)	0.0005	-0.0028	0.0018	0.0008	0.0010	0.0005
	[0.06]	[-0.34]	[0.21]	[0.10]	[0.13]	[0.06]
MARK-UP	-0.1584 ***	-0.1301 ***	-0.1659 ***	-0.1481 ***	-0.1218 ***	-0.0947 ***
	[-4.45]	[-3.84]	[-4.65]	[-4.67]	[-3.83]	[-3.00]
UD		0.0004	-0.0035	0.0049	0.0108 **	0.0030
		[0.07]	[-0.61]	[0.90]	[1.99]	[0.54]
HIGH SKILLED			0.3461	-0.7455	0.0836	-0.4055
			[0.38]	[-0.92]	[0.09]	[-0.45]
FEMALE				0.0537 ***	0.0561 ***	0.0361 ***
				[5.17]	[5.23]	[3.41]
SENIORITY					0.1379 ***	0.1284 ***
					[5.46]	[5.05]
IMPORT_PENETR						0.0224 ***
						[6.64]
LS(t-1) (ln)	0.481	0.2109	0.5737 *	0.5307 *	0.5117 *	0.4647
	[1.61]	[0.74]	[1.87]	[1.96]	[1.72]	[1.57]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummies	Yes	Yes	Yes	Yes	Yes	Yes
Aerllano-Bond (1)	-3.93 (0.000)	-3.93 (0.000)	-3.91 (0.000)	-3.90 (0.000)	-3.91 (0.000)	-3.90 (0.000)
Aerllano-Bond (2)	1.54 (0.124)	1.53 (0.125)	1.53 (0.127)	1.51 (0.130)	1.49 (0.137)	1.47 (0.142)
Sargan test	4.70 (0.095)	4.72 (0.095)	4.72 (0.095)	4.66 (0.097)	4.43 (0.109)	4.85 (0.088)
N	102,829	102,829	102,829	102,829	102,829	102,829

Note 1 Author's calculation.

2 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

3 "FE" denotes Fixed-effect model. "AB" denotes Arellano Bond GMM estimation.

4 "ln" denotes the variable is logarithmic.

5 "d" denotes the variable is a dummy variable.

6 "Arellano-Bond (1) and (2)" denotes the Arellano-Bond test of first and second order serial correlation. Parentheses indicates p-value.

7 "Sargan" denotes the Sargan test of over-identification restriction. Parentheses indicates p-value.

Table 2-5: Labor Share at the Firm Level in Japan (2001–2012) and Institutional Variables (at sector level)

	[19]	[20]	[21]	[22]	[23]	[24]
Estimation Method	AB (two step)	AB (two step)	AB (two step)	AB (two step)	AB (two step)	AB (two step)
TFP (ln)	-0.2105 ***	-0.2062 ***	-0.2106 ***	-0.2139 ***	-0.2183 ***	-0.2380 ***
	[-2.73]	[-2.67]	[-2.68]	[-2.72]	[-2.72]	[-2.82]
Kт(ln)	0.5972 ***	0.6010 ***	0.5976 ***	0.6066 ***	0.6076 ***	0.6043 ***
	[9.79]	[9.87]	[9.73]	[9.98]	[9.89]	[9.51]
E INT (ln)	0.5939 ***	0.5900 ***	0.5936 ***	0.5984 ***	0.5836 ***	0.6039 ***
	[4.32]	[4.29]	[4.31]	[4.33]	[4.27]	[4.32]
E ICT (ln)	0.1293	0.1293	0.1293	0.1324	0.1329	0.1363
	[1.34]	[1.34]	[1.34]	[1.35]	[1.35]	[1.35]
PAT (d)	-0.0037	-0.0037	-0.0037	-0.0035	-0.0034	-0.0035
	[-0.87]	[-0.88]	[-0.88]	[-0.83]	[-0.80]	[-0.83]
REG (ln)	0.1758 *	0.1821 *	0.1761 *	0.1774 *	0.1865 *	0.1713
	[1.77]	[1.84]	[1.74]	[1.76]	[1.84]	[1.61]
EXP_s (ln)	-0.1018 ***	-0.1023 ***	-0.1018 ***	-0.1021 ***	-0.1021 ***	-0.1018 ***
	[-3.08]	[-3.09]	[-3.07]	[-3.09]	[-3.09]	[-3.07]
IMP_s (ln)	-0.0249	-0.0244	-0.0249	-0.024	-0.0226	-0.0233
	[-0.70]	[-0.69]	[-0.70]	[-0.68]	[-0.64]	[-0.66]
FDI_s (ln)	-0.7887	-0.8253 **	-0.7903	-0.7946	-0.8495	-0.7703
	[-1.37]	[-1.43]	[-1.34]	[-1.35]	[-1.44]	[-1.25]
FOREIGN (d)	-0.007	-0.0071	-0.007	-0.0069	-0.007	-0.0066
	[-0.80]	[-0.81]	[-0.80]	[-0.78]	[-0.80]	[-0.75]
SIZE (ln)	0.3939	0.4195 **	0.3952	0.3995	0.4361	0.3771
	[0.99]	[1.05]	[0.97]	[0.98]	[1.07]	[0.88]
SME (d)	0.0934	0.1000 **	0.0938	0.0952	0.1047	0.0896
	[0.92]	[0.99]	[0.91]	[0.92]	[1.01]	[0.82]
PARENT (d)	0.0005	0.0003	0.0005	0.0004	0.0000	0.0008
	[0.06]	[0.04]	[0.06]	[0.04]	[-0.01]	[0.10]
MARK-UP	-0.1584 ***	-0.1554 ***	-0.1568 ***	-0.1423 ***	-0.1152 ***	-0.0966 ***
	[-4.45]	[-4.51]	[-4.45]	[-4.18]	[-3.64]	[-2.95]
UD		-0.0022	-0.0024	0.0052	0.0111 **	0.0028
		[-0.39]	[-0.42]	[0.96]	[2.06]	[0.51]
HIGH SKILLED			0.1263	-0.8468	-0.1014	-0.3505
			[0.14]	[-1.00]	[-0.11]	[-0.37]
FEMALE				0.0526 ***	0.0548 ***	0.0365 ***
				[4.97]	[5.11]	[3.39]
SENIORITY					0.1329 ***	0.1296 ***
					[5.30]	[4.93]
IMPORT_PENETR						0.0224 ***
						[6.64]
LS(t-1) (ln)	0.481	0.466	0.4797	0.4736	0.4378	0.4884
	[1.61]	[1.57]	[1.60]	[1.59]	[1.48]	[1.56]
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummies	Yes	Yes	Yes	Yes	Yes	Yes
Aerllano-Bond (1)	-2.49 (0.013)	-1.89 (0.059)	-2.65 (0.008)	-2.88 (0.004)	-2.56 (0.010)	-2.47 (0.014)
Aerllano-Bond (2)	0.93 (0.352)	0.09 (0.929)	1.18 (0.239)	1.19 (0.234)	1.02 (0.309)	0.88 (0.379)
Sargan test	4.70 (0.095)	4.72 (0.095)	4.72 (0.095)	4.66 (0.097)	4.43 (0.109)	4.85 (0.088)
N	102,829	102,829	102,829	102,829	102,829	102,829

Note 1 Author's calculation.
2 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.
3 "FE" denotes fixed-effect model. "AB" denotes Arellano Bond GMM estimation.
4 "ln" denotes the variable is logarithmic.
5 "d" denotes the variable is a dummy variable.
6 "Arellano-Bond (1) and (2)" denotes the Arellano-Bond test of first and second order serial correlation. Parentheses indicates p-value.
7 "Sargan" denotes the Sargan test of over-identification restriction. Parentheses indicates p-value.

Contrary to our expectation, the impact of the share of female workers is positive and significant (columns [17] and [18]). [17] To examine the background of the result, we confirmed the relationship between changes in the share of female workers and labor share during the research period; many sectors experienced a decline in both the share of female workers and labor share during the 2000s, along with a decrease in the number of firms and total workers.[18] In the Japanese manufacturing sector, female workers have lower wages and a lower skill level than male workers on average.[19] Thus, a decrease in the proportion of female workers indicates a decrease in workplaces for unskilled workers. This phenomenon is likely also affected by internationalization. Considering the traditional HO framework, in a country with affluent capital and skilled labor such as Japan, we can infer that production factors shifted from a labor-intensive industry to a capital-intensive industry due to economic internationalization such as an overseas expansion of labor-intensive production process, and as a result, the shift decreased the number of workplaces for unskilled female workers and directly led to a decline in firms'

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[17] First, we should note that the result does not strictly reflect a positive correlation between the firm-level share of female workers and the labor share, as the indicator is at the sector level.

[18] According to the "Labour Force Survey" that the MIC implemented, the number of female workers in the manufacturing sector was 4.33 million in 2002, following the application of the new industrial classification, but decreased to 3.17 million in 2012. During this period, except for 2006, it consistently decreased. During the same period, the proportion of women among manufacturing workers also declined from 33.5% to 29.5%.

[19] According to the Basic Survey on Wage Structure (hereafter the BSWS) implemented annually by MHLW, the average wage (contractual cash earnings in June) for female workers was approximately 60% of that for male workers during the JBSA survey period in this chapter. The ratio of female workers' average monthly wage to male workers' average monthly wage was 58.8% in 2001.Although it gradually increased afterwards, it was still only 63.3% in 2012.

labor share. [20]

In columns [17] and [18], we add the variable of seniority, which we measure as the ratio of the number of employees of different age groups (over 35 years old or under 35 years old).[21] The positive and significant coefficients are quite reasonable.

The strongly positive coefficient of the import penetration ratio is also opposite to our expectation (column [18]).[22] We observed the relationship between changes in import penetration and labor share and found a negative correlation between the two variables in many sectors, with only 10 sectors having a positive correlation. In particular, the "Electronic data processing machines, digital and analog computer equipment and accessories" (hereinafter, "Computer equipment") and "Communication equipment" sectors experienced an inflow of large amounts of imports: an increase in the import penetration rate by more than 30 percentage points. The significant decrease in sales as well as value added during the same period indicates that the two sectors suffered from decreasing competitiveness. [23] Because wage payment did not fall as quickly as value

[20] Sauré and Zoabi (2014) provided an example of research that shows internationalization leads to a decline in the share of female workers. They indicated that after joining NAFTA, in the US states adjacent to Mexico, the share of female workers decreased, and the wage gap between male and female workers widened, compared to other states.
[21] We also estimated the model with a different age threshold (40-year-olds and 45-year-olds). The results were very similar to those that we present in Table 4.
[22] We also ran estimates using an alternative definition of import impacts (import/output), and they largely confirmed the results. Furthermore, dropping the firm-level dummy variable for imports did not make any significance difference in the outcomes that we present in Table 4.
[23] According to the JIP Database, the sales, value added, and wage payment of the "Computer equipment" and "Communication equipment" sectors decreased from 2001 to 2012 as follows.

added due to wage rigidity, the labor share likely rose with import exposure. Similar results for the US industries are reported by Autor et al. (2020). [24] These two sectors may have influenced the overall outcomes. In fact, a negative correlation is observed if we estimate the correlation except for these two sectors.

6. Concluding remarks

In this chapter, we presented an analysis of the determinants of the labor share in Japan in the 2000s based on firm-level data. This is, to our knowledge, the first micro-level study on the labor share for this country. Our outcomes can be summarized as follows. As in many previous studies, a stable correlation between the total factor productivity and the labor share emerges. Noteworthy and original evidence is the significant and positive impact of tangible capital intensity, intangible assets, and ICT expenditures on the labor share. Regarding the role of intangible assets, our findings are consistent with those of Perugini, Vecchi, and Venturini (2017), who showed that

	Sales	Value added	Wage payment
Computer equipment	-77.5%	-76.1%	-70.2%
Communication equipment	-57.3%	-62.1%	-60.2%

[24] Autor et al. (2020) report that the negative effect of rising Chinese import exposure on industry payroll is smaller in absolute magnitude in US industries, and as a result, the labor share of sales or value added tends to rise with growth of industry import exposure.

increasing investments in intangible assets, such as goodwill, brand development, and training, drive the labor share upward. They based their analysis on firm data for six EU countries (Austria, France, Germany, Hungary, Italy, and Spain), and their interpretation was that investments in intangible assets require highly skilled workers who command higher wages and therefore increase the labor share. Our results indicate that a similar mechanism might hold in Japan, with expenditure for intangible assets, such as R&D and advertisement, accompanying a higher demand for skilled workers and, through this channel, increasing the labor share.

As for internationalization activities, particularly exporting, the result is consistent with the results of previous research that has highlighted a negative impact on the labor share. However, in Japan, the effect tends to be irrelevant for firms with a small share of international activities and limited only to firms that are more active on international markets. This result might imply that the mechanism of comparative advantage, offshoring or imperfect competition which explained in 2.2 work only for firms with international engagements exceeding a certain threshold.

Two questions arise here. One is the existence of a wage premium of exporting firms/plants; many empirical studies confirmed it after the 2000s. While firms' exports have the effect of decreasing the labor share, wages of exporting firms tend to be higher than those of non-exporting firms. This seemingly contradictory phenomenon will be analyzed in detail in Chapter 3.

The other is on the comparative advantage of skilled labor. As the effect of the capital-related variables suggests, the presence of skilled labor appears to have a positive influence on the determination of labor share. Meanwhile, exporting firms' negative effect on the labor share implies that exporters may decrease the number of skilled and unskilled employees. In the case of Japan, skilled labor-intensive goods have a comparative advantage, and exports are thought to be skilled labor-intensive. However the estimation results in this chapter implies that Japan's exports may not be so skilled and labor-intensive. This point will be verified in Chapter 4.

Our panel data lack some important workers' information, such as education, career, and experience at the firm level. The fact that we approximate such information with variables at the sector level might be at the basis of some unexpected result. Further research is necessary on such crucial and socially sensitive aspects, by means of matched data that combine firms' and workers' information, as explained at in Chapter 1. This is one avenue in which the present research requires development.

Finally, we would like to point out the influence of institutional factors on our results, particularly those related to the labor market. An important characteristic of

Japan's labor market is the so-called lifetime employment and seniority system. Although the system has undergone a gradual review since the 1990s, in the 2000s, manufacturing firms characterized by this system still accounted for a large share of the total. Our analysis reflects this in the positive effects of the ratio of regular employees and seniority. A deeper analysis of the effect of country- or sector-specific institutional settings on the share of output accruing to labor at the firm level is another priority on our future research agenda.

Appendix 1 Labor share determinants derived from production function

In this appendix, based on Perugini and Fukao (2021) I show the ratio of multiple capitals to output and capital augmenting technology indices are the determinants of the labor share derived from production function.

Let me start from the following assumption of production technology of a firm. Superscripts *i, j*, and *t* are omitted for simplicity.

$$Y = \quad G \; Y_T^{\gamma_T} Y_{INT}^{\gamma_{INT}} Y_{ICT}^{\gamma_{ICT}} \text{ where } \gamma_T + \gamma_{INT} + \gamma_{ICT} = 1 \tag{A1}$$

$$Y_T = \{\alpha_T (A_T K_T)^{\varepsilon_T} + (1-\alpha_T)(B_T L_T)^{\varepsilon_T}\}^{\frac{1}{\varepsilon_T}} \tag{A2}$$

$$Y_{INT} = \{\alpha_{INT} (A_{INT} K_{INT})^{\varepsilon_{IT}} + (1-\alpha_{INT})(B_{INT} L_{INT})^{\varepsilon_{INT}}\}^{\frac{1}{\varepsilon_{INT}}} \tag{A3}$$

$$Y_{ICT} = \{\alpha_{ICT} (A_{ICT} K_{ICT})^{\varepsilon_{ICT}} + (1-\alpha_{ICT})(B_{ICT} L_{ICT})^{\varepsilon_{ICT}}\}^{\frac{1}{\varepsilon_{ICT}}} \tag{A4}$$

I assume that there are four production factors: tangible capital asset, intangible capital asset, ICT capital asset and workers. *T*, *INT*, and *ICT* are superscripts of each capital.

I also assume that production process is divided into four parts: a final good production process and three processes of intermediate capital goods; tangible-asset-intensive process, which uses tangible asset K_T and workers L_T and produce intermediate output Y_T ; Intangible-capital-intensive process, which uses intangible asset K_{INT} and workers L_{INT} and produce intermediate output Y_{INT}; ICT-capital-intensive process, which uses and ICT capital K_{ICT} and workers L_{ICT}, and produce intermediate output Y_{ICT}. Each process is expressed with CES production technology as in (A2) ~ (A4). I assume that the elasticity of substitution, $1/(1-\varepsilon_i)$ is constant ($i =$ $T, INT,$ and ICT) and ε_i< 1. Three intermediate outputs are used as a input for Cobb-Douglass production process of final good Y. G denotes Hicks neutral technology growth. A_i is a capital augmenting technology index and B_i is a labor augmenting technology growth in process i.

Let p_i denote the unit production cost of each intermediate good i. From first order condition of cost minimization in production of the intermediate capital goods, we have,

$$p_T = \frac{r_T K_T + wL_T}{Y_T}$$
$$= \{\alpha_T^{\frac{1}{1-\varepsilon_T}} A_T^{\frac{\varepsilon_T}{1-\varepsilon_T}} r_T^{\frac{\varepsilon_T}{\varepsilon_T-1}} + (1-\alpha_T)^{\frac{1}{1-\varepsilon_T}} B_T^{\frac{\varepsilon_T}{1-\varepsilon_T}} w^{\frac{\varepsilon_T}{\varepsilon_T-1}}\}^{1-\frac{1}{\varepsilon_T}} \tag{A5}$$

$$p_{INT} = \frac{r_{INT} K_{INT} + wL_{INT}}{Y_{INT}}$$
$$= \{\alpha_{INT}^{\frac{1}{1-\varepsilon_{INT}}} A_{INT}^{\frac{\varepsilon_{ITT}}{1-\varepsilon_{INT}}} r_{INT}^{\frac{\varepsilon_{IT}}{\varepsilon_{IT}-1}} + (1-\alpha_{INT})^{\frac{1}{1-\varepsilon_{INT}}} B_{INT}^{\frac{\varepsilon_{INT}}{1-\varepsilon_{INT}}} w^{\frac{\varepsilon_{INT}}{\varepsilon_{INT}-1}}\}^{1-\frac{1}{\varepsilon_{INT}}} \tag{A6}$$

$$p_{ICT} = \{\alpha_{ICT}^{\frac{1}{1-\varepsilon_{ICT}}} A_{ICT}{}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} r_{ICT}{}^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}} + (1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}} B_{ICT}{}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} w^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}}\}^{1-\frac{1}{\varepsilon_{ICT}}} \tag{A7}$$

Next, we look at the profit maximization of the final good. The first order condition is

$$\gamma_i \frac{pY}{Y_i} = p_i \tag{A8}$$

p denotes final good price. Plugging (A9) into (A1), we have

$$p = \frac{1}{G} \frac{p_T^{\gamma_T} p_{INT}^{\gamma_{INT}} p_{ICT}^{\gamma_{ICT}}}{\gamma_T^{\gamma_T} \gamma_{INT}^{\gamma_{INT}} \gamma_{ICT}^{\gamma_{ICT}}} \tag{A9}$$

By substituting (A9) into (A8), we can derive

$$\frac{Y}{Y_{ICT}} = G \left(\frac{\gamma_T}{\gamma_{ICT}}\right)^{\gamma_T} \left(\frac{\gamma_{INT}}{\gamma_{ICT}}\right)^{\gamma_{INT}} \left(\frac{p_{ICT}}{p_T}\right)^{\gamma_T} \left(\frac{p_{ICT}}{p_{INT}}\right)^{\gamma_{INT}}$$
$$= G \;\; D \;\; \left(\frac{p_T}{p_{IT}}\right)^{\gamma_T} \left(\frac{p_{INT}}{p_{IT}}\right)^{\gamma_{INT}} \tag{A10}$$

where $D = \left(\frac{\gamma_T}{\gamma_{ICT}}\right)^{\gamma_T} \left(\frac{\gamma_{INT}}{\gamma_{ICT}}\right)^{\gamma_{INT}}$

Plugging (A5) ~ (A7) into (A10), we have

$$\frac{Y}{Y_{ICT}}$$

$$= G\ \ D\ \left[\frac{\{\alpha_{ICT}^{\frac{1}{1-\varepsilon_{ICT}}} A_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} r_{ICT}^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}} + (1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}} B_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} w^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}}\}^{1-\frac{1}{\varepsilon_{ICT}}}}{\{\alpha_{T}^{\frac{1}{1-\varepsilon_{T}}} A_{T}^{\frac{\varepsilon_{T}}{1-\varepsilon_{T}}} r_{T}^{\frac{\varepsilon_{T}}{\varepsilon_{T}-1}} + (1-\alpha_{T})^{\frac{1}{1-\varepsilon_{T}}} B_{T}^{\frac{\varepsilon_{T}}{1-\varepsilon_{T}}} w^{\frac{\varepsilon_{T}}{\varepsilon_{T}-1}}\}^{1-\frac{1}{\varepsilon_{T}}}}\right]^{\gamma_T}$$

$$\left[\frac{\{\alpha_{ICT}^{\frac{1}{1-\varepsilon_{ICT}}} A_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} r_{ICT}^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}} + (1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}} B_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} w^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}}\}^{1-\frac{1}{\varepsilon_{ICT}}}}{\{\alpha_{INT}^{\frac{1}{1-\varepsilon_{INT}}} A_{INT}^{\frac{\varepsilon_{ITT}}{1-\varepsilon_{INT}}} r_{INT}^{\frac{\varepsilon_{IT}}{\varepsilon_{IT}-1}} + (1-\alpha_{INT})^{\frac{1}{1-\varepsilon_{INT}}} B_{INT}^{\frac{\varepsilon_{INT}}{1-\varepsilon_{INT}}} w^{\frac{\varepsilon_{INT}}{\varepsilon_{INT}-1}}\}^{1-\frac{1}{\varepsilon_{INT}}}}\right]^{\gamma_{INT}}$$

$= G\ \ D\ \ E\ \ F$ where

$$E = \left[\frac{\{\alpha_{ICT}^{\frac{1}{1-\varepsilon_{ICT}}} A_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} (\frac{r_{ICT}}{w})^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}} + (1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}} B_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}}\}^{1-\frac{1}{\varepsilon_{ICT}}}}{\{\alpha_{T}^{\frac{1}{1-\varepsilon_{T}}} A_{T}^{\frac{\varepsilon_{T}}{1-\varepsilon_{T}}} (\frac{r_{T}}{w})^{\frac{\varepsilon_{T}}{\varepsilon_{T}-1}} + (1-\alpha_{T})^{\frac{1}{1-\varepsilon_{T}}} B_{T}^{\frac{\varepsilon_{T}}{1-\varepsilon_{T}}}\}^{1-\frac{1}{\varepsilon_{T}}}}\right]^{\gamma_T}$$

$$F = \left[\frac{\{\alpha_{ICT}^{\frac{1}{1-\varepsilon_{ICT}}} A_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}} (\frac{r_{ICT}}{w})^{\frac{\varepsilon_{ICT}}{\varepsilon_{ICT}-1}} + (1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}} B_{ICT}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}}\}^{1-\frac{1}{\varepsilon_{ICT}}}}{\{\alpha_{INT}^{\frac{1}{1-\varepsilon_{INT}}} A_{INT}^{\frac{\varepsilon_{ITT}}{1-\varepsilon_{INT}}} (\frac{r_{INT}}{w})^{\frac{\varepsilon_{IT}}{\varepsilon_{IT}-1}} + (1-\alpha_{INT})^{\frac{1}{1-\varepsilon_{INT}}} B_{INT}^{\frac{\varepsilon_{INT}}{1-\varepsilon_{INT}}}\}^{1-\frac{1}{\varepsilon_{INT}}}}\right]^{\gamma_{INT}}$$

(A11)

Y/Y_{ICT} can be expressed as a function of relative factor price, r_T/w, r_{INT}/w and r_{ICT}/w.

Next we show that each of relative factor prices is a function of factor-output ratio. From (A2), we can derive

$$\frac{K_T}{Y_T} = \left\{ \frac{1}{\alpha_T {A_T}^{\varepsilon_T} + (1-\alpha_T) {B_T}^{\varepsilon_T} \left(\frac{L_T}{K_T}\right)^{\varepsilon_T}} \right\}^{\frac{1}{\varepsilon_T}} \tag{A12}$$

From (A12),

$$\frac{L_T}{K_T} = \left\{ \frac{\left(\frac{Y_T}{K_T}\right)^{\varepsilon_{IT}} - \alpha_T {A_T}^{\varepsilon_T}}{(1-\alpha_T) {B_T}^{\varepsilon_T}} \right\}^{\frac{1}{\varepsilon_T}} \tag{A13}$$

From the first order condition of cost minimization in tangible asset production and (A13),

we can derive

$$\frac{r_T}{w} = \frac{\alpha_T}{1-\alpha_T} \left(\frac{A_T}{B_T}\right)^{\varepsilon_T} \left(\frac{L_T}{K_T}\right)^{1-\varepsilon_T}$$

$$= \frac{\alpha_T}{1-\alpha_T} \left(\frac{A_T}{B_T}\right)^{\varepsilon_T} \left\{ \frac{\left(\frac{Y_T}{K_T}\right)^{\varepsilon_T} - \alpha_T {A_T}^{\varepsilon_T}}{(1-\alpha_T) {B_T}^{\varepsilon_T}} \right\}^{\frac{1-\varepsilon_T}{\varepsilon_T}} \tag{A14}$$

Similarly, we have

$$\frac{r_{INT}}{w} = \frac{\alpha_{INT}}{1-\alpha_{INT}} \left(\frac{A_{INT}}{B_{INT}}\right)^{\varepsilon_{INT}} \left\{ \frac{\left(\frac{Y_{INT}}{M_{INT}}\right)^{\varepsilon_{INT}} - \alpha_{INT} {A_{INT}}^{\varepsilon_{INT}}}{(1-\alpha_{INT}) {B_{INT}}^{\varepsilon_{INT}}} \right\}^{\frac{1-\varepsilon_{INT}}{\varepsilon_{INT}}} \tag{A15}$$

$$\frac{r_{ICT}}{w} = \frac{\alpha_{ICT}}{1-\alpha_{ICT}} \left(\frac{A_{ICT}}{B_{ICT}}\right)^{\varepsilon_{IT}} \left\{ \frac{\left(\frac{Y_{ICT}}{K_{ICT}}\right)^{\varepsilon_{IT}} - \alpha_{ICT} {A_{ICT}}^{\varepsilon_{ICT}}}{(1-\alpha_{ICT}) {B_{ICT}}^{\varepsilon_{ICT}}} \right\}^{\frac{1-\varepsilon_{ICT}}{\varepsilon_{ICT}}} \tag{A16}$$

Substituting (A14) ~ (A16) into (A11), we have the following equation.

$$\frac{Y}{Y_{ICT}} = \quad G \;\; D \;\; E' \;\; F' \qquad \text{where}$$

$$E' = \left[\frac{\left\{\alpha_{ICT}(1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}}A_{ICT}{}^{\varepsilon_{ICT}}B_{ICT}{}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}}\dfrac{1}{\left(\frac{Y_{ICT}}{Y}\frac{Y}{K_{ICT}}\right)^{\varepsilon_{ICT}}-\alpha_{ICT}A_{ICT}{}^{\varepsilon_{ICT}}}+(1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}}B_{ICT}{}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}}\right\}^{1-\frac{1}{\varepsilon_{ICT}}}}{\left\{\alpha_{T}(1-\alpha_{T})^{\frac{1}{1-\varepsilon_{T}}}A_{T}{}^{\varepsilon_{T}}B_{T}{}^{\frac{\varepsilon_{T}}{1-\varepsilon_{T}}}\dfrac{1}{\left(\frac{Y_{T}}{Y}\frac{Y}{K_{T}}\right)^{\varepsilon_{T}}-\alpha_{T}A_{T}{}^{\varepsilon_{T}}}+(1-\alpha_{T})^{\frac{1}{1-\varepsilon_{T}}}B_{T}{}^{\frac{\varepsilon_{T}}{1-\varepsilon_{T}}}\right\}^{1-\frac{1}{\varepsilon_{T}}}}\right]^{\gamma_T}$$

$$F' = \left[\frac{\left\{\alpha_{ICT}(1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}}A_{ICT}{}^{\varepsilon_{ICT}}B_{ICT}{}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}}\dfrac{1}{\left(\frac{Y_{ICT}}{Y}\frac{Y}{K_{ICT}}\right)^{\varepsilon_{ICT}}-\alpha_{ICT}A_{ICT}{}^{\varepsilon_{ICT}}}+(1-\alpha_{ICT})^{\frac{1}{1-\varepsilon_{ICT}}}B_{ICT}{}^{\frac{\varepsilon_{ICT}}{1-\varepsilon_{ICT}}}\right\}^{1-\frac{1}{\varepsilon_{ICT}}}}{\left\{\alpha_{INT}(1-\alpha_{INT})^{\frac{1}{1-\varepsilon_{INT}}}A_{INT}{}^{\varepsilon_{INT}}B_{NIT}{}^{\frac{\varepsilon_{INT}}{1-\varepsilon_{INT}}}\dfrac{1}{\left(\frac{Y_{INT}}{Y}\frac{Y}{K_{INT}}\right)^{\varepsilon_{INT}}-\alpha_{INT}A_{INT}{}^{\varepsilon_{INT}}}+(1-\alpha_{INT})^{\frac{1}{1-\varepsilon_{INT}}}B_{INT}{}^{\frac{\varepsilon_{INT}}{1-\varepsilon_{INT}}}\right\}^{1-\frac{1}{\varepsilon_{IIT}}}}\right]^{\gamma_{INT}}$$

(A17)

That is, Y/Y_{ICT} is expressed as an implicit function with endogenous variables of Y/Y_T, Y/Y_{INT} and Y/Y_{ICT} itself. Similarly, Y/Y_T and Y/Y_{INT} can be expressed as a similar implicit function.

In the case that $Y/Y_T > 0$, $Y/Y_{INT} > 0$ and $Y/Y_{ICT} > 0$, the three implicit functions are continuous and differentiable with respect to Y/Y_T, Y/Y_{INT} and Y/Y_{ICT}. Therefore, we can apply a standard implicit function theorem for the system of three implicit functions, and we have

$$\frac{Y}{Y_T} = \theta_T\left(\frac{K_T}{Y}, \frac{K_{INT}}{Y}, \frac{K_{ICT}}{Y}, G, A_T, A_{INT}, A_{ICT}, B_T B_{INT}, B_{ICT}\right) \tag{A18}$$

$$\frac{Y}{Y_{INT}} = \theta_{INT}\left(\frac{K_T}{Y}, \frac{K_{INT}}{Y}, \frac{K_{ICT}}{Y}, G, A_T, A_{INT}, A_{ICT}, B_T B_{INT}, B_{ICT}\right) \tag{A19}$$

$$\frac{Y}{Y_{ICT}} = \theta_{ICT}\left(\frac{K_T}{Y}, \frac{K_{INT}}{Y}, \frac{K_{ICT}}{Y}, G, A_T, A_{INT}, A_{ICT}, B_T B_{INT}, B_{ICT}\right) \tag{A20}$$

By the theorem, Y/Y_T is an increasing function of K_T/Y and a decreasing function of K_{INT}/Y and K_{ICT}/Y. In a similar way, Y/Y_{INT} is an increasing function of K_{INT}/Y and a decreasing function of K_T/Y and K_{ICT}/Y. Y/Y_{ICT} is an increasing function of K_{ICT}/Y and a decreasing function of K_T/Y and K_{INT}/Y.

Next, we calculate the labor share of each intermediate good production process, $S_{i,L}$. From the first order condition of profit maximization, we have

$$\begin{aligned} S_{T,L} &= 1 - \alpha_T\left(A_T \frac{K_T}{Y_T}\right)^{\varepsilon_T} \\ &= 1 - \alpha_T\left(A_T \frac{K_T}{Y}\right)^{\varepsilon_T}\left(\frac{Y}{Y_T}\right)^{\varepsilon_T} \end{aligned} \tag{A21}$$

$$S_{INT,L} = 1 - \alpha_{INT}\left(A_{INT} \frac{K_{INT}}{Y}\right)^{\varepsilon_{INT}}\left(\frac{Y}{Y_{INT}}\right)^{\varepsilon_{INT}} \tag{A22}$$

$$S_{ICT,L} = 1 - \alpha_{ICT}\left(A_{NIT} \frac{K_{ICT}}{Y}\right)^{\varepsilon_{ICT}}\left(\frac{Y}{Y_{ICT}}\right)^{\varepsilon_{ICT}} \tag{A23}$$

Finally, we can derive the labor share S_L function as follows.

$$
\begin{aligned}
S_L &= \frac{wL_T + wL_{INT} + wL_{ICT}}{pY} \\
&= \frac{p_T Y_T}{pY}\frac{wL_T}{p_T Y_T} + \frac{p_{INT}Y_{INT}}{pY}\frac{wL_{INT}}{p_{INT}Y_{INT}} + \frac{p_{ICT}Y_{ICT}}{pY}\frac{wL_{ICT}}{p_{NIT}Y_{ICT}} \\
&= 1 - \gamma_T \alpha_T \left(A_T \frac{K_T}{Y}\right)^{\varepsilon_T} \theta_T^{\varepsilon_T} - \gamma_{INT}\alpha_{INT}\left(A_{INT}\frac{K_{INT}}{Y}\right)^{\varepsilon_{INT}} \theta_{INT}^{\varepsilon_{INT}} \\
&\quad -\gamma_{ICT}\alpha_{ICT}\left(A_{ICT}\frac{K_{ICT}}{Y}\right)^{\varepsilon_{ICT}} \theta_{ICT}^{\varepsilon_{ICT}} \qquad \text{(A24)}
\end{aligned}
$$

That is, S_L is directly affected by K_T/Y, K_{INT}/Y and K_{ICT}/Y and technology indices A_T, A_{INT}, and A_{ICT}. Hicks neutral technology change G and labor augmenting technology indices B_T, B_{INT}, and B_{ICT} do not affect directly on the labor share.

Appendix 2 List of variables

Table 2-A1: List of variables

label	level	Type	Description	Source
LS	firm	percentage	Total payroll to employees / value added	(1)
TFP	firm	continuous	Total Factor Productivity, estimated by Olley-Pakes Method, normalised by sector average in 2000	(1), (2)
K τ	firm	continuous	Real tangible fixed asset - real sales ratio	(1), (2)
E INT	firm	continuous	Real expenditure for intangible asset - real sales ratio	(1), (2)
E ICT	firm	percentage	Real ICTcost - real sales cost ratio	(1), (2)
E K	firm	percentage	Real acquisition of tangible fixed asset - real sales ratio	(1), (2)
PAT (d)	firm	binary	Company having patents developed by itself (=1, 0 otherwise)	(1)
REG	firm	percentage	Regular employees / total employees	(1)
EXP (d)	firm	binary	Company exporting outputs abroad (=1, 0 otherwise)	(1)
IMP (d)	firm	binary	Company importing iinputs from foreign countries (=1, 0 otherwise)	(1)
FDI (d)	firm	binary	Company having foeign subsidies (=1, otherwise 0)	(1)
FOREIGN (d)	firm	binary	Company partially or completely owned by foreign company (=1, otherwise 0)	(1)
EXP_s	firm	continuous	Export / Sales	(1)
IMP_s	firm	continuous	Import / Sales Cost	(1)
FDI_s	firm	continuous	Employees in foreign subsidies/total domestic employees	(1)
SIZE	firm	continuous	Number of total domestic employees	(1)
SME (d)	firm	binary	Firm with 300 or fewer employees	(1)
PARENT (d)	firm	binary	Firm owned by other companies	(1)
MARK-UP	sector	continuous	Sales / total cost	(2)
UD	sector	percentage	Union members / total workers	(2), (3)
HIGH SKILLED	sector	percentage	Number of hours worked by high skilled workers / number of hours worked by total workers	(2)
FEMALE	sector	percentage	Number of female workers / total workers	(2)
SENIORITY	sector	continuous	Number of employed > 35 years old / number of employed < 35 years old	(2)
IM_PENET	sector	continuous	Import/(Output + Import - Export)	(2)

Note: 1 In the "source" column, (1) denotes the JBSA survey. (2) denotes the JIP Database. (3) denotes the "Basic Survey on Labour Unions" conducted by MHLW.
2 On the calculation of TFP, see Appendix 3.
3 On the calculation of K, E INT , E ICT and E K, see Appendix 4.

Appendix 3 Estimation of firm's total factor productivity (TFP)

We estimated firms' total factor productivity (TFP) by Olley-Pakes Method, suggested in Olley and Pakes (1996). For the estimation, we prepare the following variables.

(1) Real output

Real output of firm i is calculated by dividing "sales" from the JBSA survey by sector-level output deflator.

$$R\ Y_{i,j,t} = Sales_{i,j,t}/P\ Y_{j,t}$$

$R\ Y_{i,j,t}$: Real sales of firm i in sector j in year t
$Sales_{i,j,t}$: Sales of firm i in sector j in year t
$P\ Y_{j,t}$: Output deflator of sector j in year t

Sector-level output deflator $P\ Y_{j,t}$ is calculated by dividing nominal output $N\ Y_{j,t}$ by real output $R\ Y_{j,t}$, that is, $P\ Y_{j,t} = N\ Y_{j,t}/\ R\ Y_{j,t}$. $N\ Y_{j,t}$ and $R\ Y_{j,t}$ are provided in the JIP Database.

(2) Labor input

"Number of total domestic employees" from the JBSA survey is used as a variable of labor input.

(3) Tangible fixed asset

“Fixed tangible asset” from the JBSA survey cannot be used as a variable of real capital asset because it includes land value and it is a nominal variable. Therefore we conducted the following treatment.

(i) Exclusion of land value

The JBSA survey in 1997 and 1998 has a questionnaire of firms’ land value. Therefore a ratio of land value to tangible fixed asset can be calculated.

Under the assumption that the ratio is constant during our research period, we have the tangible fixed asset except land value by multiplying a value of tangible fixed asset by (1 - the ratio).

(ii) Convert nominal value to real value

The amount of tangible fixed asset in the JBSA survey is nominal. To estimate the total factor productivity, we convert it to real value in the following steps.

a) By using the real capital stock $RK_{j,t}$ and real investment $RINV_{j,t}$ provided in the JIP Database, we calculate the nominal capital stock $NK_{j,t}$ for each sector j .

$$NK_{j,t} = \begin{cases} RK_{j,t} & if \;\; t = 2000 \\ NK_{j,t-1} * (1 - dep_{j,t}) & if \;\; t = 2001 \sim 2012 \end{cases}$$

$$dep_{j,t} = \frac{RINV_{j,t} - (RK_{j,t} - RK_{j,t-1})}{RK_{j,t-1}}$$

$NK_{j,t}$: Nominal capital stock (tangible fixed asset) of sector j in year t
$RK_{j,t}$: Real capital stock of sector j in year t
$RINV_{j,t}$: Real investment of sector j in year t
$dep_{j,t}$: Depreciation rate of sector j in year t

b) We convert the nominal tangible fixed asset of firm i, $NK_{i,j,t}$ to real value $RK_{i,j,t}$ by using the ratio of nominal and real capital stock of sector j.

$$RK_{i,j,t} = NK_{i,j,t} * \frac{RK_{j,t}}{NK_{j,t}}$$

$RK_{i,j,t}$: Real tangible asset of firm i in sector j in year t
$NK_{i,j,t}$: Nominal tangible asset of firm i in sector j in year t

Finally, following Yasar et al. (2008) with the data mentioned above and Stata command "opreg", we estimated firms' TFP, normalized by sector average in 2000.

$$TFP_{i,j,t} = \widehat{TFP_{i,j,t}} - \overline{TFP_{j,2000}}$$

$TFP_{i,j,t}$: Firm's TFP in year t normalized by sector j's average in 2000
$\widehat{TFP_{i,j,t}}$: Firm's TFP in year t estimated by Olley-Pakes Method
$\overline{TFP_{j,2000}}$: Average TFP of sector j in 2000

Appendix 4 Calculation of Kτ, E INT, E ICT, and E K

The variables of *Kτ*, *E INT, E ICT*, and *E K* are calculated as follows.

$$K\tau_{ij,t} = RK_{i,j,t}/(Sales_{i,j,t}/P\ \ Y_{j,t})$$

$K\tau_{ij,t}$: Real tangible fixed asset - real sales ratio of firm i in sector j in year t
$RK_{i,j,t}$: Real tangible asset of firm i in sector j in year t (see Appendix 3)
$Sales_{i,j,t}$: Sales of firm i in sector j in year t
$P\ \ Y_{j,t}$: Output deflator of sector j in year t (see Appendix 3)

$$E\ \ INT_{ij,t} = \left(\frac{RD_{i,j,t}}{P\ \ RD_t} + \frac{ADV_{i,j,t}}{P\ \ ADV_t}\right)/(Sales_{i,j,t}/PY_{j,t})$$

$E\ \ INT_{ij,t}$: Real expenditure for intangible asset - real sales ratio of firm i in sector j in year t
$RD_{i,j,t}$: Cost for research and development of firm i in sector j in year t
$ADV_{i,j,t}$: Cost for advertisement of firm i in sector j in year t
$P\ \ RD_t$: Output deflator of research and development sector in year t
$P\ \ ADV_t$: Output deflator of advertisement sector in year t

$$E\ \ ICT_{ij,t} = \left(ICT_{i,j,t}/P\ \ ICT_t\right)/(Sales\ \ cost_{i,j,t}/PY_{j,t})$$

$E\ \ ICT_{ij,t}$: Real ICT cost - real sales cost ratio of firm i in sector j in year t
$ICT_{ij,t}$: ICT cost of firm i in sector j in year t
$P\ \ ICT_t$: Output deflator of information service sector in year t
$Sales\ \ cost_{i,j,t}$: Sales cost of firm i in sector j in year t

$$E\ \ K_{ij,t} = \left(AC_{i,j,t}/P\ \ INV_{j,t}\right)/(Sales_{i,j,t}/PY_{j,t})$$

$E\ \ K_{ij,t}$: Real acquisition of tangible asset - real sales ratio of firm i in sector j in year t
$E\ \ K_{ij,t}$: Real acquisition of tangible asset
$P\ \ INV_{j,t}$: Investment deflator of sector j in year t

In the calculation of the variables, we utilize sector-level deflators, $P\ \ Y_{j,t}$, $P\ \ RD_t$, $P\ \ ADV_t$, $P\ \ ICT_t$ and $P\ \ INV_{j,t}$ derived from the nominal and real output data from the JIP Database. The derivation of $P\ \ RD_t$, $P\ \ ADV_t$, $P\ \ ICT_t$ and $P\ \ INV_{j,t}$ is in the same way as that of $P\ \ Y_{j,t}$ explained in Appendix 3.

When we convert these variables to logarithmic form, we add 1 to the original variable.

Appendix 5 Summary statistics of sector variables

Table A2: Summary statistics of sector variables

variables	observations	mean	std	min.	max.
MARK-UP	147,725	0.990	0.095	0.751	1.331
UD	147,725	30.166	19.838	7.400	94.700
HIGH SKILLED	147,725	0.330	0.003	0.318	0.336
FEMALE	147,725	0.314	0.140	0.111	0.661
SENIORITY	147,725	2.434	0.592	1.391	5.686
IMPORT_PENETR	147,725	0.144	0.125	0.004	0.723

Note: Author's calculation on the JIP database and the "Basic Survey on Labour Unions" conducted by MHLW.

Appendix 6 Summary statistics of sector variables

Table A3: Drivers of the Labor Share at the Firm Level in Japan (2001–2012)

Real acquisition of tangible fixed asset used rather than stock of tangible fixed asset

	[A1]	[A2]	[A3]	[A4]	[A5]	[A6]
Estimation Method	FE	AB (one step)	AB (two step)	FE	AB (one step)	AB (two step)
TFP (ln)	-0.3677 ***	-0.3945 ***	-0.3842 ***	-0.3681 ***	-0.4025 ***	-0.3911 ***
	[-66.31]	[-6.26]	[-4.05]	[-66.33]	[-7.03]	[-4.53]
E K (ln)	-0.0255 ***	0.0615 ***	0.0576 *	-0.0253 ***	0.0613 ***	0.0568 *
	[-2.93]	[2.62]	[1.66]	[-2.90]	[2.65]	[1.67]
E INT (ln)	0.5570 ***	0.7220 ***	0.7083 ***	0.5592 ***	0.7289 ***	0.7140 ***
	[13.41]	[9.29]	[4.79]	[13.47]	[9.58]	[4.88]
E ICT (ln)	0.1574 ***	0.2001 ***	0.1994	0.1581 ***	0.1987 ***	0.1980
	[2.68]	[2.66]	[1.40]	[2.70]	[2.63]	[1.40]
PAT (d)	-0.0019	-0.0034	-0.0033	-0.0016	-0.0033	-0.0032
	[-0.89]	[-0.93]	[-0.80]	[-0.76]	[-0.92]	[-0.78]
REG (ln)	0.0867 ***	0.1962 ***	0.2065 **	0.0878 ***	0.1941 ***	0.2054 **
	[8.46]	[2.79]	[2.08]	[8.57]	[2.91]	[2.19]
EXP (d)	0.0012	-0.0043	-0.0047			
	[0.51]	[-0.97]	[-0.88]			
IMP (d)	0.0030	-0.0016	-0.0012			
	[1.38]	[-0.45]	[-0.28]			
FDI (d)	-0.0016	-0.0132 *	-0.0134			
	[-0.52]	[-1.95]	[-1.47]			
EXP_s (ln)				-0.0817 ***	-0.1118 ***	-0.1125 ***
				[-6.26]	[-4.91]	[-3.46]
IMP_s (ln)				0.0345 ***	-0.0245	-0.0196
				[2.64]	[-1.04]	[-0.58]
FDI (d)				-0.1197 **	-0.8649 **	-0.922 *
				[-2.55]	[-2.32]	[-1.69]
FOREIGN (d)	-0.0042	-0.0069	-0.0076	-0.0036	-0.0073	-0.0080
	[-0.94]	[-0.83]	[-0.91]	[-0.80]	[-0.86]	[-0.95]
SIZE (ln)	0.0120 ***	0.4193	0.4630	0.0136 ***	0.4058	0.4541
	[3.69]	[1.50]	[1.15]	[4.15]	[1.55]	[1.21]
SME (d)	-0.0093 ***	0.1109	0.1215	-0.0094 ***	0.1044	0.1160
	[-2.58]	[1.54]	[1.17]	[-2.59]	[1.57]	[1.22]
PARENT (d)	-0.0076 **	-0.0001	-0.0015	-0.0076 **	0.0005	-0.0008
	[-2.32]	[-0.01]	[-0.18]	[-2.33]	[0.08]	[-0.10]
LS(t-1) (ln)	0.2883 ***	0.4117 **	0.3624	0.2880 ***	0.4263 **	0.3730
	[103.00]	[2.09]	[1.19]	[102.91]	[2.29]	[1.30]
CONST	-0.4612 ***			-0.4657 ***		
	[-2.65]			[-2.68]		
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Prefecture dummies	Yes	Yes	Yes	Yes	Yes	Yes
Aerllano-Bond (1)		-3.52 (0.000)	-2.14 (0.033)		-3.76 (0.000)	-2.28 (0.022)
Aerllano-Bond (2)		0.98 (0.329)	0.47 (0.639)		1.12 (0.261)	0.54 (0.586)
Sargan test		4.19 (0.123)	4.19 (0.123)		3.75 (0.153)	3.75 (0.153)
R-squared	0.1664			0.1673		
N	127,057	102,829	102,829	127,057	102,829	102,829

Note 1 Author’s calculation.

2 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

3 “FE” denotes Fixed-effect model. “AB” denotes Arellano Bond GMM estimation.

4 “ln” denotes the variable is logarithmic.

5 “d” denotes the variable is a dummy variable.

6 “Arellano-Bond (1) and (2)” denotes the Arellano-Bond test of first and second order serial correlation. Parentheses indicates p-value.

7. “Sargan” denotes the Sargan test of over-identification restriction. Parentheses indicates p-value.

Chapter 3 Wage Premium of Exporting Plants in Japan: An Analysis of Matched Employer-Employee Data

1. Introduction

Although in the previous chapter we found the negative impact of firms' internationalization activities on their labor share in Japan, this fact does not mean that firms engaged in international activities pay lower wages than non-international firms.

Previous studies focusing on a salary, a representative indicator of benefits for workers, indicated mean of wages at exporting firms is higher than that at non-exporting firms. The difference between them is called a "wage premium of exporting firms", and it has been observed in various countries around the world (Schank et al. 2007), including Japan (Wakasugi et al. 2008). The observed wage premium seems to be benefit for employees in exporting firms and inconsistent with the low labor share of exporting firms, observed in Chapter 2.

However, we should not conclude that employees in exporting firms obtain higher wages by exporting due to a wage premium because wages are affected by other firm or plant characteristics and individual workers' characteristics. Only if confirming that a wage premium of exporters exists after such various characteristics are controlled for, we can say employees at exporters receive higher wages. To control for them, recent studies have linked employer–employee data, combining data from firms and their employees and confirm the existence wage premium of exporters.

Following the recent studies, this chapter constructs Japan's cross-sectional employer–employee data by merging plants' data and employees' data from the public statistics, and estimates a Mincer-type wage function in the Japanese manufacturing sector to examine the existence of part of the wage premium that cannot be explained by other characteristics of workers and plants, i.e., a part purely correlated with exports.

Due to the data characteristics of Japanese public statistics, a matched employer–employee panel data cannot be constructed and we cannot exclude the possibility that unobservable characteristics of workers and plants affect wages. To minimize the effect, I also estimate a wage function by firm size, based on the idea that such differences are small among firms with a similar size.

In addition, to compare the degree of relative impact of exports to other factors, a Blinder－Oaxaca decomposition is conducted.

2. Previous studies

2.1 Studies on wage gaps between large and small firms

Before research on a wage premium of exporters became common in the 2000s, studies on wage differentials between large and small firms have been conducted. In Japan, the existence of a wage differential between large and small enterprises has been recognized for a long time, and theoretical interpretations of the phenomenon have been accumulated.[25]

In a normal perfect-competition economy, a wage should be equal to labor productivity. Therefore, assuming perfect competition, a wage differential according to firm size is caused by a difference in labor productivity among firm size. This hypothesis regarding the productivity gap is still effective today. For example, Fukao et al. (2014) factorized Japan's wage differential by firm size from 1975 to 2010 into labor share and labor productivity and indicated that the latter is greater.

If we investigate workers' side, it is possible that a difference in workers' inherent capabilities that does not appear in the data brings about a wage differential. Genda (1996) and Okui (2000) examined capability difference hypotheses and focused on this concept. They used data on workers who moved between companies of different

[25] For example, see the Small and Medium Enterprise Agency (1963).

sizes and decomposed their change in wages before and after the movement into the effects of the workers' specific skills/capabilities and other effects, showing that the former has a large effect.

2.2 Analyses of a wage premium of exporters

Analyses of an exporters' wage premium using microdata date back to Bernard and Jensen (1995), which made various comparisons between exporting and non-exporting plants using plant-level data of the manufacturing sector in the United States to show the significance of exporting. As a part of this, in a comparison of employees' average annual incomes and remunerations, exporting plants pay higher wages (prescribed salary) by 14.5% and remuneration (other than the prescribed salary) by 32.7% than do non-exporting plants. Furthermore, a regression was performed using the plants' average annual incomes and remunerations as a dependent variable, indicating that after controlling for plants' attributes, such as size and capital–labor ratio, the coefficient of the export dummy was significantly positive (4.4% for wage, 7.6% for remuneration), i.e., exporting plants paid higher wages than non-exporting plants. In the 2000s, similar studies were conducted in many countries. According to Schank et al. (2007), most of 21 empirical studies covering 22 countries confirmed the existence of a wage premium after controlling for other firms' or plants' variables in the same way Bernard and Jensen (1995) did.

However, the need to control for employee' attributes was noted from the first studies that detected a wage premium, which controlled for only the attributes of firms/plants. In his comment on Bernard and Jensen (1995), Lawrence (1995), noting the wage premium would shrink when the capital–labor ratio and size of plants were controlled for, wrote, "One suspects, moreover, that the premiums would be even further reduced if the authors were able to control for worker characteristics."

To control for workers' characteristics in addition to characteristics of firms/plants, it is necessary to conduct analyses using matched employer–employee data that connect data on employees and firms/plants. Whereas matched employer–employee data had been used in the field of labor economics, Schank et al. (2007) used them for the first time in an analysis of a wage premium of exporters.[26] They estimated a wage function using plant data for the manufacturing sector in the former West Germany. They verified the coefficient of the export dummy was not statistically significant by controlling for the characteristics of plants and employee. This means that there was no

[26] Initial studies using matched employer–employee data include Carrington and Troske (1998), which analyzed the wage differential between men and women among establishments, and Troske (1999) which analyzed the relationships between the sizes of workplaces and their wages.

wage gap due to exporting. [27]

Many other similar types of analyses also report that the significance of the export dummy disappears after employees' characteristics are controlled for.[28] Among them, Munch and Skaksen (2008), who address skilled-worker intensity of plants, are noteworthy. Using Denmark's matched employer-employee data, they estimated the wage function, including the intersection term of the sales–export ratio and the skilled-worker ratio. Here, the coefficients of the interaction term became significant, but the coefficient of the sales–export ratio became insignificant. They interpret this as indicating that firms with low skilled-labor ratios produce homogeneous goods, which compete with goods produced in low-income countries overseas, and as a result their suppressed profits makes it hard for them to raise workers' wages (rent sharing).

In Japan, Wakasugi et al. (2008) calculated the wage premium of exporters by using firm-level data from the JBSA survey (1997–2005). They estimated the average wage for exporting firms as 19–25% higher than that of non-exporting firms.

A small number of studies on wages using matched employer–employee data

[27] In addition, Schank et al. (2007) estimated the wage function, including the sales–export ratio instead of the export dummy to check whether the wage premium stems from export dependency, and they showed that the coefficient was significantly positive. This result implies that wage disparities exist only between plants with a high dependence on exports and other plants.

[28] See Wagner (2012) for a survey of analyses on a wage premium for exports using matched employer–employee data.

have also been conducted in Japan. Kawaguchi et al. (2006), constructing cross-sectional employer–employee data for each of 1993 to 2003, estimated the production function and wage function at establishment level, thereby calculating the gap between labor productivity and wage using workers' characteristics.[29]

From the viewpoint of globalization and wages, Tanaka (2015) and Endoh (2016) should also be noted as an analysis using matched employer–employee data in Japan.; the former focused on the wage premium of foreign-affiliated firms, and the latter analyzed the wage premium of offshoring firms. Both also confirmed and reject the existence of the wage premium of exporters. However it should be taken noted that [30] the data they used were extracted from relatively larger plants or firms, which tend to have good performance regardless export status. Thus, in this chapter, I use data covering smaller plants and the wage function is also estimated by firm size.

2.3 Theoretical interpretation of a wage premium of exporters

In the 2000s, research on trade theory explaining heterogeneity of trade behavior in firms

[29] According to Kawaguchi et al.'s (2006) estimation, the slope of the wage profile was larger than the slope of the productivity profile in the Japanese manufacturing sector, meaning that young workers receive rewards below their productivity on the one hand and middle-aged and older workers receive more rewards more than their productivity.

[30] The detail is explained in Section 3.

became more widespread, and a wage premium of exporters became popular to be theoretically interpreted.

Early research results include Yeaple (2005), who showed a model in which a wage premium between exporting and non-exporting firms would occur under perfect competition, and Helpman et al. (2010), who constructed a model in which a wage premium of exporting firm occurs between exporting and non-exporting firms in scenarios involving monopolistic competition and a search-type labor market.

In the model of Yeaple (2005), workers' skills are different and their distribution follows a constant probability density function. Because firms are homogeneous, it is possible for a firm to freely select any of three technologies (from low to high): production technology of homogeneous goods, low-level heterogeneous goods, and high-level heterogeneous goods. More-skilled workers are required for high-level technology. In this economy, he showed that firms with high-level technology employ workers with higher skills and pay higher wages, and found that under certain assumptions regarding fixed costs associated with the production of heterogeneous goods, only firms that select high-level heterogeneous good production technology come to export in an open economy. Since there is no heterogeneity among firms in the model, the wage premium of exporters stems from differences in workers' skills.[31]

Meanwhile, Helpman et al. (2010) constructed a model in which a wage premium arises between exporting and non-exporting firms in a monopolistic competition model assuming firm heterogeneity. Firms acquire profits according to their productivity under monopolistic competition. In the labor market, assumed to be a search-type market, firms must pay exploration and examination costs to hire workers. Firms that earn higher profits can pay higher exploration costs and higher wages than firms with lower profits. When exports become possible, only firms with high productivity export, thus expanding profits and increasing wages further. The wage premium in this case is considered to be based on differences in rent sharing among firms.[32]

According to Yeaple (2005), a wage premium can be explained fully by a difference in worker' skill, whereas a wage premium is attributed to the difference of firms' exporting status according to Helpman et al. (2010). Below, I will examine these hypotheses for Japan.

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[31] Verhoogen (2008) and Kugler and Verhoogen (2012) are also examples of studies that regard differences in workers' skills as a cause of the wage export premium.

[32] Other studies like Helpman et al. (2010), showing that differences in rent sharing among exporters and non-exporters bring wage export premiere, include Cosar et al. (2016), and Macis and Schvardi (2016).

3. Methodology

3.1 Estimation of a Mincer-type wage function

In this chapter, the following equation is estimated by OLS; it adds a dummy variable showing the presence or absence of exporting activity of plant or sales–export ratio:[33] [34]

$$
\begin{aligned}
\text{log\_}W_{ij} = {} & \alpha_0 + \alpha_1 \text{d\_export}_j + \alpha_2 \text{ log\_Skilled\_worker\_ratio}_j \\
& + \alpha_3 \text{ log\_Sales\_export\_ratio}_j * \text{ log\_Skilled\_worker\_ratio}_j \\
& + \alpha_4 \text{ d\_DOL}_j + \alpha_5 \text{log\_emp}_j + \alpha_6 \text{ d\_Firm\_size}_j + \alpha_7 \text{ d\_School}_{ij} \\
& + \alpha_8 \text{Potential\_Experience}_{ij} + \alpha_9 (\text{Potential\_Experience}_{ij})^2 + \alpha_{10} \text{ d\_Age60}_{ij} \\
& + \alpha_{11} \text{ d\_Line\_Product}_{ij} + \alpha_{12} \text{ d\_Emp\_style}_{ij} + \alpha_{13} \text{ d\_Female}_{ij} \qquad (1)
\end{aligned}
$$

i and j are indexes of employees and plants, respectively. W_{ij} is a salary of an employee in term of hourly wage as in many previous studies on wage function estimation. In this chapter, we consider two possible definitions of a wage. As discussed in Chapter 2, if firms' international activities bring about a permanent effect on the labor

[33] Kawaguchi (2011) is the source for the estimation of the Mincer-type wage function. Kawaguchi (2011) recommends that the analysis target be limited to workers under 59 years old, based on the fact that the wage profile becomes discontinuous before and after the retirement age of 60 in Japan. However, in this chapter the issue was dealt with by introducing age dummy variables.

[34] The endogeneity stemming from the reverse causality from wage to export dummy doesn't happen because it is highly unlikely that employee' wage level affects plants' export status. Therefore, many previous research including Schank et al. (2007) and Tanaka (2015) adopted OLS.

share, they must also have a constant effect on the scheduled cash earnings to be paid. Therefore, we first defined a wage as the amount of contractual cash earnings divided by contractual working hours (contractual wage). However, if the profitability of firms' international activities is unstable, firms may not reflect the profits from international activities in the constant increase in wage; rather, they may reflect them in the lump-sum payment linked to business performance. Therefore, we also used another definition of a wage: real cash earnings including overtime allowance and bonuses divided by actual working hours (actual wage). [35] The estimation of a wage function was conducted separately for each wage based on both definitions. The explanatory variables consisted of variables indicating the characteristics of the plants and firms in which employees work and variables indicating the characteristics of the employees (see Appendix Table 2-A1 for details on the variables). Following Munch and Skaksen (2008), the skilled-worker ratio of plants and its interaction term with the sales–export ratio were included as explanatory variables. The skilled-worker ratio measures the spillover effect of skilled labor on employees' wages. The sign can be either positive or negative. A plant with high skilled-labor ratio may produce differentiated goods that compete with few competitors and, as a result, can afford to raise wages. However, the spillover effect of skilled labor

[35] Please refer to Section 4 for the details of wage calculation.

may decrease in plants with abundant skilled labor because the rarity of skilled labor is diluted.

The interaction term measures the effect of a plant's competence in the context of the international market. In addition, the sign of the coefficient may be positive or negative. If a plant produces differentiated goods with highly skilled labor, it may supply its goods to overseas markets where competition is not fierce, and it may raise wages; that is, the sign is positive. On the other hand, if competition in foreign markets is fiercer, the sign might be negative.

An education dummy, potential experience in years and its square have been traditional explanatory variables of a wage function since Mincer (1974). In Japan, the applicable wage system is considered to differ depending on the working status (line or staff), section (management or production in the case of the manufacturing sector), and employment type of employees. Thus, dummy variables to classify these factors were used as explanatory variables. In addition, a dummy variable for workers over the age of 60 was inserted because many of them may retire and be rehired at reduced wage. The wage gap between male and female workers is not legally permitted when performing the same work, but because it is observed in reality, a female dummy was also added as an explanatory variable.

The export dummy is indispensable for analyzing exporters' wage premiums. It should be noted that plants with high wages may begin exporting. Because the causal relationship between exporting and wages cannot be strictly examines due to a lack of panel data, an alternative method was applied here. We estimated a wage function by replacing the export dummy with a variable revealing the export experience of a plant (number of exports during the investigation period, 2001- 2011). If the productivity of plants increases by exporting, more experienced exporters may pay higher wages.

$$\begin{aligned}\text{log\_}W_{ij} = {} & \alpha_0 + \alpha_1 \text{ Export\_experience}_j + \alpha_2 \text{ log\_Skilled\_worker\_ratio}_j \\ & + \alpha_3 \text{ log\_Sales\_export\_ratio}_j * \text{ log\_Skilled\_worker\_ratio}_j \\ & + \alpha_4 \text{ d\_DOL}_j + \alpha_5 \text{log\_emp}_j + \alpha_6 \text{ d\_Firm\_size}_j + \alpha_7 \text{ d\_School}_{ij} \\ & + \alpha_8 \text{Potential\_Experience}_{ij} + \alpha_9 (\text{Potential\_Experience}_{ij})^2 + \alpha_{10} \text{ d\_Age60}_{ij} \\ & + \alpha_{11} \text{ d\_Line\_Product}_{ij} + \alpha_{12} \text{ d\_Emp\_style}_{ij} + \alpha_{13} \text{ d\_Female}_{ij} \qquad (2)\end{aligned}$$

In addition, it is possible that wages may differ depending on export dependence even among exporting plants. Therefore, equation (3) is also estimated using sales–export ratio $\text{Sales\_export\_ratio}_j$, to control for export dependence of plants accurately:

$$\log\_W_{ij} = \alpha_0 + \alpha_1 \text{ Sales\_export\_ratio}_j + \alpha_2 \text{ log\_Skilled\_worker\_ratio}_j$$

$$+ \alpha_3 \text{ log\_Sales\_export\_ratio}_j * \text{ log\_Skilled\_worker\_ratio}_j$$

$$+ \alpha_4 \text{ d\_DOL}_j + \alpha_5 \text{log\_emp}_j + \alpha_6 \text{ d\_Firm\_size}_j + \alpha_7 \text{ d\_School}_{ij}$$

$$+ \alpha_8 \text{Potential\_Experience}_{ij} + \alpha_9 (\text{Potential\_Experience}_{ij})^2 + \alpha_{10} \text{ d\_Age60}_{ij}$$

$$+ \alpha_{11} \text{ d\_Line\_Product}_{ij} + \alpha_{12} \text{ d\_Emp\_style}_{ij} + \alpha_{13} \text{ d\_Female}_{ij} \qquad (3)$$

In addition to the baseline estimation mentioned above, we also estimated the wage functions by firm size to diminish the possibility that unobservable characteristics of employees and plants could affect the result of the estimation because, in general, such differences in characteristics are considered small among firms of a similar scale.

3.2 Blinder —Oaxaca Decomposition

The existence of a wage premium for exporters purely correlated with exporting behavior could be found by estimating the wage function explained above. The reason why we perform Blinder—Oaxaca decomposition is to grasp the relative importance of exporting relative to parts attributable to characteristics of workers and plants/firms.[36]

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[36] Blinder—Oaxaca decomposition is a wage factorization method proposed by Blinder (1973) and Oaxaca (1973). To quantify the part based on racial discrimination among the race-based wage disparities among companies in the United States, both decomposed wage differentials among racial diversity into a part based on workers' characteristics such as academic background and years of experience and a part

Specifically, the sample is divided into two groups: a group of employees at exporting plants and a group of employees at non-exporting plants. The wage function for each group was then estimated separately, and the differences of the logarithmic average wage between the two groups are decomposed as follows:

$$\overline{\ln w_i^{ex}} - \overline{\ln w_i^{nx}} = \sum_i \alpha^*(\overline{x_i^{ex}} - \overline{x_i^{nx}}) + \sum_i \overline{x_i^{ex}}(\alpha^{ex} - \alpha^*) + \sum_i \overline{x_i^{nx}}(\alpha^* - \alpha^{nx}) \qquad (4)$$

Here, subscripts *ex* and *nx* stand for exporters and non-exporters, respectively. α^{ex}, α^{nx}, and α^* are coefficients of export dummy in equation (1), estimated for the employees at exporting plants, for the employees at non-exporting plants, and for all employees in our data, respectively. [37]

that cannot be explained by difference in workers' characteristics, that is, part by discrimination). This method is explained in detail by Ogawa (2006).

This method is also applied to analysis of wage disparities between men and women, and recently, Yasui et al. (2016a, 2016b) applies it to the analysis analyzed of the wage differential between unlimited regular employees and limited regular employees as well as the wage gap between regular employees and fixed-term employees.

[37] Oaxaca (1973) shows the Blinder—Oaxaca decomposition utilizes one of the two coefficients calculated from two different group as a standard and, as a result, can be implemented in two methods. Based on the notation in this chapter, $\overline{\ln w_i^{ex}} - \overline{\ln w_i^{nx}}$ can be expressed in two alternative ways; that is,

$$\overline{\ln w_i^{ex}} - \overline{\ln w_i^{nx}} = \sum_i \alpha^{ex}(\overline{x_i^{ex}} - \overline{x_i^{nx}}) + \sum_i \overline{x_i^{nx}}(\alpha^{ex} - \alpha^{nx})$$

and

$$\overline{\ln w_i^{ex}} - \overline{\ln w_i^{nx}} = \sum_i \alpha^{nx}(\overline{x_i^{ex}} - \overline{x_i^{nx}}) + \sum_i \overline{x_i^{ex}}(\alpha^{ex} - \alpha^{nx})$$

Of course, the value of the first and second term on the left-hand side in the second equations is different from that of the same term in the first equation.

Regarding the choice of the two expressions, Newmark (1988) suggested a new expression, equation (4), which uses a coefficient calculated from the entire sample, which indicates a situation

On the right-hand side, the first term $(\sum_i \alpha^*(\overline{x_i^{ex}} - \overline{x_i^{nx}}))$ is based on the difference in attributes of plants. The other two terms form a part that cannot be explained by the difference between those attributes, stemming from the criteria dividing the two groups (in this case, the presence or absence of exporting).

4. Data

In this chapter, the following statistics conducted by the Government of Japan are utilized.

4.1 Basic Survey on Wage Structure

Individual employees' data including wage are extracted from the Basic Survey on Wage Structure (BSWS) implemented annually by MHLW. It is intended to identify the actual situation of employees' wages in major industries according to categories such as type of employment, type of labor, occupation, gender, age, level of education, length of service, and occupational career.

In the BSWS, samples of private establishments employing five regular

without difference/discrimination between two groups. This chapter follows the new method.

employees or more and public establishments employing 10 regular employees or more in major industries are required to report information on the establishment and employees, including attributes of the establishment, employment size of a firm to which a plant belongs, employees' types of employment, types of labor, levels of education, days and hours worked, cash earnings, and so on. It is impossible to construct panel employee-employer data because different identification numbers are assigned to each employee' information each year. For this reason, in this chapter, the individual employee data of the BSWS 2012 are linked with individual plant data from the Economic Census for Business Activity to construct a cross sectional data.

We used only the data of regular employees only[38] and we classified them into four groups according to whether they were full-time employees and whether they work on a time-specific contract. They are also classified into four groups by working section (management or production) and position (line or staff).

4.2 Economic Census for Business Activity

The Economic Census for Business Activity (ECBA), implemented by the MIC and

[38] In our data from the BSWS, "regular employee" refers to a worker who comes under any of the followings:
1 A worker employed with no defined period of employment
2 A worker employed for a defined period of employment that exceeds one month
3 A worker employed on a daily basis or for a defined period of one month or less, who was employed for 18 days or more in both April and May of 2012.

METI, is utilized to have individual plant data.

The objective of the ECBA is to identify the structure of establishments and enterprises in all industries on the national and regional levels and to obtain basic information for conducting various statistical surveys by investigating the economic activity of establishments and enterprises.

In this chapter, data from all manufacturing plants with four or more employees from the ECBA 2012 are linked with the individual employee data from the BSWS 2012. In the cross-section employer–employee data, 255,351 employees' data and 9,981 plant data are connected.

Also, the plant data from the ECBA are used to construct plant-level panel data after integration with data from the Census of Manufacture.

To identify exporting or non-exporting establishments, we use plants' response to the questionnaire "Ratio of direct export value to amount of shipment of manufactured goods" in the ECBA; if there is no answer or zero is recorded, we regard the plants as non-exporters, and other plants were regarded as exporters.

4.3 Census of Manufacture

The individual plant data from the Census of Manufacturer 2000 to 2010 are used together with the plant data of the ECBA 2012 to have information on plants' export experience.

The Census of Manufacture, which is conducted by METI to clarify actual conditions of the nation's manufacturing sector, is an annual survey of all plants with four or more employees in the manufacturing sector. The information collected from plants includes the amount of capital or investment, number of employees, costs of raw materials, value of manufactured goods shipments, etc.

5. Descriptive statistics

In this section, descriptive statistics for the sample used in this chapter are outlined.

5.1 Employees

The employees' characteristics are shown in Table 3-1. In addition to the attributes of the entire sample, the attributes of the employees by exporting and non-exporting plants are also shown. It is clear that employees of exporting plants are more educated on average, that is, that exporting plants are more skilled-labor-intensive. In this study, the mean of years of education, which is a proxy for the quality of employees, was 13.18 for exporting plants, 0.43 years longer than that for non-exporting plants, and the ratio of college and university graduates was 26.7% for exporting plants, 10 percentage points higher than that for non-exporting plants (16.4%). As a result, the average potential experience of workers at exporting plants was shorter than that of workers at non-exporting plants.

The percentage of elderly workers (aged 60 and over) was low: 8.9% for all plants. For exporting plants, the percentage is 6.2%, which is slightly lower than 9.4% for non-exporting plants.

The share of female workers was nearly 30% for all plants. The share for exporting plants was 18.8%, which is considerably lower than that for non-exporting plants (30.9%). There was no significant difference in the share of workers with managerial posts in the non-production departments between exporting and non-exporting plants. As for the staff (employees without managerial posts), the share exceeded 80% for both export and non-export establishments. However, exporting plants tended to deploy more staff members in non-production departments at exporting plants.

The percentage of regular employees (full-time employees without fixed employment terms) was nearly 80% (77.8%). Exporting plants surpassed this with a rate of 84.7%, which is nearly 10 percentage points higher than that for non-exporting plants (76.5%). For non-exporting plants, the proportion of unlimited non-regular employees, who are not regular employees, was relatively higher (21.6%) than that for exporting plants (13.9%).

There was a substantial difference in the size of firms where employees work between export and non-exporting plants. For exporting plants 72.5% of employees work for large firms with 300 or more regular workers, while for non-exporting plants, 74.7% of employees work for small and medium plants with fewer than 300 employees.

Table 3-1 Descriptive data for workers (2012)

	Whole sample			Non-exporting plants			Exporting plants		
	mean	std error	sample	mean	std error	sample	mean	std error	sample
Age	42.08	12.37	252,602	42.27	12.45	211,019	41.11	11.88	41,583
Years of education	12.82	1.84	228,320	12.75	1.81	188,519	13.18	1.93	39,801
Potential experience	28.53	12.47	228,320	28.73	12.54	188,519	27.57	12.11	39,801
Share					―			―	
Graduate from Univ/Grad School	18.1%	―	45,733	16.4%	―	34,629	26.7%	―	11,104
Management & line	13.2%	―	33,312	13.1%	―	27,570	13.8%	―	5,742
Management & staff	24.8%	―	62,754	23.6%	―	49,809	31.1%	―	12,945
Production & line	4.1%	―	10,297	3.8%	―	7,942	5.7%	―	2,355
Production & staff	57.9%	―	146,239	59.6%	―	125,698	49.4%	―	20,541
60 years or older workers	8.9%	―	22,490	9.4%	―	19,897	6.2%	―	2,593
Female	28.9%	―	73,054	30.9%	―	65,230	18.8%	―	7,824
Full-timer & permanent	77.8%	―	196,596	76.5%	―	161,382	84.7%	―	35,214
Full-timer & fixed term	1.9%	―	4,745	2.0%	―	4,154	1.4%	―	591
Part-time & permanent	7.4%	―	18,608	8.4%	―	17,634	2.3%	―	974
Part-time & fixrd term	12.9%	―	32,653	13.2%	―	27,849	11.6%	―	4,804
Firm size									
5～9 workers	4.7%	―	11,987	5.6%	―	11,752	0.6%	―	235
10～29 workers	12.2%	―	30,941	14.2%	―	30,022	2.2%	―	919
30～99 workers	20.4%	―	51,458	22.7%	―	47,975	8.4%	―	3,483
100～299 workers	21.2%	―	53,653	22.2%	―	46,869	16.3%	―	6,784
300～999 workers	17.0%	―	43,026	16.2%	―	34,116	21.4%	―	8,910
1,000～ workers	24.4%	―	61,537	19.1%	―	40,285	51.1%	―	21,252

Note 1 Author's calculation from the employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 "Years of education" is calculated based on the response to terminal stage of education: junior high school = 9, high school = 12, junior college = 14, university/graduate school = 16.
3 "Potential experience" is calculated as age minus education year.

5.2 Plants

The characteristics of the plants where employees work are summarized in Table 3-2. The number of the exporting plants was 1,043, accounting for 10.5% of the entire sample plants, 9,952. The table shows that exporting plants are larger than non-exporting plants on average. The mean number of employees at exporting plants (557.61) was more than four times greater than that of non-exporting plants (129.88). The mean number of shipments of manufactured goods was also more than nine times greater than that of non-exporting plants. These findings indicate that there is a scale differential between the two. The dependence of exporters on exports is 23.3%, on average. The exporting plants were more skilled-labor-intensive; their average skilled- worker ratio was almost twice as high as that of non-exporting plants.

Table 3-3 shows composition ratios according to the plants' characteristics. In total, the proportion of single plants that do not have a head office or business establishment in other locations is smaller among exporting plants than among non-exporting plants, and the scale of plants and firms of exporting plants is larger than that of non-exporting plants. By industry, the proportion of exporting plants in the machinery, steel, chemical and leather footwear industries exceeds the average of the manufacturing sector.

Table 3-2 Descriptive data of plants (2012)

	Whole sample			Non-exporting plants			Exporting plants		
	mean	std error	sample	mean	std error	sample	mean	std error	sample
Number of employees	174.71	516.82	9,952	129.88	421.92	8,909	557.61	930.08	1,043
Shipment of manufactured goods (10 thousand yen)	829,169	4,212,264	9,952	443,974	2,501,516	8,909	4,119,397	10,190,447	1,043
Sales Export Ratio	0.02	0.11	9,952	—	—	—	0.23	0.26	1,043
Skilled worker ratio	0.15	0.17	9,952	0.13	0.16	8,909	0.26	0.17	1,043
Export ratio * Skill ratio	0.01	0.04	9,952	—	—	—	0.06	0.10	1,043

Note Author’s calculation from the employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

Table 3-3 Structure of plants according to characteristics (2012)

	Whole sample		Non-exporting plants		Exporting plants	
	Samples	Share	Samples	Share	Samples	Share
Number of plants						
single plant	4,761	53.6%	4,566	58.2%	195	18.7%
multiple plants	4,126	46.4%	3,278	41.8%	848	81.3%
total	8,887	100.0%	7,844	100.0%	1,043	100.0%
Size of plant						
～20 workers	3,282	33.0%	3,205	36.0%	77	7.4%
21～50 workers	2,290	23.0%	2,186	24.5%	104	10.0%
51～100 workers	1,367	13.7%	1,244	14.0%	123	11.8%
101～200 workers	1,374	13.8%	1,161	13.0%	213	20.4%
201～300 workers	428	4.3%	337	3.8%	91	8.7%
301～ workers	1,211	12.2%	776	8.7%	435	41.7%
total	9,952	100.0%	8,909	100.0%	1,043	100.0%
Size of firm						
5～9 workers	3,674	36.9%	3,586	40.3%	88	8.4%
10～29 workers	2,089	21.0%	1,962	22.0%	127	12.2%
30～99 workers	1,815	18.2%	1,596	17.9%	219	21.0%
100～299 workers	508	5.1%	422	4.7%	86	8.2%
300～999 workers	564	5.7%	445	5.0%	119	11.4%
1,000 or more workers	1,302	13.1%	898	10.1%	404	38.7%
total	9,952	100.0%	8,909	100.0%	1,043	100.0%
Industry						
food and beverage	1,068	10.7%	1,013	11.4%	55	5.3%
textile	445	4.5%	424	4.8%	21	2.0%
wood, furniture, pulp	1,505	15.1%	1,475	16.6%	30	2.9%
chemical	1,293	13.0%	1,107	12.4%	186	17.8%
leather, ceramic, other	947	9.5%	836	9.4%	111	10.6%
steel	384	3.9%	338	3.8%	46	4.4%
nonferrous metals	921	9.3%	840	9.4%	81	7.8%
general machinery	1,384	13.9%	1,157	13.0%	227	21.8%
electric machinery	1,367	13.7%	1,180	13.2%	187	17.9%
transport machinery	635	6.4%	536	6.0%	99	9.5%
total	9,949	100.0%	8,906	100.0%	1,043	100.0%

Note Author’s calculation from the employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

5.3 Wage and wage premium of exporters

Next, we confirm the wage premiums for exporting plants. In Table 3-4, the average logarithm of wages is compared between exporting and non-exporting plants. The means for contractual wage and actual wage of the entire sample were 2.66 and 2.84, respectively. The median of the wages based on both definitions was close to the mean, although slightly lower. We were able to confirm the wage premiums of the exporting plants. In regard to contractual wage, the mean of the exporting plants was 30.3% higher when converted to real numbers than that of the non-export business plants, that is, the wage premium was 30.3%. Similarly, when we converted the mean of the actual wages of the export and non-exporting plants to real numbers and compared them, the wage premium was 41.9%. [39] The wage premiums by firm size were also measured and observed for all sizes. However, there was no monotonous relationship in which the premium increases as firm size expands.

Figure 3-1 shows the distribution of contract and real wages. Both types of wages generally followed a normal distribution. In particular, the upper part of the mean fits the normal distribution.

[39] This figure was larger than the wage export premium (19–25%) found by Wakasugi et al. (2008). Although the survey year for this chapter differs from that of Wakasugi et al. (2008), it is natural that a larger differential is confirmed because this chapter uses the survey form of the Census of Manufacture, including smaller establishments.

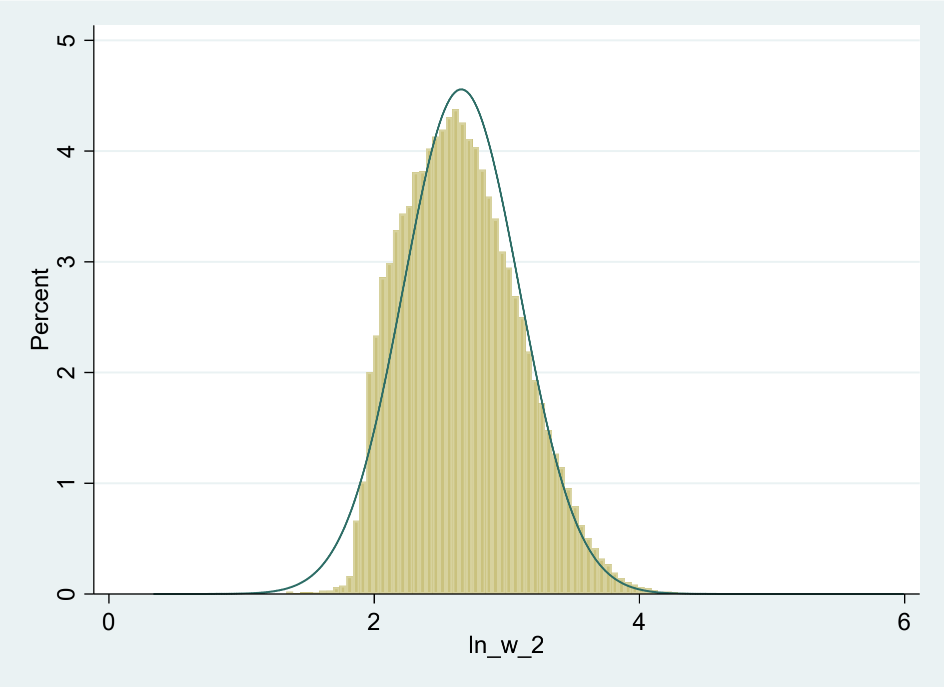
Table 3-4 Logarithmic wages for exporting and non-exporting plants

	Whole sample				Non-exporting plants				Exporting plants				Wage premium (real term)
	mean	meidan	std error	sample	mean	meidan	std error	sample	mean	meidan	std error	sample	
Contractual wage	2.66	2.63	0.44	252,602	2.61	2.58	0.43	211,019	2.88	2.87	0.42	41,583	1.303
by size offirm													
5～9 workers	2.44	2.42	0.38	11,987	2.44	2.42	0.38	11,752	2.54	2.53	0.37	235	1.104
10～29 workers	2.44	2.40	0.37	30,941	2.43	2.40	0.37	30,022	2.62	2.60	0.39	919	1.201
30～99 workers	2.49	2.46	0.37	51,458	2.48	2.45	0.37	47,975	2.61	2.59	0.39	3,483	1.139
100～299 workers	2.60	2.58	0.39	53,653	2.59	2.56	0.38	46,869	2.71	2.70	0.39	6,784	1.135
300～999 workers	2.74	2.72	0.41	43,026	2.71	2.70	0.41	34,116	2.81	2.80	0.38	8,910	1.105
1,000 or more workers	2.94	2.94	0.43	61,537	2.90	2.89	0.44	40,285	3.01	3.02	0.40	21,252	1.126
Actuial wage	2.84	2.82	0.52	252,602	2.78	2.76	0.51	211,019	3.13	3.14	0.49	41,583	1.419
by size of firm													
5～9 workers	2.51	2.49	0.41	11,987	2.51	2.49	0.41	11,752	2.63	2.61	0.42	235	1.124
10～29 workers	2.52	2.49	0.41	30,941	2.51	2.48	0.41	30,022	2.70	2.68	0.43	919	1.207
30～99 workers	2.61	2.60	0.42	51,458	2.60	2.58	0.42	47,975	2.76	2.74	0.44	3,483	1.171
100～299 workers	2.78	2.77	0.45	53,653	2.76	2.75	0.45	46,869	2.91	2.92	0.45	6,784	1.164
300～999 workers	2.96	2.97	0.48	43,026	2.94	2.95	0.49	34,116	3.06	3.06	0.44	8,910	1.134
1,000 or more workers	3.21	3.25	0.50	61,537	3.16	3.19	0.51	40,285	3.31	3.34	0.45	21,252	1.165

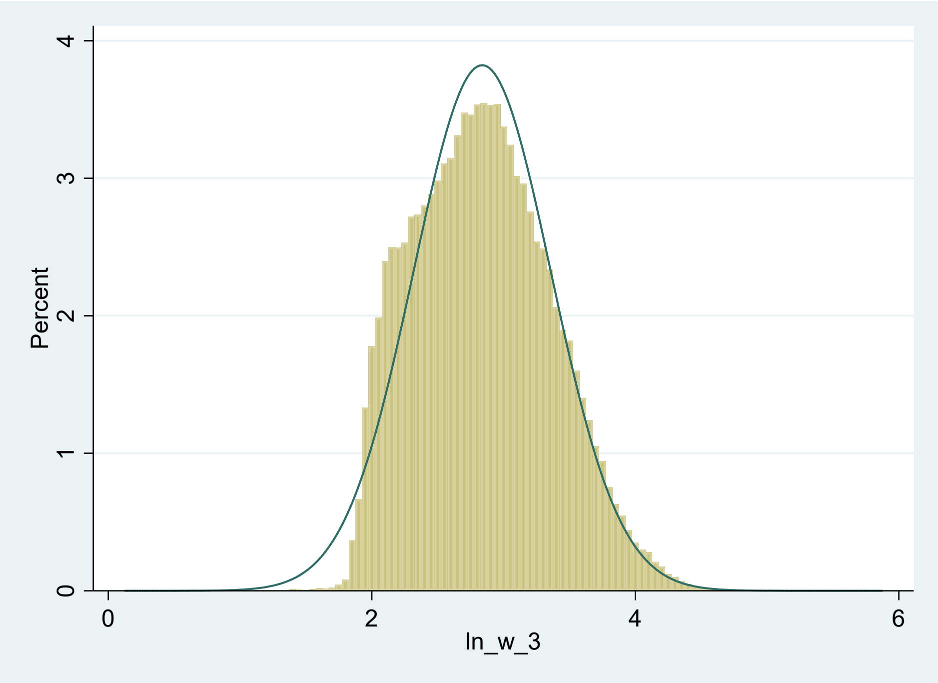
Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 "Contractual wage" is defined as regular salary/regular working hours. Meanwhile, "Real wage" is defined as (regular salary plus bonus/12) / (regular working hours + overtime hours worked).
3 The mean is calculated by averaging logarithmic transformation of wages.
4 The wage premium of exporters (real term) is a ratio of realized mean of logarithm of wages of exporters and non-exporters.

Figure 3-1 Distribution of wage

(1) Contractual wage



(2) Actual wage



Note: 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

2 The line reveals the normal distribution.

6. Result of estimation of Mincer-type wage function

6.1 Baseline estimation

Table 3-6 indicates the result of estimating a Mincer-type wage function based on contractual wages in 2012. Estimates were made including prefectural dummies, sector classification dummies and the same firm dummy for identifying business establishments belonging to the same firm for all estimates.

The results show that the effect of the export dummy on wages is clear. In the estimations without skill intensity and interaction of skill and export intensity (column [1]), the coefficient of the export dummy is significantly positive. As this estimation does not control for skill intensity, an estimation including skill intensity was performed (column [2]). Although the coefficient of the export dummy decreased slightly, it was still significantly positive. This result means that the wage premium of exporters observed in column [1] cannot be explained by the effect of skill intensity alone.

Furthermore, looking at the results of the model including the intersection term (column [3]), the coefficient of the intersection term is significantly negative, in contrast to the result from Munch and Skaksen (2008). This result is consistent with the hypothesis that exporters face a fierce competition in foreign markets.

From Heckscher and Ohlin's trade theory, another hypothesis that exporters that have more university graduates raise the wages of only the university graduates can be proposed. To confirm this hypothesis, we estimated the wage function of non-university graduate workers and university graduate workers separately (columns [4] and [5]). As expected, the coefficient of the interaction term in column [5] is positive, implying that the export premium tends to be higher for exporting plants where the skill level of workers is intensive. On the other hand, the negative sign of the coefficient of skill intensity implies that the spillover effect of skilled labor on skilled workers' wages decreases with firm size. In contrast, column [4] shows that the spillover effect of skilled labor on unskilled workers' wages is positive, but the effect decreases in plants with high dependence on exports. This is because of the dependence of skilled labor on exporting plants.

In comparison to many previous studies with export dummy coefficients that are not statistically significant, including the case of Japan, as studied by Tanaka (2015) and Endoh (2016), this result is quite similar, although the data in this chapter include relatively smaller plants. The effect of export dummies is extremely limited, albeit significant. The coefficient of the export dummy is 0.0195, meaning that only 2.0% (= exp (0.0195) − 1) of the wage premium of 30.3% for the exporting plants is a part not attributable to the characteristics of employees and other characteristics of the plants and firms.

Table 3-6 Wage function: Baseline estimation: export dummy, contractual wage

	[1]	[2]	[3]	[4]	[5]
	Whole workers	Whole workers	Whole workers	Unskilled workers	Skilled workers
d export	0.0195 ***	0.0136 ***	0.0171 ***	0.0178 ***	-0.0046
	[10.99]	[7.60]	[8.77]	[8.94]	[-0.42]
Skilled worker ratio		0.1228 ***	0.1270 ***	0.1331 ***	-0.5104 ***
		[25.53]	[25.92]	[26.26]	[-4.26]
Export ratio * skill ratio			-0.0674 ***	-0.0596 ***	1.2089 **
			[-4.47]	[-3.94]	[2.51]
d DoL	0.0123 ***	0.0081 ***	0.0082 ***	0.0054 ***	0.0251 ***
	[8.36]	[5.52]	[5.53]	[3.42]	[5.44]
log emp	0.0229 ***	0.0197 ***	0.0200 ***	0.0203 ***	0.0058
	[26.20]	[22.36]	[22.62]	[21.97]	[1.39]
d Firm size 2	-0.0288 ***	-0.0327 ***	-0.0337 ***	-0.0291 ***	-0.1816 ***
	[-5.98]	[-6.79]	[-6.98]	[-5.90]	[-6.67]
d Firm size 3	-0.0745 ***	-0.0814 ***	-0.0825 ***	-0.0821 ***	-0.1730 ***
	[-14.20]	[-15.52]	[-15.71]	[-15.23]	[-6.04]
d Firm size 4	-0.0922 ***	-0.0973 ***	-0.0984 ***	-0.0952 ***	-0.2152 ***
	[-17.42]	[-18.40]	[-18.60]	[-17.53]	[-7.57]
d Firm size 5	-0.1730 ***	-0.1777 ***	-0.1788 ***	-0.176 ***	-0.2948 ***
	[-33.25]	[-34.19]	[-34.37]	[-32.93]	[-10.57]
d Firm size 6	-0.1800 ***	-0.1843 ***	-0.1851 ***	-0.1841 ***	-0.3088 ***
	[-32.50]	[-33.32]	[-33.45]	[-32.29]	[-10.62]
d Firm size 7	-0.2072 ***	-0.2119 ***	-0.2122 ***	-0.2141 ***	-0.3202 ***
	[-33.93]	[-34.75]	[-34.80]	[-33.78]	[-10.44]
d Firm size 8	-0.5066 ***	-0.5116 ***	-0.5115 ***	-0.5119 ***	-0.5648 ***
	[-71.18]	[-71.97]	[-71.96]	[-68.88]	[-16.90]
d School 2	0.0341 ***	0.0337 ***	0.0336 ***	0.034 ***	0.0257 ***
	[13.70]	[13.56]	[13.53]	[12.58]	[4.14]
d School 3	0.0774 ***	0.0736 ***	0.0735 ***	0.0746 ***	0.0568 ***
	[25.14]	[23.91]	[23.89]	[22.54]	[6.75]
d School 4	0.1505 ***	0.1389 ***	0.1388 ***	0.1419 ***	0.1216 ***
	[51.61]	[47.11]	[47.09]	[44.96]	[13.45]
Potential experience	0.0299 ***	0.0299 ***	0.0299 ***	0.0304 ***	0.0242 ***
	[131.04]	[131.36]	[131.37]	[126.84]	[34.39]
(Potential experience)^2	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***
	[-78.53]	[-78.71]	[-78.72]	[-75.06]	[-21.83]
d Age60	-0.1168 ***	-0.1170 ***	-0.1169 ***	-0.1255 ***	-0.0681 ***
	[-37.80]	[-37.90]	[-37.88]	[-38.05]	[-8.01]
d Line Product 2	-0.2285 ***	-0.2297 ***	-0.2296 ***	-0.2301 ***	-0.1908 ***
	[-102.08]	[-102.73]	[-102.69]	[-101.24]	[-17.33]
d Line Product 3	-0.1664 ***	-0.1648 ***	-0.1649 ***	-0.1642 ***	-0.1442 ***
	[-52.80]	[-52.36]	[-52.39]	[-51.01]	[-10.54]
d Line Product 4	-0.337 ***	-0.3351 ***	-0.335 ***	-0.3315 ***	-0.3351 ***
	[-152.07]	[-151.34]	[-151.32]	[-146.57]	[-32.11]
d Emp style 2	-0.1509 ***	-0.1501 ***	-0.1503 ***	-0.1576 ***	-0.1304 ***
	[-38.01]	[-37.87]	[-37.91]	[-36.20]	[-13.33]
d Emp style 3	-0.2656 ***	-0.2644 ***	-0.2643 ***	-0.2669 ***	-0.2468 ***
	[-86.39]	[-86.14]	[-86.12]	[-80.60]	[-30.34]
d Emp style 4	-0.2718 ***	-0.2714 ***	-0.2714 ***	-0.2762 ***	-0.235 ***
	[-134.66]	[-134.67]	[-134.69]	[-130.53]	[-36.49]
d Female	-0.2541 ***	-0.2533 ***	-0.2532 ***	-0.2481 ***	-0.2794 ***
	[-182.83]	[-182.49]	[-182.45]	[-168.41]	[-69.78]
Prefectural dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes
N	201,869	201,869	201,869	179,095	22,774
Adj--R-squared	0.6787	0.6797	0.6797	0.6883	0.5617

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

2 t-statistics in brackets

3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

The coefficients of the other variables show the same signs as those in previous studies, and they are strongly statistically significant. Wages increase as the number of employees at the firm size increase. Regarding the form of employment, full-time employees who do not have employment periods receive the highest wages, and wages decrease in the order of regular employees with fixed employment periods and non-regular employees. As employees' academic careers and years of latent experience become longer, the wages they receive become higher. Women's wages are lower than men's. By category and occupation, wages of employees with managerial posts in administrative departments are the highest, and wages decrease in the following order: employees with managerial positions in production departments, professionals in management departments, and professionals in production departments.

We estimated the wage function using actual wage data. The result, shown in Table 3-7, is similar to Table 3-6. However, in the estimation of wage function for skilled labor (column [5]), the coefficient of the export dummy is significantly negative and the effect of the interaction term is relatively higher than in Table 3-6.

Table 3-7 Wage function: Baseline estimation: export dummy, actual wage

	[1]	[2]	[3]	[4]	[5]
	Whole workers	Whole workers	Whole workers	Unskilled workers	Skilled workers
d export	0.0227 *** [11.52]	0.0149 *** [7.53]	0.0210 *** [9.68]	0.0225 *** [10.15]	-0.0315 *** [-2.59]
Skilled worker ratio		0.1617 *** [30.24]	0.1689 *** [31.01]	0.1738 *** [30.88]	-0.5498 *** [-4.16]
Export ratio * skill ratio			-0.1156 *** [-6.89]	-0.1069 *** [-6.36]	1.8015 *** [3.39]
d DoL	0.0102 *** [6.24]	0.0047 *** [2.89]	0.0048 *** [2.91]	0.0011 [0.64]	0.0313 *** [6.16]
log emp	0.0383 *** [39.34]	0.0341 *** [34.74]	0.0345 *** [35.14]	0.0348 *** [33.91]	0.0176 *** [3.84]
d Firm size 2	-0.0377 *** [-7.03]	-0.0428 *** [-7.99]	-0.0444 *** [-8.29]	-0.0391 *** [-7.13]	-0.1884 *** [-6.27]
d Firm size 3	-0.0893 *** [-15.30]	-0.0984 *** [-16.87]	-0.1003 *** [-17.18]	-0.0987 *** [-16.49]	-0.2179 *** [-6.90]
d Firm size 4	-0.1196 *** [-20.32]	-0.1263 *** [-21.50]	-0.1283 *** [-21.81]	-0.1220 *** [-20.23]	-0.2813 *** [-8.97]
d Firm size 5	-0.2273 *** [-39.29]	-0.2335 *** [-40.43]	-0.2355 *** [-40.72]	-0.2312 *** [-38.94]	-0.3657 *** [-11.89]
d Firm size 6	-0.2698 *** [-43.80]	-0.2755 *** [-44.80]	-0.2769 *** [-45.00]	-0.2772 *** [-43.75]	-0.4061 *** [-12.66]
d Firm size 7	-0.3257 *** [-47.95]	-0.3319 *** [-48.96]	-0.3325 *** [-49.05]	-0.3354 *** [-47.65]	-0.4423 *** [-13.07]
d Firm size 8	-0.6468 *** [-81.70]	-0.6534 *** [-82.68]	-0.6533 *** [-82.68]	-0.6555 *** [-79.40]	-0.7095 *** [-19.24]
d School 2	0.0311 *** [11.22]	0.0305 *** [11.05]	0.0304 *** [11.01]	0.0304 *** [10.11]	0.0246 *** [3.59]
d School 3	0.0741 *** [21.63]	0.0691 *** [20.18]	0.0690 *** [20.15]	0.0691 *** [18.79]	0.0590 *** [6.35]
d School 4	0.1441 *** [44.43]	0.1288 *** [39.30]	0.1286 *** [39.27]	0.1316 *** [37.56]	0.1082 *** [10.85]
Potential experience	0.0356 *** [140.32]	0.0357 *** [140.76]	0.0357 *** [140.79]	0.0364 *** [136.50]	0.0280 *** [36.16]
(Potential experience)^2	-0.0004 *** [-90.81]	-0.0004 *** [-91.08]	-0.0004 *** [-91.11]	-0.0004 *** [-87.52]	-0.0003 *** [-24.38]
d Age60	-0.0863 *** [-25.10]	-0.0865 *** [-25.21]	-0.0864 *** [-25.19]	-0.0918 *** [-25.05]	-0.0551 *** [-5.87]
d Line Product 2	-0.2463 *** [-98.91]	-0.2478 *** [-99.71]	-0.2476 *** [-99.66]	-0.2475 *** [-98.04]	-0.2118 *** [-17.43]
d Line Product 3	-0.1688 *** [-48.14]	-0.1667 *** [-47.64]	-0.1668 *** [-47.67]	-0.1657 *** [-46.32]	-0.1513 *** [-10.02]
d Line Product 4	-0.3555 *** [-144.21]	-0.3529 *** [-143.40]	-0.3529 *** [-143.38]	-0.3483 *** [-138.61]	-0.3607 *** [-31.32]
d Emp style 2	-0.1892 *** [-42.83]	-0.1881 *** [-42.69]	-0.1884 *** [-42.76]	-0.1988 *** [-41.12]	-0.1611 *** [-14.93]
d Emp style 3	-0.3519 *** [-102.92]	-0.3504 *** [-102.69]	-0.3502 *** [-102.66]	-0.3554 *** [-96.63]	-0.3164 *** [-35.26]
d Emp style 4	-0.3809 *** [-169.65]	-0.3804 *** [-169.80]	-0.3804 *** [-169.84]	-0.3881 *** [-165.10]	-0.3270 *** [-45.99]
d Female	-0.2697 *** [-174.50]	-0.2687 *** [-174.16]	-0.2686 *** [-174.10]	-0.2635 *** [-160.99]	-0.2934 *** [-66.41]
Prefectural dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes
N	201,869	201,869	201,869	179,095	22,774
Adj--R-squared	0.7150	0.7163	0.7163	0.7242	0.5894

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-8 displays the estimation results of the wage function, in which the explanatory variables on exports are replaced with the export experience, for contractual wages. The coefficients of the explanatory variables are similar to the results in Table 3-6. In the case of columns [1]–[3], wages increase by 0.09~0.18% for each additional export experience. This implies the effect of learning by exporting works. The coefficient of the interaction term of skilled labor intensity and export intensity (in column [3]) is negative as in column [3] of Table 3-6, implying that plants with high export dependency face fierce competition.

Table 3-9 shows the results of the estimation of equation (2) using actual wage data. As in the estimation of equation (1), the difference between contractual and actual wage is quite limited.

Table 3-8 Wage function: Baseline estimation: export experience, contractual wage

	[1]	[2]	[3]	[4]	[5]
	Whole workers	Whole workers	Whole workers	Unskilled workers	Skilled workers
Export experience	0.0018 ***	0.0009 ***	0.0011 ***	0.0013 ***	-0.0036 **
	[7.98]	[4.09]	[4.55]	[5.59]	[-2.27]
Skilled worker ratio		0.1247 ***	0.1267 ***	0.1322 ***	-0.511 ***
		[25.85]	[25.79]	[26.02]	[-4.27]
Export ratio * skill ratio			-0.0318 **	-0.0264 *	1.4691 ***
			[-2.22]	[-1.84]	[3.21]
d DoL	0.0127 ***	0.0085 ***	0.0086 ***	0.0057 ***	0.0253 ***
	[8.62]	[5.76]	[5.79]	[3.63]	[5.49]
log emp	0.0231 ***	0.0200 ***	0.0201 ***	0.0204 ***	0.0061
	[26.38]	[22.63]	[22.73]	[22.07]	[1.47]
d Firm size 2	-0.0319 ***	-0.0347 ***	-0.0354 ***	-0.031 ***	-0.1701 ***
	[-6.61]	[-7.20]	[-7.33]	[-6.27]	[-6.14]
d Firm size 3	-0.0779 ***	-0.0835 ***	-0.0843 ***	-0.084 ***	-0.1634 ***
	[-14.83]	[-15.92]	[-16.03]	[-15.57]	[-5.65]
d Firm size 4	-0.0948 ***	-0.0989 ***	-0.0997 ***	-0.0965 ***	-0.2067 ***
	[-17.90]	[-18.72]	[-18.82]	[-17.76]	[-7.22]
d Firm size 5	-0.1756 ***	-0.1796 ***	-0.1803 ***	-0.1775 ***	-0.2871 ***
	[-33.80]	[-34.59]	[-34.66]	[-33.22]	[-10.22]
d Firm size 6	-0.1827 ***	-0.1862 ***	-0.1868 ***	-0.1857 ***	-0.3011 ***
	[-33.00]	[-33.69]	[-33.76]	[-32.58]	[-10.30]
d Firm size 7	-0.2098 ***	-0.2137 ***	-0.2141 ***	-0.2159 ***	-0.3125 ***
	[-34.37]	[-35.05]	[-35.09]	[-34.07]	[-10.14]
d Firm size 8	-0.509 ***	-0.5131 ***	-0.5133 ***	-0.5135 ***	-0.5564 ***
	[-71.48]	[-72.16]	[-72.18]	[-69.08]	[-16.59]
d School 2	0.0341 ***	0.0337 ***	0.0336 ***	0.034 ***	0.0255 ***
	[13.71]	[13.56]	[13.55]	[12.60]	[4.12]
d School 3	0.0775 ***	0.0736 ***	0.0736 ***	0.0746 ***	0.0569 ***
	[25.15]	[23.90]	[23.89]	[22.55]	[6.76]
d School 4	0.1507 ***	0.1389 ***	0.1388 ***	0.1419 ***	0.1214 ***
	[51.66]	[47.10]	[47.09]	[44.98]	[13.43]
Potential experience	0.0299 ***	0.0299 ***	0.0299 ***	0.0304 ***	0.0242 ***
	[131.02]	[131.34]	[131.35]	[126.83]	[34.43]
(Potential experience)^2	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***
	[-78.50]	[-78.69]	[-78.69]	[-75.04]	[-21.86]
d Age60	-0.1169 ***	-0.1170 ***	-0.1170 ***	-0.1256 ***	-0.0678 ***
	[-37.82]	[-37.92]	[-37.91]	[-38.08]	[-7.98]
d Line Product 2	-0.2283 ***	-0.2295 ***	-0.2294 ***	-0.23 ***	-0.1905 ***
	[-101.99]	[-102.66]	[-102.63]	[-101.17]	[-17.30]
d Line Product 3	-0.1663 ***	-0.1648 ***	-0.1648 ***	-0.1641 ***	-0.1441 ***
	[-52.76]	[-52.34]	[-52.35]	[-50.97]	[-10.54]
d Line Product 4	-0.3369 ***	-0.335 ***	-0.335 ***	-0.3314 ***	-0.3349 ***
	[-151.97]	[-151.28]	[-151.26]	[-146.49]	[-32.10]
d Emp style 2	-0.1506 ***	-0.1499 ***	-0.15 ***	-0.1571 ***	-0.1308 ***
	[-37.91]	[-37.82]	[-37.83]	[-36.08]	[-13.37]
d Emp style 3	-0.2656 ***	-0.2644 ***	-0.2644 ***	-0.2669 ***	-0.2469 ***
	[-86.40]	[-86.15]	[-86.13]	[-80.60]	[-30.36]
d Emp style 4	-0.2718 ***	-0.2715 ***	-0.2715 ***	-0.2763 ***	-0.2358 ***
	[-134.67]	[-134.70]	[-134.71]	[-130.54]	[-36.56]
d Female	-0.2541 ***	-0.2533 ***	-0.2532 ***	-0.2482 ***	-0.2794 ***
	[-182.83]	[-182.49]	[-182.46]	[-168.41]	[-69.80]
Prefectural dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes
N	201,869	201,869	201,869	179,095	22,774
Adj--R-squared	0.6786	0.6797	0.6797	0.6882	0.5618

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

2 t-statistics in brackets

3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-9 Wage function: Baseline estimation: export experience, actual wage

	[1]	[2]	[3]	[4]	[5]
	Whole workers	Whole workers	Whole workers	Unskilled workers	Skilled workers
Export experience	0.0027 ***	0.0016 ***	0.0020 ***	0.0024 ***	-0.0090 ***
	[11.09]	[6.54]	[7.76]	[9.33]	[-5.22]
Skilled worker ratio		0.1618 ***	0.1673 ***	0.1715 ***	-0.5586 ***
		[30.18]	[30.63]	[30.39]	[-4.23]
Export ratio * skill ratio			-0.0841 ***	-0.0784 ***	2.0754 ***
			[-5.27]	[-4.91]	[4.11]
d DoL	0.0103 ***	0.0049 ***	0.0050 ***	0.0012	0.0318 ***
	[6.30]	[2.98]	[3.05]	[0.71]	[6.26]
log emp	0.0381 ***	0.0341 ***	0.0345 ***	0.0347 ***	0.0188 ***
	[39.12]	[34.69]	[34.99]	[33.75]	[4.09]
d Firm size 2	-0.0418 ***	-0.0454 ***	-0.0472 ***	-0.0421 ***	-0.1608 ***
	[-7.79]	[-8.47]	[-8.80]	[-7.66]	[-5.26]
d Firm size 3	-0.0939 ***	-0.1013 ***	-0.1034 ***	-0.1020 ***	-0.1925 ***
	[-16.08]	[-17.36]	[-17.68]	[-17.02]	[-6.04]
d Firm size 4	-0.1230 ***	-0.1285 ***	-0.1305 ***	-0.1242 ***	-0.2596 ***
	[-20.90]	[-21.86]	[-22.16]	[-20.58]	[-8.21]
d Firm size 5	-0.2305 ***	-0.2356 ***	-0.2376 ***	-0.2333 ***	-0.3459 ***
	[-39.88]	[-40.84]	[-41.10]	[-39.30]	[-11.17]
d Firm size 6	-0.2730 ***	-0.2776 ***	-0.2792 ***	-0.2793 ***	-0.3854 ***
	[-44.34]	[-45.18]	[-45.39]	[-44.10]	[-11.95]
d Firm size 7	-0.3291 ***	-0.3341 ***	-0.3351 ***	-0.3380 ***	-0.4208 ***
	[-48.47]	[-49.30]	[-49.43]	[-48.02]	[-12.38]
d Firm size 8	-0.6501 ***	-0.6554 ***	-0.6559 ***	-0.6579 ***	-0.6852 ***
	[-82.09]	[-82.93]	[-82.98]	[-79.69]	[-18.52]
d School 2	0.0311 ***	0.0305 ***	0.0305 ***	0.0305 ***	0.0243 ***
	[11.24]	[11.06]	[11.04]	[10.14]	[3.55]
d School 3	0.0741 ***	0.0691 ***	0.0690 ***	0.0692 ***	0.0593 ***
	[21.64]	[20.19]	[20.17]	[18.83]	[6.39]
d School 4	0.1442 ***	0.1288 ***	0.1288 ***	0.1318 ***	0.1079 ***
	[44.45]	[39.32]	[39.30]	[37.60]	[10.82]
Potential experience	0.0356 ***	0.0357 ***	0.0357 ***	0.0364 ***	0.0281 ***
	[140.31]	[140.75]	[140.77]	[136.50]	[36.25]
(Potential experience)^2	-0.0004 ***	-0.0004 ***	-0.0004 ***	-0.0004 ***	-0.0003 ***
	[-90.79]	[-91.07]	[-91.08]	[-87.51]	[-24.47]
d Age60	-0.0865 ***	-0.0866 ***	-0.0865 ***	-0.092 ***	-0.0544 ***
	[-25.15]	[-25.24]	[-25.23]	[-25.10]	[-5.80]
d Line Product 2	-0.2461 ***	-0.2476 ***	-0.2475 ***	-0.2474 ***	-0.2112 ***
	[-98.85]	[-99.66]	[-99.60]	[-97.98]	[-17.39]
d Line Product 3	-0.1686 ***	-0.1666 ***	-0.1666 ***	-0.1655 ***	-0.1518 ***
	[-48.08]	[-47.60]	[-47.62]	[-46.27]	[-10.06]
d Line Product 4	-0.3553 ***	-0.3528 ***	-0.3527 ***	-0.3481 ***	-0.3603 ***
	[-144.08]	[-143.33]	[-143.30]	[-138.49]	[-31.31]
d Emp style 2	-0.1886 ***	-0.1878 ***	-0.1879 ***	-0.1981 ***	-0.1621 ***
	[-42.70]	[-42.61]	[-42.64]	[-40.97]	[-15.02]
d Emp style 3	-0.3519 ***	-0.3504 ***	-0.3503 ***	-0.3554 ***	-0.3163 ***
	[-102.92]	[-102.69]	[-102.67]	[-96.62]	[-35.27]
d Emp style 4	-0.3809 ***	-0.3804 ***	-0.3804 ***	-0.3881 ***	-0.3288 ***
	[-169.64]	[-169.80]	[-169.83]	[-165.09]	[-46.20]
d_Female	-0.2697 ***	-0.2687 ***	-0.2686 ***	-0.2635 ***	-0.2934 ***
	[-174.50]	[-174.16]	[-174.12]	[-161.00]	[-66.44]
Prefectural dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes
N	201,869	201,869	201,869	179,095	22,774
Adj--R-squared	0.6786	0.6797	0.6797	0.6883	0.5617

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-10 indicates the result of the estimation of wage function based on contractual wage with the sales–export ratio. In the case of the estimation with the entire sample (columns [1]–[3]), all the coefficients were statistically significant and positive. However, the effect was not so large. In column [3], if the proportion of sales–export increases by 10 percentage points, wages increase by only 0.68%. This implies that, in general, the observed wage disparities correlated with exports between exporting and non-exporting plants in the Japanese manufacturing sector are small, whereas when the dependence on exports rises, wages rise in relation to exports, and the wage gap between exporting plants expands.

The primary difference between Table 3-10 and the previous tables is the result for skilled workers. As indicated in column [5] of Table 3-10, the sales–export ratio and interaction term have significant coefficients. Because the estimation controls for the export intensity more accurately than the estimation with the export dummy and export experience, this result means that exports have no effect on skilled workers' wages. The negative sign of the skilled worker ratio is also seen in the previous tables.

To summarize, in general, the effect of exports on wages is significant. However, the effect is extremely small and almost nearly the same as in previous studies that confirmed no effect of exports. The positive effect of the skilled labor ratio was observed steadily. A certain portion of the observable wage premium of exports stems from this attribute. The negative sign of interaction term suggests fierce competition in overseas markets. Regarding unskilled labor, exports have a positive effect on wages, the effect decreases as the ratio of skilled labor increases. In contrast, exports have no effect on boosting the wages of skilled labor.

Table 3-10 Wage function: Baseline estimation: sales-export ratio, contractual wage

	[1] Whole workers	[2] Whole workers	[3] Whole workers	[4] Unskilled workers	[5] Skilled workers
Sales export ratio	0.0306 ***	0.0198 ***	0.0680 ***	0.0705 ***	-0.0116
	[6.41]	[4.14]	[8.38]	[8.33]	[-0.21]
Skilled worker ratio		0.1259 ***	0.1355 ***	0.1418 ***	-0.5117 ***
		[26.29]	[27.30]	[27.57]	[-4.28]
Export ratio * skill ratio			-0.1718 ***	-0.1668 ***	1.2591
			[-7.35]	[-6.97]	[1.56]
d DoL	0.0130 ***	0.0085 ***	0.0082 ***	0.0054 ***	0.0250 ***
	[8.82]	[5.77]	[5.54]	[3.40]	[5.43]
log emp	0.0234 ***	0.0200 ***	0.0202 ***	0.0205 ***	0.0059
	[26.79]	[22.69]	[22.92]	[22.26]	[1.42]
d Firm size 2	-0.0273 ***	-0.0319 ***	-0.0299 ***	-0.0251 ***	-0.1818 ***
	[-5.63]	[-6.58]	[-6.16]	[-5.06]	[-6.68]
d Firm size 3	-0.0725 ***	-0.0804 ***	-0.0783 ***	-0.0776 ***	-0.1728 ***
	[-13.75]	[-15.24]	[-14.83]	[-14.31]	[-6.03]
d Firm size 4	-0.0902 ***	-0.0962 ***	-0.0943 ***	-0.0908 ***	-0.2150 ***
	[-16.96]	[-18.10]	[-17.73]	[-16.62]	[-7.57]
d Firm size 5	-0.1716 ***	-0.1770 ***	-0.1750 ***	-0.1719 ***	-0.2947 ***
	[-32.80]	[-33.87]	[-33.43]	[-31.96]	[-10.57]
d Firm size 6	-0.1789 ***	-0.1838 ***	-0.1814 ***	-0.1802 ***	-0.3084 ***
	[-32.17]	[-33.09]	[-32.59]	[-31.41]	[-10.61]
d Firm size 7	-0.2060 ***	-0.2114 ***	-0.2084 ***	-0.2101 ***	-0.3197 ***
	[-33.66]	[-34.57]	[-34.02]	[-33.01]	[-10.43]
d Firm size 8	-0.5054 ***	-0.5110 ***	-0.5078 ***	-0.5078 ***	-0.5642 ***
	[-70.92]	[-71.79]	[-71.22]	[-68.10]	[-16.90]
d School 2	0.0340 ***	0.0336 ***	0.0334 ***	0.0338 ***	0.0257 ***
	[13.68]	[13.54]	[13.46]	[12.51]	[4.15]
d School 3	0.0774 ***	0.0735 ***	0.0732 ***	0.0742 ***	0.0569 ***
	[25.12]	[23.87]	[23.78]	[22.43]	[6.76]
d School 4	0.1508 ***	0.1388 ***	0.1385 ***	0.1416 ***	0.1217 ***
	[51.70]	[47.07]	[47.00]	[44.87]	[13.45]
Potential experience	0.0299 ***	0.0299 ***	0.0300 ***	0.0305 ***	0.0242 ***
	[131.03]	[131.35]	[131.41]	[126.88]	[34.39]
(Potential experience)^2	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0003 ***
	[-78.50]	[-78.70]	[-78.74]	[-75.07]	[-21.83]
d Age60	-0.1169 ***	-0.1170 ***	-0.1170 ***	-0.1255 ***	-0.0680 ***
	[-37.81]	[-37.91]	[-37.90]	[-38.06]	[-8.00]
d Line Product 2	-0.2284 ***	-0.2296 ***	-0.2296 ***	-0.2301 ***	-0.1909 ***
	[-102.01]	[-102.69]	[-102.70]	[-101.24]	[-17.34]
d Line Product 3	-0.1666 ***	-0.1649 ***	-0.1651 ***	-0.1646 ***	-0.1443 ***
	[-52.85]	[-52.38]	[-52.47]	[-51.10]	[-10.55]
d Line Product 4	-0.3373 ***	-0.3352 ***	-0.3352 ***	-0.3318 ***	-0.3350 ***
	[-152.14]	[-151.36]	[-151.41]	[-146.66]	[-32.11]
d Emp style 2	-0.1507 ***	-0.1500 ***	-0.1501 ***	-0.1573 ***	-0.1304 ***
	[-37.96]	[-37.83]	[-37.87]	[-36.15]	[-13.33]
d Emp style 3	-0.2657 ***	-0.2645 ***	-0.2644 ***	-0.2669 ***	-0.2467 ***
	[-86.44]	[-86.17]	[-86.15]	[-80.62]	[-30.34]
d Emp style 4	-0.2720 ***	-0.2715 ***	-0.2716 ***	-0.2764 ***	-0.2350 ***
	[-134.75]	[-134.75]	[-134.78]	[-130.62]	[-36.48]
d Female	-0.2541 ***	-0.2533 ***	-0.2531 ***	-0.2480 ***	-0.2793 ***
	[-182.83]	[-182.49]	[-182.36]	[-168.30]	[-69.78]
Prefectural dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes
N	201,869	201,869	201,869	179,095	22,774
Adj--R-squared	0.6786	0.6797	0.6797	0.6883	0.5617

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-11 Wage function: Baseline estimation: sales-export ratio, actual wage

	[1]	[2]	[3]	[4]	[5]
	Whole workers	Whole workers	Whole workers	Unskilled workers	Skilled workers
Sales export ratio	0.0261 ***	0.0118 **	0.0740 ***	0.0751 ***	0.001
	[4.90]	[2.23]	[8.20]	[8.00]	[0.02]
Skilled worker ratio		0.1659 ***	0.1784 ***	0.1835 ***	-0.5615 ***
		[31.17]	[32.33]	[32.09]	[-4.25]
Export ratio * skill ratio			-0.2216 ***	-0.2103 ***	1.1728
			[-8.53]	[-7.91]	[1.32]
d DoL	0.0112 ***	0.0053 ***	0.0049 ***	0.0013	0.0311 ***
	[6.85]	[3.26]	[2.99]	[0.71]	[6.12]
log emp	0.0391 ***	0.0346 ***	0.0349 ***	0.0352 ***	0.0182 ***
	[40.18]	[35.26]	[35.52]	[34.32]	[3.96]
d Firm size 2	-0.0369 ***	-0.043 ***	-0.0404 ***	-0.035 ***	-0.1908 ***
	[-6.84]	[-7.98]	[-7.49]	[-6.34]	[-6.35]
d Firm size 3	-0.0881 ***	-0.0984 ***	-0.0958 ***	-0.094 ***	-0.2160 ***
	[-15.01]	[-16.78]	[-16.32]	[-15.60]	[-6.84]
d Firm size 4	-0.1184 ***	-0.1263 ***	-0.1239 ***	-0.1174 ***	-0.2807 ***
	[-20.01]	[-21.37]	[-20.95]	[-19.35]	[-8.95]
d Firm size 5	-0.2269 ***	-0.2341 ***	-0.2314 ***	-0.2271 ***	-0.3653 ***
	[-39.00]	[-40.29]	[-39.78]	[-37.99]	[-11.87]
d Firm size 6	-0.2697 ***	-0.2761 ***	-0.2729 ***	-0.2732 ***	-0.4039 ***
	[-43.58]	[-44.71]	[-44.12]	[-42.86]	[-12.60]
d Firm size 7	-0.3253 ***	-0.3323 ***	-0.3285 ***	-0.3315 ***	-0.4392 ***
	[-47.77]	[-48.89]	[-48.24]	[-46.86]	[-12.99]
d Firm size 8	-0.6461 ***	-0.6535 ***	-0.6493 ***	-0.6513 ***	-0.7048 ***
	[-81.50]	[-82.59]	[-81.93]	[-78.62]	[-19.13]
d School 2	0.0310 ***	0.0305 ***	0.0302 ***	0.0302 ***	0.0248 ***
	[11.20]	[11.03]	[10.94]	[10.04]	[3.63]
d School 3	0.0741 ***	0.069 ***	0.0686 ***	0.0687 ***	0.0593 ***
	[21.62]	[20.15]	[20.04]	[18.69]	[6.38]
d School 4	0.1445 ***	0.1287 ***	0.1284 ***	0.1314 ***	0.1086 ***
	[44.54]	[39.26]	[39.18]	[37.47]	[10.88]
Potential experience	0.0356 ***	0.0357 ***	0.0357 ***	0.0364 ***	0.028 ***
	[140.30]	[140.75]	[140.82]	[136.53]	[36.17]
(Potential experience)^2	-0.0004 ***	-0.0004 ***	-0.0004 ***	-0.0004 ***	-0.0003 ***
	[-90.77]	[-91.07]	[-91.12]	[-87.52]	[-24.39]
d Age60	-0.0864 ***	-0.0865 ***	-0.0864 ***	-0.0919 ***	-0.0548 ***
	[-25.11]	[-25.22]	[-25.20]	[-25.07]	[-5.85]
d Line Product 2	-0.2461 ***	-0.2476 ***	-0.2476 ***	-0.2475 ***	-0.2122 ***
	[-98.80]	[-99.64]	[-99.65]	[-98.03]	[-17.46]
d Line Product 3	-0.169 ***	-0.1668 ***	-0.1671 ***	-0.1661 ***	-0.1524 ***
	[-48.19]	[-47.65]	[-47.75]	[-46.42]	[-10.09]
d Line Product 4	-0.3558 ***	-0.353 ***	-0.3531 ***	-0.3485 ***	-0.3606 ***
	[-144.27]	[-143.41]	[-143.47]	[-138.68]	[-31.32]
d Emp style 2	-0.189 ***	-0.1880 ***	-0.1882 ***	-0.1985 ***	-0.1609 ***
	[-42.78]	[-42.66]	[-42.71]	[-41.05]	[-14.91]
d Emp style 3	-0.3521 ***	-0.3504 ***	-0.3503 ***	-0.3555 ***	-0.3158 ***
	[-102.95]	[-102.70]	[-102.69]	[-96.65]	[-35.20]
d Emp style 4	-0.3812 ***	-0.3806 ***	-0.3806 ***	-0.3884 ***	-0.3267 ***
	[-169.76]	[-169.88]	[-169.93]	[-165.19]	[-45.94]
d Female	-0.2698 ***	-0.2687 ***	-0.2685 ***	-0.2634 ***	-0.2932 ***
	[-174.50]	[-174.15]	[-174.01]	[-160.89]	[-66.37]
Prefectural dummy	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes
N	201,869	201,869	201,869	179,095	22,774
Adj--R-squared	0.7148	0.7162	0.7163	0.7242	0.5893

Note 1 Author’s calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

6.2 Estimation by firm size

Tables 3-12 and 3-13 show the estimation results of the wage functions by firm size using export dummies. While Table 3-12 uses contract wages, Table 3-13 uses actual wages. In both tables, the coefficients of the export dummy variable are significantly positive for many firm-size groups. For the plants of firms with 5–9 employees, the export dummy is not significant, but the interaction term is significantly positive. The exception is the plants of firms with 300–999 employees, with a significantly negative coefficient. The effect of skilled workers was likely remarkable for this group. For skilled labor intensity, a stable positive effect on wages was observed. The major difference between Tables 3-12 and 3-13 is the difference in the results of the intersection terms. In Table 3-13, the interaction terms are significant for many groups. Actual wages tend to be higher in plants that are highly skilled-labor-intensive and highly dependent on exports. The exception is plants of firms with 30–99 employees.

The estimated wage functions by firm size using export experiences are shown in Tables 3-14 and 3-15. Surprisingly, export experiences had a positive effect only in the group including plants of firms with 10–299 employees. In large-scale plants, the difference in wages due to export experience becomes negligible. Similar to the estimation using export dummies, the degree of skilled labor intensity had a stable positive effect on wages. The effect of the interaction term was not significant in many estimates, and even when it was significant, the signs were mixed.

Table 3-12 Wage function by firm size: export dummy, contractual wage

Number of employees	5～9	10～29	30～99	100～299	300～999	1,000～
d_export	0.0171	0.0519 ***	0.0325 ***	0.0255 ***	-0.0228 ***	0.0124 ***
	[0.63]	[4.31]	[6.02]	[6.59]	[-5.45]	[3.40]
Skilled_worker_ratio	0.0927 ***	0.1854 ***	0.1954 ***	0.1449 ***	0.0471 ***	0.0822 ***
	[3.11]	[9.78]	[16.49]	[14.92]	[4.12]	[7.68]
Export_ratio * skill ratio	0.5251 **	-0.0307	-0.3803 ***	-0.0433	0.1282	-0.0086
	[2.09]	[-0.19]	[-4.72]	[-0.95]	[3.99]	[-0.43]
d_DoL	0.0398 **	0.0031	0.0296	-0.0069	0.0009	-0.0002
	[2.03]	[0.62]	[11.10]	[-2.60]	[0.23]	[-0.02]
log_emp	-0.0182	-0.0036	0.0351 ***	0.0342 ***	0.0206 ***	0.0099 ***
	[-1.51]	[-0.73]	[13.61]	[18.21]	[11.55]	[6.19]
d_School_2	0.0468 ***	0.0218 ***	0.0309 ***	0.0359 ***	0.0438 ***	0.0415 ***
	[4.65]	[3.57]	[6.02]	[6.87]	[6.56]	[7.26]
d_School_3	0.1404 ***	0.0833 ***	0.0642 ***	0.0586 ***	0.0676 ***	0.0935 ***
	[9.74]	[9.91]	[9.88]	[9.36]	[8.66]	[13.87]
d_School_4	0.1570 ***	0.1099 ***	0.1191 ***	0.1198 ***	0.1490 ***	0.2053 ***
	[10.21]	[12.97]	[18.79]	[19.80]	[19.97]	[32.32]
Potential_experience	0.0288 ***	0.0262 ***	0.0270 ***	0.0236 ***	0.0292 ***	0.0383 ***
	[22.29]	[36.76]	[52.53]	[51.43]	[56.24]	[90.07]
(Potential_experience)^2	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0002 ***	-0.0003 ***	-0.0004 ***
	[-16.35]	[-24.17]	[-31.93]	[-27.69]	[-30.67]	[-52.59]
d_Age60	-0.0409 ***	-0.0585 ***	-0.0871 ***	-0.1214 ***	-0.1285 ***	-0.2128 ***
	[-2.90]	[-6.91]	[-13.35]	[-18.69]	[-16.87]	[-33.21]
d_Line_Product_2		0.1548 ***	0.1645 ***	-0.2358 ***	-0.2458 ***	-0.2551 ***
		[36.33]	[58.32]	[-60.82]	[-59.06]	[-75.68]
d_Line_Product_3				-0.1631 ***	-0.1651 ***	-0.1468 ***
				[-34.58]	[-29.36]	[-30.65]
d_Line_Product_4				-0.3334 ***	-0.3108 ***	-0.2965 ***
				[-94.38]	[-75.47]	[-83.97]
d_Emp_style_2	-0.0560 ***	-0.1467 ***	-0.1346 ***	-0.1931 ***	-0.1694 ***	-0.2260 ***
	[-3.21]	[-16.49]	[-16.68]	[-22.11]	[-15.09]	[-20.80]
d_Emp_style_3	-0.2373 ***	-0.2370 ***	-0.2434 ***	-0.2441 ***	-0.2907 ***	-0.3104 ***
	[-16.20]	[-29.70]	[-42.46]	[-38.73]	[-36.72]	[-36.35]
d_Emp_style_4	-0.1717 ***	-0.1991 ***	-0.2051 ***	-0.2384 ***	-0.3401 ***	-0.3249 ***
	[-7.20]	[-19.70]	[-41.22]	[-63.31]	[-84.18]	[-91.02]
d_Female	-0.2861 ***	-0.3099 ***	-0.2988 ***	-0.2309 ***	-0.2066 ***	-0.1895 ***
	[-36.84]	[-72.26]	[-103.18]	[-85.66]	[-66.89]	[-65.48]
State dummy	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	8,668	23,258	41,612	45,343	35,222	47,766
Adj--R-squared	0.4026	0.4935	0.5593	0.6579	0.7025	0.7499

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-13 Wage function by firm size: export dummy, actual wage

Number of employees	5～9	10～29	30～99	100～299	300～999	1,000～
d_export	0.0294	0.0256 *	0.0364 ***	0.0221 ***	-0.0244 ***	0.0251 ***
	[1.01]	[1.95]	[6.01]	[5.04]	[-5.30]	[6.54]
Skilled_worker_ratio	0.1539 ***	0.2571 ***	0.2532 ***	0.1710 ***	0.0648 ***	0.0895 ***
	[4.80]	[12.42]	[19.02]	[15.50]	[5.15]	[7.91]
Export_ratio * skill ratio	0.5810 **	0.3869 **	-0.4435 ***	0.0026	0.1407 ***	-0.0607 ***
	[2.14]	[2.23]	[-4.90]	[0.05]	[3.98]	[-2.85]
d_DoL	0.0317	0.0072	0.0377 ***	-0.0092 ***	-0.0208 ***	-0.0174 **
	[1.50]	[1.31]	[12.57]	[-3.08]	[-4.77]	[-2.33]
log_emp	0.0221 *	0.0069	0.0647 ***	0.0614 ***	0.0319 ***	0.0140 ***
	[1.70]	[1.29]	[22.31]	[28.74]	[16.24]	[8.29]
d_School_2	0.0463 ***	0.0200 ***	0.0266 ***	0.0324 ***	0.0427 ***	0.0400 ***
	[4.26]	[3.00]	[4.62]	[5.45]	[5.81]	[6.63]
d_School_3	0.1508 ***	0.0863 ***	0.0606 ***	0.0486 ***	0.0589 ***	0.0890 ***
	[9.71]	[9.41]	[8.31]	[6.84]	[6.86]	[12.50]
d_School_4	0.1454 ***	0.1004 ***	0.1061 ***	0.1058 ***	0.1421 ***	0.2034 ***
	[8.77]	[10.85]	[14.90]	[15.39]	[17.32]	[30.31]
Potential_experience	0.0310 ***	0.0293 ***	0.0313 ***	0.0293 ***	0.0360 ***	0.0464 ***
	[22.31]	[37.70]	[54.10]	[56.13]	[63.06]	[103.36]
(Potential_experience)^2	-0.0004 ***	-0.0003 ***	-0.0004 ***	-0.0003 ***	-0.0004 ***	-0.0005 ***
	[-16.96]	[-25.88]	[-35.60]	[-34.11]	[-38.08]	[-64.49]
d_Age60	-0.0403 ***	-0.0561 ***	-0.0706 ***	-0.0887 ***	-0.0684 ***	-0.1374 ***
	[-2.65]	[-6.07]	[-9.63]	[-12.01]	[-8.16]	[-20.30]
d_Line_Product_2		0.1529 ***	0.1654 ***	-0.2399 ***	-0.2539 ***	-0.2714 ***
		[32.87]	[52.20]	[-54.47]	[-55.48]	[-76.19]
d_Line_Product_3				-0.1597 ***	-0.1626 ***	-0.1562 ***
				[-29.81]	[-26.28]	[-30.87]
d_Line_Product_4				-0.3449 ***	-0.3164 ***	-0.3087 ***
				[-85.96]	[-69.86]	[-82.74]
d_Emp_style_2	-0.0586 ***	-0.1729 ***	-0.1650 ***	-0.2658 ***	-0.2072 ***	-0.3094 ***
	[-3.12]	[-17.80]	[-18.20]	[-26.79]	[-16.78]	[-26.94]
d_Emp_style_3	-0.2723 ***	-0.2870 ***	-0.3142 ***	-0.3433 ***	-0.4091 ***	-0.4538 ***
	[-17.24]	[-32.94]	[-48.80]	[-47.95]	[-46.99]	[-50.31]
d_Emp_style_4	-0.1985 ***	-0.2323 ***	-0.2690 ***	-0.3406 ***	-0.4781 ***	-0.484 ***
	[-7.72]	[-21.05]	[-48.15]	[-79.62]	[-107.63]	[-128.34]
d_Female	-0.2877 ***	-0.3208 ***	-0.3128 ***	-0.2473 ***	-0.2237 ***	-0.2027 ***
	[-34.35]	[-68.51]	[-96.21]	[-80.75]	[-65.87]	[-66.28]
State dummy	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	8,668	23,258	41,612	45,343	35,222	47,766
Adj--R-squared	0.4083	0.491	0.5615	0.6665	0.7284	0.7818

Note 1 Author’s calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-14 Wage function by firm size: sales experience, contractual wage

Number of employees	5～9	10～29	30～99	100～299	300～999	1,000～
Export_experience	0.0035	0.0125 ***	0.0055 ***	0.0050 ***	0.0000	-0.0010 ***
	[0.82]	[7.07]	[7.07]	[10.14]	[0.08]	[-2.76]
Skilled_worker_ratio	0.0926 ***	0.1808 ***	0.1911 ***	0.1372 ***	0.0407 ***	0.0789 ***
	[3.11]	[9.55]	[16.07]	[14.07]	[3.55]	[7.38]
Export_ratio * skill ratio	0.5425 **	-0.0462	-0.2757 ***	-0.0489	0.0449	0.0340 *
	[2.35]	[-0.31]	[-3.65]	[-1.14]	[1.50]	[1.80]
d_DoL	0.0400 **	0.0034	0.0299 ***	-0.0081 ***	0.0004	0.0029
	[2.04]	[0.68]	[11.25]	[-3.06]	[0.09]	[0.40]
log_emp	-0.0186	-0.0037	0.0346 ***	0.0338 ***	0.0196 ***	0.0103 ***
	[-1.54]	[-0.76]	[13.40]	[17.99]	[10.92]	[6.46]
d_School_2	0.0469 ***	0.0222 ***	0.0307 ***	0.0357 ***	0.0434 ***	0.0415 ***
	[4.66]	[3.63]	[5.99]	[6.83]	[6.50]	[7.27]
d_School_3	0.1403 ***	0.0830 ***	0.0639 ***	0.0583 ***	0.0669 ***	0.0934 ***
	[9.74]	[9.89]	[9.84]	[9.32]	[8.56]	[13.86]
d_School_4	0.1571 ***	0.1098 ***	0.1191 ***	0.1196 ***	0.1486 ***	0.2054 ***
	[10.22]	[12.97]	[18.79]	[19.78]	[19.90]	[32.33]
Potential_experience	0.0288 ***	0.0262 ***	0.0271 ***	0.0236 ***	0.0292 ***	0.0383 ***
	[22.29]	[36.74]	[52.58]	[51.42]	[56.23]	[90.04]
(Potential_experience)^2	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0002 ***	-0.0003 ***	-0.0004 ***
	[-16.35]	[-24.13]	[-31.97]	[-27.68]	[-30.69]	[-52.54]
d_Age60	-0.0408 ***	-0.0591 ***	-0.0872 ***	-0.1214 ***	-0.1284 ***	-0.2129 ***
	[-2.90]	[-6.98]	[-13.37]	[-18.69]	[-16.84]	[-33.23]
d_Line_Product_2		0.1553 ***	0.1643 ***	-0.2356 ***	-0.2460 ***	-0.2549 ***
		[36.49]	[58.22]	[-60.82]	[-59.08]	[-75.60]
d_Line_Product_3				-0.1627 ***	-0.1651 ***	-0.1467 ***
				[-34.52]	[-29.34]	[-30.64]
d_Line_Product_4				-0.3332 ***	-0.3109 ***	-0.2965 ***
				[-94.41]	[-75.46]	[-83.97]
d_Emp_style_2	-0.0558 ***	-0.1455 ***	-0.1345 ***	-0.1924 ***	-0.1691 ***	-0.2254 ***
	[-3.20]	[-16.38]	[-16.66]	[-22.04]	[-15.05]	[-20.74]
d_Emp_style_3	-0.2372 ***	-0.2362 ***	-0.2434 ***	-0.2439 ***	-0.2901 ***	-0.3111 ***
	[-16.19]	[-29.62]	[-42.48]	[-38.73]	[-36.63]	[-36.43]
d_Emp_style_4	-0.1718 ***	-0.1982 ***	-0.2045 ***	-0.2384 ***	-0.3397 ***	-0.3252 ***
	[-7.21]	[-19.63]	[-41.12]	[-63.37]	[-84.06]	[-91.09]
d_Female	-0.2862 ***	-0.3096 ***	-0.2986 ***	-0.2309 ***	-0.2066 ***	-0.1896 ***
	[-36.86]	[-72.26]	[-103.13]	[-85.71]	[-66.88]	[-65.53]
State dummy	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	8,668	23,258	41,612	45,343	35,222	47,766
Adj--R-squared	0.4026	0.4942	0.5595	0.6584	0.7023	0.7499

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

2 t-statistics in brackets

3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-15 Wage function by firm size: sales experience, actual wage

Number of employees	5～9	10～29	30～99	100～299	300～999	1,000～
Export_experience	0.0025	0.0110 ***	0.0069 ***	0.0068 ***	-0.0002	0.0006
	[0.55]	[5.72]	[7.98]	[12.12]	[-0.40]	[1.62]
Skilled_worker_ratio	0.1542 ***	0.2496 ***	0.2471 ***	0.1582 ***	0.0587 ***	0.0842 ***
	[4.81]	[12.07]	[18.51]	[14.29]	[4.65]	[7.46]
Export_ratio * skill ratio	0.6726 ***	0.2566	-0.338 ***	-0.0681	0.0567 *	-0.0099
	[2.71]	[1.57]	[-3.99]	[-1.39]	[1.72]	[-0.50]
d_DoL	0.0320	0.0069	0.0378 ***	-0.0110 ***	-0.0213 ***	-0.0139 *
	[1.51]	[1.25]	[12.66]	[-3.68]	[-4.88]	[-1.87]
log_emp	0.0218 *	0.0067	0.0639 ***	0.0603 ***	0.0309 ***	0.0144 ***
	[1.68]	[1.27]	[22.03]	[28.28]	[15.67]	[8.57]
d_School_2	0.0464 ***	0.0201 ***	0.0264 ***	0.0322 ***	0.0423 ***	0.0402 ***
	[4.27]	[3.02]	[4.59]	[5.43]	[5.75]	[6.66]
d_School_3	0.1508 ***	0.0862 ***	0.0604 ***	0.0484 ***	0.0582 ***	0.0892 ***
	[9.70]	[9.40]	[8.28]	[6.82]	[6.77]	[12.52]
d_School_4	0.1456 ***	0.1003 ***	0.1061 ***	0.1057 ***	0.1416 ***	0.2037 ***
	[8.78]	[10.84]	[14.91]	[15.40]	[17.25]	[30.33]
Potential_experience	0.031 ***	0.0293 ***	0.0313 ***	0.0293 ***	0.0361 ***	0.0464 ***
	[22.30]	[37.67]	[54.16]	[56.14]	[63.06]	[103.30]
(Potential_experience)^2	-0.0004 ***	-0.0003 ***	-0.0004 ***	-0.0003 ***	-0.0004 ***	-0.0005 ***
	[-16.95]	[-25.83]	[-35.65]	[-34.11]	[-38.09]	[-64.42]
d_Age60	-0.0403 ***	-0.0567 ***	-0.0707 ***	-0.0887 ***	-0.0682 ***	-0.1378 ***
	[-2.65]	[-6.14]	[-9.65]	[-12.04]	[-8.13]	[-20.35]
d_Line_Product_2		0.1533 ***	0.1650 ***	-0.2398 ***	-0.2541 ***	-0.271 ***
		[32.97]	[52.09]	[-54.53]	[-55.49]	[-76.07]
d_Line_Product_3				-0.1592 ***	-0.1626 ***	-0.1562 ***
				[-29.77]	[-26.27]	[-30.86]
d_Line_Product_4				-0.3448 ***	-0.3165 ***	-0.3085 ***
				[-86.04]	[-69.86]	[-82.66]
d_Emp_style_2	-0.0584 ***	-0.1726 ***	-0.1648 ***	-0.2646 ***	-0.207 ***	-0.3082 ***
	[-3.11]	[-17.79]	[-18.18]	[-26.70]	[-16.75]	[-26.83]
d_Emp_style_3	-0.2723 ***	-0.2863 ***	-0.3143 ***	-0.3428 ***	-0.4084 ***	-0.4544 ***
	[-17.24]	[-32.87]	[-48.84]	[-47.94]	[-46.90]	[-50.34]
d_Emp_style_4	-0.1984 ***	-0.2319 ***	-0.2684 ***	-0.3402 ***	-0.4778 ***	-0.4842 ***
	[-7.72]	[-21.03]	[-48.06]	[-79.67]	[-107.52]	[-128.33]
d_Female	-0.2879 ***	-0.3206 ***	-0.3126 ***	-0.2473 ***	-0.2238 ***	-0.2029 ***
	[-34.39]	[-68.52]	[-96.16]	[-80.85]	[-65.86]	[-66.35]
State dummy	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	8,668	23,258	41,612	45,343	35,222	47,766
Adj--R-squared	0.4083	0.4917	0.5618	0.6674	0.7281	0.7816

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

The estimation results of the wage function by firm size using the sales export ratio are shown in Tables 3-16 and 3-17. Significant effects were observed in large plants, as opposed to estimates using export experience. As with the export dummy, while the coefficient was significantly negative for the plants of firms with 300–999 employees, positive coefficients were obtained for the other plant groups with 100 or more employees. This implies that wage disparities exist only among large plants with a high dependence on exports and other large plants. Similar to the estimation using export dummies, the degree of skilled labor intensity had a stable positive effect on wages.

We confirmed that the wage export premium was extremely small in the estimation of the entire sample. As a result of aligning the unobserved attributes of plants as much as possible, it became clear that the impact of exports on wages is biased depending on the size of the firms. On the other hand, the effect of the ratio of skilled labor is stable and positive regardless of the size of the establishment. The estimation results of a wage function by firm size reinforce the result in Section 6.1, which concluded that a large portion of wage export premiums is explained by the skilled labor ratio.

Table 3-16 Wage function by firm size: sales export ratio, contractual wage

Number of employees	5～9	10～29	30～99	100～299	300～999	1,000～
Sales_export_ratio	0.0996	0.2333 ***	0.0324	0.1143 ***	-0.0412 *	0.0198 *
	[1.31]	[3.63]	[0.99]	[5.24]	[-1.74]	[1.81]
Skilled_worker_ratio	0.0949 ***	0.199 ***	0.2005 ***	0.1544 ***	0.0374 ***	0.0861 ***
	[3.19]	[10.53]	[16.87]	[15.88]	[3.23]	[7.62]
Export_ratio * skill ratio	0.3776	-0.5896 **	-0.284 **	-0.2147 ***	0.1469 **	-0.0221
	[1.36]	[-2.13]	[-2.46]	[-3.05]	[2.27]	[-0.74]
d_DoL	0.0401 **	0.0033	0.031 ***	-0.0072 ***	0.0007	0.0014
	[2.05]	[0.65]	[11.66]	[-2.73]	[0.18]	[0.20]
log_emp	-0.0186	-0.0037	0.0359 ***	0.035 ***	0.0198 ***	0.0099 ***
	[-1.55]	[-0.75]	[13.91]	[18.67]	[11.13]	[6.21]
d_School_2	0.0469 ***	0.0221 ***	0.0307 ***	0.0357 ***	0.0435 ***	0.0414 ***
	[4.65]	[3.61]	[5.97]	[6.82]	[6.52]	[7.25]
d_School_3	0.1405 ***	0.083 ***	0.0636 ***	0.0581 ***	0.0672 ***	0.0934 ***
	[9.75]	[9.88]	[9.80]	[9.29]	[8.59]	[13.85]
d_School_4	0.1571 ***	0.11 ***	0.1187 ***	0.1195 ***	0.1487 ***	0.2053 ***
	[10.22]	[12.98]	[18.72]	[19.75]	[19.93]	[32.32]
Potential_experience	0.0287 ***	0.0262 ***	0.0271 ***	0.0236 ***	0.0292 ***	0.0383 ***
	[22.28]	[36.81]	[52.57]	[51.42]	[56.25]	[90.07]
(Potential_experience)^2	-0.0003 ***	-0.0003 ***	-0.0003 ***	-0.0002 ***	-0.0003 ***	-0.0004 ***
	[-16.33]	[-24.21]	[-31.97]	[-27.67]	[-30.70]	[-52.57]
d_Age60	-0.0411 ***	-0.0584 ***	-0.0871 ***	-0.1216 ***	-0.1284 ***	-0.213 ***
	[-2.92]	[-6.90]	[-13.35]	[-18.70]	[-16.85]	[-33.24]
d_Line_Product_2		0.155 ***	0.1649 ***	-0.2354 ***	-0.2459 ***	-0.255 ***
		[36.38]	[58.44]	[-60.70]	[-59.07]	[-75.64]
d_Line_Product_3				-0.1628 ***	-0.1651 ***	-0.1468 ***
				[-34.52]	[-29.34]	[-30.66]
d_Line_Product_4				-0.3332 ***	-0.3108 ***	-0.2965 ***
				[-94.33]	[-75.44]	[-83.94]
d_Emp_style_2	-0.0556 ***	-0.1457 ***	-0.1353 ***	-0.1928 ***	-0.1694 ***	-0.2252 ***
	[-3.19]	[-16.38]	[-16.76]	[-22.06]	[-15.08]	[-20.72]
d_Emp_style_3	-0.2375 ***	-0.2372 ***	-0.2427 ***	-0.2447 ***	-0.2903 ***	-0.3107 ***
	[-16.21]	[-29.72]	[-42.32]	[-38.83]	[-36.65]	[-36.39]
d_Emp_style_4	-0.1712 ***	-0.1985 ***	-0.2045 ***	-0.2388 ***	-0.3398 ***	-0.3251 ***
	[-7.18]	[-19.64]	[-41.09]	[-63.44]	[-84.08]	[-91.06]
d_Female	-0.2861 ***	-0.3094 ***	-0.2988 ***	-0.2309 ***	-0.2067 ***	-0.1895 ***
	[-36.85]	[-72.13]	[-103.16]	[-85.64]	[-66.89]	[-65.48]
State dummy	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	8,668	23,258	41,612	45,343	35,222	47,766
Adj--R-squared	0.4027	0.4934	0.5589	0.6578	0.7023	0.7498

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

Table 3-17　Wage function by firm size: sales export ratio, actual wage

Number of employees	5～9	10～29	30～99	100～299	300～999	1,000～
Sales_export_ratio	0.0687	0.2809	0.0063	0.1188 ***	-0.0533 ***	0.0343 ***
	[0.84]	[4.00]	[0.17]	[4.80]	[-2.05]	[2.98]
Skilled_worker_ratio	0.1558 ***	0.2672 ***	0.2580 ***	0.1801 ***	0.0536 ***	0.0954 ***
	[4.85]	[12.96]	[19.33]	[16.30]	[4.21]	[7.99]
Export_ratio * skill ratio	0.5608 *	-0.4976 *	-0.2555 **	-0.1977 **	0.1834 ***	-0.0756 **
	[1.87]	[-1.65]	[-1.97]	[-2.47]	[2.58]	[-2.40]
d_DoL	0.0320	0.0063	0.0393 ***	-0.0097 ***	-0.0209 ***	-0.014 *
	[1.52]	[1.15]	[13.16]	[-3.21]	[-4.80]	[-1.88]
log_emp	0.0217 *	0.0068	0.0657 ***	0.0620 ***	0.0310 ***	0.0141 ***
	[1.68]	[1.27]	[22.65]	[29.12]	[15.87]	[8.37]
d_School_2	0.0464 ***	0.0200 ***	0.0264 ***	0.0322 ***	0.0424 ***	0.0400 ***
	[4.27]	[2.99]	[4.57]	[5.42]	[5.78]	[6.62]
d_School_3	0.1509 ***	0.0861 ***	0.0600 ***	0.0482 ***	0.0585 ***	0.0889 ***
	[9.71]	[9.39]	[8.23]	[6.79]	[6.80]	[12.48]
d_School_4	0.1455 ***	0.1004 ***	0.1056 ***	0.1056 ***	0.1418 ***	0.2034 ***
	[8.78]	[10.85]	[14.83]	[15.36]	[17.28]	[30.30]
Potential_experience	0.0310 ***	0.0293 ***	0.0313 ***	0.0293 ***	0.0361 ***	0.0464 ***
	[22.30]	[37.74]	[54.14]	[56.13]	[63.07]	[103.33]
(Potential_experience)^2	-0.0004 ***	-0.0003 ***	-0.0004 ***	-0.0003 ***	-0.0004 ***	-0.0005 ***
	[-16.94]	[-25.91]	[-35.63]	[-34.09]	[-38.11]	[-64.44]
d_Age60	-0.0406 ***	-0.0561 ***	-0.0706 ***	-0.0888 ***	-0.0683 ***	-0.1378 ***
	[-2.67]	[-6.07]	[-9.63]	[-12.03]	[-8.15]	[-20.36]
d_Line_Product_2		0.1529 ***	0.1658 ***	-0.2395 ***	-0.2540 ***	-0.2711 ***
		[32.88]	[52.32]	[-54.38]	[-55.49]	[-76.09]
d_Line_Product_3				-0.1594 ***	-0.1625 ***	-0.1563 ***
				[-29.76]	[-26.27]	[-30.88]
d_Line_Product_4				-0.3448 ***	-0.3163 ***	-0.3085 ***
				[-85.93]	[-69.83]	[-82.67]
d_Emp_style_2	-0.0582 ***	-0.173 ***	-0.1657 ***	-0.2654 ***	-0.2073 ***	-0.3077 ***
	[-3.10]	[-17.83]	[-18.27]	[-26.74]	[-16.78]	[-26.79]
d_Emp_style_3	-0.2725 ***	-0.2872 ***	-0.3132 ***	-0.3438 ***	-0.4086 ***	-0.4545 ***
	[-17.25]	[-32.96]	[-48.64]	[-48.03]	[-46.93]	[-50.37]
d_Emp_style_4	-0.1979 ***	-0.2322 ***	-0.2684 ***	-0.3409 ***	-0.4778 ***	-0.4843 ***
	[-7.70]	[-21.04]	[-48.03]	[-79.72]	[-107.54]	[-128.38]
d_Female	-0.2879 ***	-0.3204 ***	-0.3129 ***	-0.2473 ***	-0.2238 ***	-0.2027 ***
	[-34.38]	[-68.42]	[-96.20]	[-80.74]	[-65.87]	[-66.28]
State dummy	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes
Same firm dummy	Yes	Yes	Yes	Yes	Yes	Yes
N	8,668	23,258	41,612	45,343	35,222	47,766
Adj--R-squared	0.4083	0.4913	0.5611	0.6665	0.7282	0.7816

Note 1 Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.
2 t-statistics in brackets
3 ***, **, * denote significance at the 1, 5, 10 percent level, respectively.

7. Blinder－Oaxaca Decomposition

Through the estimation of a Mincer-type wage function, I could confirm the existence of pure export premium of wages; however, to compare the degree of relative impact to other factors, a Blinder－Oaxaca Degradation is conducted.

Table 3-18 shows the results of decomposition with contractual wages. The average wage deviates by 0.261 (logarithmic term) and 29.8% (real term) between exporting and non-exporting plants. The part explained by the difference in characteristics between the two groups accounted for most of the premium, and the other part, that is, the difference in wages correlated with exports ((d) in each table, the last two terms of the right hand side in equation (4)), accounted for only 2.1%, consisting of 8.0 % (= 0.021 / 0.261) of the wage premium. Similarly, in the case of decomposition with actual wages, the difference in wages correlated with exports was 7.8 % of the wage difference between the exporting and non-exporting plants (Table 3-19).

However, in small-scale firms, exports may have a larger influence than other factors. To examine this point, a decomposition of actual wages is also implemented according to firm size. As expected, the influence of exports on wages is remarkable in small-scale firms. In particular, at plants with 99 or fewer employees, the share of wages correlated with exports in the export premium exceeds 30 % (column [8] in Table 3-19). In contrast, at plants of firms with more than 300 employees, this figure drastically drops.

Table 3-18 Blinder－Oaxaca Decomposition, contractual wage

	mean	std error	Z value	samples
Whole sample				202,043
Exporting plants (a)	2.903	0.002	1662.32	39,801
Non-exporting plants (b)	2.642	0.001	3293.16	162,242
Wage premium of eporters (a) - (b)	0.261	0.002	135.95	
Part from difference of characteristics (c)	0.241	0.002	130.67	
Other part (correlated with exports) (d)	0.021	0.000	58.73	
Breakdown of (c)				
difference of workers' characteristics (e)	0.053			
difference of plants/firms' characteristics (f)	0.188			

Note Author's calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

Table 3-19 Blinder－Oaxaca Decomposition, actual wage, by firm size

[1] All employees

	mean	std error	Z value	samples
Whole sample				202,043
Exporting plants (a)	3.163	0.002	1,542.02	39,801
Non-exporting plants (b)	2.818	0.001	2,910.38	162,242
Wage premium of eporters (a) - (b)	0.345	0.002	151.96	
Part from difference of characteristics (c)	0.318	0.002	147.07	
Other part (correlated with exports) (d)	0.027	0.000	61.91	
Breakdown of (c)				
difference of workers' characteristics (e)	0.057			
difference of plants/firms' characteristics (f)	0.262			

[2] Employees at firms with 5 ~ 9 employees

	Wage	Std error	Z value	samples
Whole sample				8,668
Exporting plants (a)	2.731	0.0283	96.51	184
Non-exporting plants (b)	2.592	0.0043	603.50	8,484
Wage premium of eporters (a) - (b)	0.139	0.0286	4.85	
Part from difference of characteristics (c)	0.109	0.0239	4.56	
Other part (correlated with exports) (d)	0.030	0.0274	1.08	
Breakdown of (c)				
difference of workers' characteristics (e)	0.049			
difference of plants/firms' characteristics (f)	0.060			

[3] Employees at firms with 10 ~ 29 employees

	Wage	Std error	Z value	samples
Whole sample				23,287
Exporting plants (a)	2.769	0.015	190.18	797
Non-exporting plants (b)	2.587	0.003	986.36	22,490
Wage premium of eporters (a) - (b)	0.181	0.015	12.26	
Part from difference of characteristics (c)	0.154	0.014	11.31	
Other part (correlated with exports) (d)	0.027	0.014	1.91	
Breakdown of (c)				
difference of workers' characteristics (e)	0.032			
difference of plants/firms' characteristics (f)	0.122			

[4] Employees at firms with 30 ~ 99 employees

	Wage	Std error	Z value	samples
Whole sample				41,612
Exporting plants (a)	2.811	0.007	380.860	3196
Non-exporting plants (b)	2.666	0.002	1308.700	38,416
Wage premium of eporters (a) - (b)	0.146	0.008	19.020	
Part from difference of characteristics (c)	0.098	0.007	15.000	
Other part (correlated with exports) (d)	0.048	0.006	8.130	
Breakdown of (c)				
difference of workers' characteristics (e)	0.035			
difference of plants/firms' characteristics (f)	0.063			

[5] Employees at firms with 100 ~ 299 employees

	mean	std error	Z value	samples
Whole sample				45,391
Exporting plants (a)	2.950	0.005	550.41	6379
Non-exporting plants (b)	2.800	0.002	1305.71	39,012
Wage premium of eporters (a) - (b)	0.151	0.006	26.09	
Part from difference of characteristics (c)	0.118	0.005	22.76	
Other part (correlated with exports) (d)	0.032	0.004	7.25	
Breakdown of (c)				
difference of workers' characteristics (e)	0.049			
difference of plants/firms' characteristics (f)	0.069			

[6] Employees at firms with 300 ~ 999 employees

	mean	std error	Z value	samples
Whole sample				35,268
Exporting plants (a)	3.081	0.005	669.88	8648
Non-exporting plants (b)	2.971	0.003	1061.18	26,620
Wage premium of eporters (a) - (b)	0.110	0.005	20.41	
Part from difference of characteristics (c)	0.127	0.006	22.10	
Other part (correlated with exports) (d)	-0.017	0.005	-3.55	
Breakdown of (c)				
difference of workers' characteristics (e)	0.055			
difference of plants/firms' characteristics (f)	0.072			

[7] Employees at firms with 1,000 ~ employees

	mean	std error	Z value	samples
Whole sample				47,817
Exporting plants (a)	3.337	0.003	1110.880	20597
Non-exporting plants (b)	3.173	0.003	1120.880	27,220
Wage premium of eporters (a) - (b)	0.164	0.004	39.800	
Part from difference of characteristics (c)	0.138	0.005	28.080	
Other part (correlated with exports) (d)	0.027	0.004	6.930	
Breakdown of (c)				
difference of workers' characteristics (e)	0.056			
difference of plants/firms' characteristics (f)	0.081			

[8] Effect of exports on wage premiums

	wage premium of eporters (log)	Correlation with exports (log)	wage premium of eporters (real)	Correlation with exports (real)	Correlation with exports/premium
	(a)-(b)	(d)	(g)=exp^{(a)-(b)}	(h)=exp^(d)	((h)-1)/((g)-1)
Whole sample	0.345	0.034	1.365	1.034	**9.45%**
Firm size					
5～9 employees	0.139	0.077	1.149	1.080	**53.50%**
10～29 employees	0.181	0.062	1.199	1.064	**32.40%**
30～99 employees	0.146	0.052	1.157	1.053	**33.70%**
100～299 employees	0.151	0.047	1.163	1.048	**29.60%**
300～999 employees	0.110	-0.002	1.116	0.998	**-1.30%**
1,000～ employees	0.164	0.026	1.179	1.026	**14.80%**

Note Author’s calculation from employer–employee data constructed from the BSWS 2012 and the ECBA 2012.

8. Conclusion

From the foregoing analysis, the following points were clarified:

(1) For the Japanese manufacturing sector, the estimated wages at exporting plants were higher than those at non-exporting plants even after controlling for the characteristics of employees and plants. However, in the manufacturing sector as a whole, the portion of the wage premium correlated with exports constitutes is very limited, at less than 10% of the wage premium according to the Blinder－Oaxaca decomposition. The limited effect of exports is observed for the wages of non-skilled employees whereas exports have no effect on the wages of skilled labor.

(2) Skilled labor intensity has a stable positive effect on the wages of non-skilled employees. A certain portion of the observable wage premium of exports stems from this attribute.

(3) The estimation of a Mincer-type wage function and Blinder－Oaxaca decomposition according to firm size indicates that the wage premium correlated with exports is biased toward remarkable in relatively small firms with fewer than 300 employees.

In other words, we found that the wage premium for exporting firms is generally small, as Tanaka (2015) and Endoh (2018) concluded; that is, unlike firms, employees in exporting plants do not receive benefits from exporting. [40] A considerable portion of the wage export premium is ascribed to the difference in the attributes of plants and workers, particularly the ratio of skilled workers. This finding is consistent with the low labor share of exporting firms, and is consistent with Yeaple (2005), who emphasized the role of skills in the wage premiums of exporters, rather than Helpman et al. (2010).

Finally, we would like to explain how to expand and develop Chapters 2 and 3 in the future. In Chapter 2, the information on the attributes of workers was insufficient because of data constraints; thus, we could not construct panel data in Chapter 3. More detailed information on the attributes of employees in the manufacturing sector can be obtained from public statistics data and used in the analysis, and be applied for the analyses of the labor share. This research plan has been adopted as a part of the FY2020 Project Research Program of Joint Usage and Research Center, the Economic Research Institute, Hitotsubashi University. Following Autor et al. (2020) and Kehrig and Vincent (2021), the project aims to (i) construct a cross-sectional employer-employee dataset that

[40] Generally, it is thought that firms engaged in globalization benefit in various ways. Firms self-select whether to make efforts to globalize, thus, there is no need for them to tackle the task if they do not expect benefits. For this reason, it is expected that firms engaged in globalization currently benefit or judge that they will benefit in the future even if they are not benefiting at present.

Many empirical studies of the causal relationship between firms' international activities (export/FDI) and their productivity have been conducted since the 2000s. Although their results vary depending on the country and the period, in Japan Ito (2011) and Kurita (2014) have shown the existence of the causal relationship from starting exportation and productivity improvement.

merges Japanese plant-level and employee data and calculate industry-level average employees' characteristics; (ii) generate sector-level information on employees and merge it into firm-level panel data; and (iii) evaluate the impact of firms' activities on firm-level labor share, controlling for employees' characteristics. In addition, the analysis can be extended to target the non-manufacturing sector.

Appendix

Table 3-A1 Variables used in the estimation of the wage function

log_W_{ij}	: log of salary of worker The following two definitions of salary of worker is used. 1. regular salary/regular working hours 2. (regular salary+ special allowance*1/12) / (regular working hours + overtime hours worked)
d_export_j	: export dummy (0: non-exporting, 1: exporting)
$Sales\_export\_ratio_j$	: sales–export ratio (ratio of direct export value to the amount of shipment of manufactured goods)
$export\_experience_j$	: export experience (number of exports during the investigation period, 2001–2010)
$Skilled\_worker\_ratio_j$	: skilled worker ratio (ratio of employees who graduate from university/graduate school to all employees)
Export_ratio & skill ratio$_j$	: interaction term of $Sales\_export\_ratio_j$ and $Skilled\_worker\_ratio_j$
d_DOL_j	: division of labor dummy (0: single plant, 1: independent headquarter or multiple plants)
log_emp_j	: log of workers at plant
$d\_Firm\_size_j$	: firm size dummy (1: 1,000 or more regular employees, 2: 300~999 regular employees, 3: 100~299 regular employees, 4: 30~99 regular employees, 5: 10~29 regular employees, 6:~ 9 regular employees)
d_School_i	: education dummy (1: junior high school, 2: high school, 3: junior college, 4: university/graduate school)
$Potential\_Experience_{ij}$	: latent experience year (= age–education year)
d_Age60_{ij}	: dummy of 60 years old or older (0: 59 years old or younger, 1:60 years old or older)
$d\_Line\_Product_{ij}$	: dummy of working section (1: management section and line, 2: management section and staff, 3: production section and line, 4: production section and staff)

$d\_Emp\_style_{ij}$: employment type dummy (1: full-time and permanent, 2: full-time and fixed term, 3: part-time and permanent, 4: part-time and fixed term in 2012)

d_Female_{ij} : female dummy (0: male, 1: female)

Chapter 4 Japan's Participation in Global Value Chains: Splitting the IO Table into Production for Export and Domestic Sale

1. Introduction

The analysis in Chapter 2 suggests that Japanese exports may not be skilled-labor-intensive. To confirm this point, this chapter analyzes the degree of factor content including skilled labor in Japanese exports and domestic sales.

The firm-level or plant-level data we used in Chapters 2 and 3 are not appropriate for to calculate the skilled-labor-intensity of exports. The JBSA survey and the ECBA do not include the number of skilled labor workers (university-graduate workers) working at firms or plants. The matched employer-employee data we used in Chapter 3 contains information on employees, but the ECBA, the basis of the employer–employee data, does not collect information on headquarters or non-plant establishments where business operations necessary for exports, such as determining export destinations and customs clearance procedures are carried out. Therefore, in this chapter, we use a new approach, that is, the split multinational input–output table (MIOT) proposed by Koopmans et al.

(2012, 2014) and Ahmad et al. (2013) is used to distinguish the differences in the factor content of exports and domestic sale.

Recently many studies that attempt to measure the significance of global value chains (GVCs) in global production rely on MIOTs (see, e.g., Koopman et al., 2014). There have been several initiatives to construct such tables, among them are those outlined in Piacentini and Fortanier (2015), Timmer et al. (2015) and Meng et al. (2013). The aim of these tables is to link national supply–use tables (SUTs) via international trade flows. Furthermore, in line with the theoretical and empirical literature on international trade highlighting the role of firm heterogeneity (Melitz, 2003; Bernard et al., 2007), recent research on MIOTs has attempted to account for firm heterogeneity in terms of firm size, ownership, trade mode, etc., into account in order to obtain a better understanding of countries' participation in GVCs (Ahmad et al., 2013; Ma et al., 2015; Fetzer and Strassner, 2015). Few such studies have been conducted on Japan, however.

Using a unique dataset containing Japanese manufacturing plant-level data, we attempt to contribute to research on MIOTs by accounting for firm heterogeneity. As a first goal we propose an estimation procedure to create an extended MIOT that considers exports from Japanese plants. Our second goal is to compute Japan's GVC participation using the extended MIOT and to explore the benefits that such an extended MIOT provides. Finally, we clarify the demand of exporting and non-exporting activities for factor inputs to compare the change in skilled-labor-intensity.

Methodologically, our estimation procedure is similar to the one employed by Ma et al. (2015). Specifically, using plant-level data from the ECBA, we split output in each industry of Japan's manufacturing sector in the OECD ICIO table into output for export and domestic sale. We then employ quadratic programming and compute all elements of the extended ICIO table. Finally, we compute trade in value added (TiVA) indicators for Japan from our extended ICIO table and compare them to indicators computed from the original OECD ICIO table. Further, as an extension, we compute Japan's factor inputs induced by world final demand from the extended and original ICIO table and compare the skilled-labor-intensity between output for export and domestic sale. [41] The method we use to compute the domestic and foreign value-added shares in a country's exports follows that of Hummels et al. (2001), which is widely used for computing TiVA indicators. One of the key assumptions is that the intensity of intermediate input use is the same for production for export and production for domestic sale. Clearly, this simplification likely lead to underestimation of GVC participation indicators if production for export more extensively relies on foreign intermediate inputs. While we

[41] To conduct these estimations, we obtain the necessary factor input data by matching the data from the ECBA and the BSWS.

follow the assumption at the beginning of quadratic programming, it does not hold after the estimation by quadratic programming. Employing the split ICIO table, we can measure backward and forward linkages in the Japanese manufacturing sector GVCs more accurately than can analyses based on the traditional ICIO table. Since Hummels et al. (2001), several studies have examined GVC participation measures (e.g., Johnson and Noguera, 2012; Koopman et al., 2014). Of particular interest as a measure of intercountry linkages and involvement in GVCs is countries' backward and forward linkages in GVCs (Kowalski et al., 2015). Analyses of these linkages have been increasingly important in the trade theory literature (Grossman and Rossi-Hansberg, 2012; Costinot et al., 2013; Baldwin and Venables, 2015). In the case of Japan, it has been argued that the manufacturing sector has relatively strong forward linkages, so that foreign final-demand shocks may have a considerable impact on the Japanese economy (Fukao and Yuan, 2009).[42] To confirm this point, we calculate the domestic value added in exports (*DVA*), the foreign value added in exports (*FVA*), the domestic value added embodied in foreign final demand (*FFD_DVA*), and the factor inputs induced by foreign final demand (*FFD_F*), and then compare these statistics to TiVA estimates based on the traditional ICIO table.[43]

[42] In this study, we distinguish between sectors and industries. The term "sector" refers to broad classifications such as the manufacturing sector and the service sector. We reserve the term "industry" for categories within these sectors, such as the textile industry in the manufacturing sector.

[43] Note, that TiVA indicators do not include factor inputs induced by foreign final demand. We compute *FFD_F* from both the original non-split and the extended split version of the ICIO table and compare the

Finally, we find that the intensity of factor use induced by foreign final demand varies significantly across and within industries.

2. Literature review

Our study builds on a growing literature that attempts to identify within-industry heterogeneity in the MIOT framework. To reflect such heterogeneity, most studies produce split IO tables using micro-level data to show the benefits of such a split.

Several important studies have been conducted by the OECD. Using Turkish micro data for 2006, Ahmad et al. (2013) were the first attempt to consider firm heterogeneity within the IO framework. They examined the statistical properties of several indicators such as firms' export intensity (export/output ratio), firms' intermediate import ratio (intermediate imports/intermediate consumption ratio), firms' value added per unit of output, firms' value added, and exporting firms' share in total output. Considering heterogeneity in firm ownership – i.e., whether firms are foreign-owned or domestically owned – and in firm size, they found that, on average, the observed statistics increase with firm size and are greater for foreign firms.

results obtained. We use matched employer–employee data to obtain factor inputs for the split ICIO table.

Ahmad and Ribarsky (2014) follow-up and suggested various ways to take heterogeneity into account using trade statistics via both the OECD's Trade by Enterprise Characteristics (TEC) and TiVA databases. Taking heterogeneity in firm size and ownership into account, they documented the distribution of indicators such as the share of firms that export, firms' export value, and firms' export to turnover ratios for 25 European countries, Canada, and the United States. They argued that for some countries it may be better to consider other types of heterogeneity, such as firms engaged in processing trade in the case of China, global manufacturers and domestic firms in the case of Mexico, or whether firms are operating inside or outside export zones in the case of Costa Rica.

Piacentini and Fortanier (2015) broadened the number of countries (mainly European countries, as well as the United States and Latin American countries, but only a small number of countries in Asia and Africa) by linking several micro databases (namely, the OECD Trade by Enterprise Characteristics database and Activity of Multinational Enterprises databases). By accounting for firm size and ownership heterogeneity, they found that large, foreign-owned firms generally have higher export/turnover, import/turnover, and VA/employment ratios.[44] In addition, they identify

[44] Piacentini and Fortanier (2015) also compared VA/turnover ratios, but the results are mixed.

the important role of SMEs as suppliers of intermediate inputs for exports.

Perhaps because of its rising economic dominance, China also has been a focus. Chen et al. (2012), for instance, presented an input–output (IO) approach that distinguishes processing exports (P), non-processing exports (N), and output for domestic use (D) in production activity. One of their important contributions was their product-by-product (so-called "DPN") IO table for China. They argue that domestic final demand in China induced higher domestic value added and employment than did final demand generated by exports. The OECD used their DPN IO table for China to account for domestic use, processing exports, and non-processing exports in the OECD ICIO table. Chen et al. (2018) argued that including the product-by-product DPN IO table within the industry-by-industry OECD ICIO table framework requires strong assumptions, so they proposed an alternative using WIOD tables (Timmer et al., 2015). They compared China's exports and imports of value added in 2007 derived from the non-extended WIOD tables, the extended OECD ICIO table, and their extended DPN world input-output tables (WIOT) and concluded that value-added trade is overestimated in the non-extended WIOD tables and the extended OECD-ICIO table. In this regard, Chen et al. (2019) work was closely related to ours. However our approach differs from theirs in that we use plant-level data to distinguish production for export and domestic sale. This allows us to split

Japan's manufacturing sector output in the industry-by-industry OECD ICIO table more accurately into output for export and domestic sale.

Another study related to ours is that by Koopman et al. (2012). They divided production activities in China into processing exports, normal exports, and production for the domestic market, and conclude that *DVA* in exports increased after China joined the WTO. Furthermore, extending previous studies using micro data and taking trade regimes and firm ownership heterogeneity (domestic-owned enterprises and foreign-invested enterprises) within industries in China into account, Ma et al. (2014) argued that foreign-owned enterprises make the largest contribution to domestic VA in exports (about 45%). Meanwhile, domestic-owned processing firms account for a much smaller share of domestic content in exports (less than 5%). They also found that the income share captured by foreign factor owners is about 52.6%. In sum these studies focus on how processing trade production activities affect the distribution of domestic value-added among industries in China, and how capital and labor income is captured by Chinese or foreign factor owners.

For the United States, extended IO tables that consider firm heterogeneity have been created by researchers from the Bureau of Economic Analysis (BEA) and the US International Trade Commission. Fetzer and Strassner (2015) and Fetzer et al. (2018)

considered the role of firm heterogeneity by distinguishing among multinational enterprises (MNEs) headquartered in the United States, foreign MNEs' affiliates operating in the United States, and domestic non-MNE firms. They then create extended IO tables based on this distinction. By comparing TiVA statistics derived from the extended and non-extended SUTs, they argued that the variance in TiVA statistics is greater when firm heterogeneity is accounted.

In summary, these studies provide alternative ways in which firm heterogeneity within industries is considered in IO tables. Most of the studies focus on firm heterogeneity in terms of firm ownership, size, and trade mode. Against this backdrop, we introduce heterogeneity within industries in the ICIO table by distinguishing production for foreign and the domestic markets to observe skilled-labor-intensity of export and domestic sale. To consider such heterogeneity, we split the output of each industry in the IO table into exports and domestic sales following the approach of Koopman et al. (2012). This allows us to identify how much domestic value in production for export and domestic sale is induced directly and indirectly via foreign final demands.[45]

[45] While many previous studies examining IO linkages focus on ownership and size to construct split IO tables, it may not make much sense to perform a similar analysis in Japan for two reasons. First, there are relatively few foreign-owned firms in Japan (Paprzycki and Fukao, 2008); thus, they are unlikely to have a significant impact on the GVC participation of Japanese plants. Second, in terms of size, exporting firms tend to be large, so large firms are quite likely to engage in GVCs. Therefore, if we consider firm-size heterogeneity, we should expect results that are similar to prior studies that recognize export-domestic sale heterogeneity of production.

Overall, we add to the IO literature in the following respects. First, our study is the first to use plant-level data. Second, we distinguish between production for export and domestic sale when considering plant heterogeneity and split the ICIO table accordingly. Doing so enhances our understanding of the participation of Japan's manufacturing sector in GVCs. Third, we rely on detailed labor data from the BSWS. This allows us to compute labor input induced by foreign final demand and to infer the effect of participation in GVCs on domestic factor input demand. To the best of our knowledge, due to data limitations, previous studies do not consider domestic factor input demand induced by foreign final demand.

3. Differences in production for export and domestic sale: empirical findings

In this section, we examine the differences between production for export and domestic sale in the Japanese manufacturing sector. In addition, we present some basic data on plants' performance and factor content in production using our micro data.

Table 4-1 shows the distribution of manufacturing plants in the ECBA micro data in terms of their export intensity. First, non-exporting plants (plants with a 0% export/sales ratio) make up 97.4% of our sample, indicating that exporting plants are extremely rare (2.6%). The table further shows that the number of plants generally decreases with the degree of export intensity.

To examine the heterogeneity in plants' production for export and domestic sale, we present here the value added/sales ratio and labor productivity computed as described in Section 4.2. The total value added in each industry is split into the valued added of production for export and for domestic sale using the shares of exports and domestic sales in the total output of each industry. The same approach is applied to aggregate the number of workers involved in production for export and domestic sale for each industry. This allows us to compute the value added/sales ratio and labor productivity.

Table 4-1 Number of observations by export/sales ratio

Export / sales ratio	Observations	Share
0%	323,784	97.40%
More than 0% to 10%	4,667	1.40%
More than 10% to 20%	1,290	0.40%
More than 20% to 30%	733	0.20%
More than 30% to 40%	481	0.10%
More than 40% to 50%	410	0.10%
More than 50% to 60%	271	0.10%
More than 60% to 70%	225	0.10%
More than 70% to 80%	174	0.10%
More than 80% to 90%	126	0.00%
More than 90% to 100%	199	0.10%
Total	332,360	100.00%

Note: Authors' calculations based on the ECBA micro data.

The result presented in Table 4-2 indicates that in most industries the difference between the value added/sales ratios of production for export and for domestic sale is small. Although on average the ratio is higher in the case of production for domestic sale, in most industries the ratios are quite similar. On the other hand, Table 4-2 shows that there is significant heterogeneity in labor productivity and a clear size relationship of the two variables in each industry: labor productivity of production for export tends to exceed that of production for domestic sale.

Table 4-2 Value added/sales ratio and labor productivity of production for export and domestic sale

	Value added/sales ratio		Labor productivity	
	Domestic Sale	Export	Domestic Sale	Export
Food products, beverages, and tobacco	31.7%	41.6%	3,208	5,394
Textiles, textile products, leather, and footwear	34.4%	20.0%	1,612	3,548
Wood and products of wood and cork	26.9%	27.8%	2,549	1,055
Pulp, paper, paper products, printing, and publishing	33.8%	26.5%	3,202	6,406
Coke, refined petroleum products, and nuclear fuel	10.0%	11.8%	74,670	121,847
Chemicals and chemical products	37.5%	30.1%	7,905	8,484
Rubber and plastics products	34.8%	37.6%	2,898	5,627
Other non-metallic mineral products	38.0%	38.1%	3,110	5,265
Basic metals	13.9%	10.9%	8,235	14,696
Fabricated metal products	34.9%	33.8%	2,658	3,158
Machinery and equipment	33.1%	28.0%	3,061	5,712
Computer, electronic, and optical equipment	29.0%	26.0%	3,738	5,123
Electrical machinery and apparatus, nec	29.6%	24.9%	3,088	4,227
Motor vehicles, trailers, and semi-trailers	17.7%	3.9%	4,854	7,376
Other transport equipment	35.1%	34.6%	3,702	7,955
Manufacturing nec; recycling	31.3%	27.0%	3,146	3,332
Total	27.2%	19.6%	4,137	6,757

Note 1 Authors' calculations based on ECBA micro data.
2 Labor productivity = output (10,000 yen) / number of regular workers

A comparison of factor content in production for export and domestic sale reveals a clear difference. Table 4-3 shows that capital/sales ratio and share of university graduates for export and domestic sale. It is clear that production for export is more capital-intensive and more skilled-labor-intensive than production for domestic sale, as predicted by trade theories (such as the Heckscher-Ohlin framework).

Table 4-3 Capital/sales ratio and share of university graduates for export and domestic sale

	Capital/sales ratio		**Share of university graduates**	
	Domestic Sale	**Export**	**Domestic Sale**	**Export**
Food products, beverages, and tobacco	19.00%	24.50%	12.50%	21.80%
Textiles, textile products, leather, and footwear	24.30%	57.50%	7.80%	19.40%
Wood and products of wood and cork	21.60%	47.20%	11.90%	24.00%
Pulp, paper, paper products, printing, and publishing	36.30%	25.00%	18.70%	44.60%
Coke, refined petroleum products, and nuclear fuel	8.90%	6.10%	19.20%	26.10%
Chemicals and chemical products	23.80%	29.20%	31.60%	33.10%
Rubber and plastics products	28.20%	32.60%	14.40%	23.60%
Other non-metallic mineral products	43.90%	77.60%	16.10%	29.50%
Basic metals	25.70%	31.60%	18.10%	20.30%
Fabricated metal products	24.60%	31.30%	14.40%	29.20%
Machinery and equipment	20.90%	15.90%	25.10%	34.80%
Computer, electronic, and optical equipment	20.90%	30.40%	25.90%	35.30%
Electrical machinery and apparatus, nec	16.80%	18.30%	20.90%	28.40%
Motor vehicles, trailers, and semi-trailers	17.30%	15.30%	17.90%	18.10%
Other transport equipment	19.20%	14.90%	22.60%	33.40%
Manufacturing nec; recycling	18.00%	22.40%	19.90%	28.30%
Total	21.50%	22.30%	18.70%	27.60%

Note Authors' calculations based on ECBA micro data.

In short, the observed heterogeneity across plants in terms of their value added/sales ratios, labor productivity and factor intensity when distinguishing between production for export and production for domestic sale suggests that making this distinction can provide important insights when examining input–output linkages.

4. Data and method of estimating the split IO table

4.1. Data description

We use several different sources of data in our analysis.

4.1.1. Economic Census for Business Activity (ECBA)

The ECBA, which we also used in Chapter 3, was conducted for the first time in 2012 by MIC and METI. It was designed to identify the structure of establishments and enterprises in all industries on a national and regional level and to enable Japan to obtain basic information for conducting various statistical surveys. The first survey targeted almost all establishments and enterprises (hereafter referred to as plants for short) in Japan as of February 1, 2012. Note that the ECBA data that we use cover only manufacturing and we only split industries in the manufacturing sector because we are interested in factor contents in export of goods. [46]

The ECBA data that we use cover basic information such as the sales, capital, and number of employees of all plants with four or more employees in the manufacturing sector, comprising a total of 332,360 plants. They also include data on the share of the

[46] In our IO analysis we assume that service industries use the same technology for production for export and for domestic sale.

value of direct exports to sales, which we use to distinguish plants' exports and domestic sales in our analysis. From the ECBA, we use the information on tangible fixed assets,[47] shipments for domestic sale, and exports.

4.1.2. Basic Survey on Wage Structure (BSWS)

As explained in Chapter 3, the employees-level micro data of the BSWS is connected with the plant-level micro data to form the employer-employee data. We use information on the number of non-regular workers and university graduates from the employer-employee data.

4.1.3. The Intercountry Input–Output (ICIO) database

The ICIO table released by the OECD consists of 62 countries/areas and 34 sectors based on the International Standard Industrial Classification of All Economic Activities (ISIC), revision 3, released by the Statistics Division of the United Nations.[48] We split the table for Japanese manufacturing industries, of which there are 16 in the ICIO table. Note that we use the ECBA, which covers almost all manufacturing plants in Japan, to split value added, output, and IO linkages.[49]

[47] Land is not included in the value of tangible fixed assets.
[48] We work with the ICIO SNA93, ISIC REV.3 version of the OECD ICIO table.
[49] For the factor input analysis we use the employer–employee matched data to compute labor input as described in Section 6.

4.2. Estimation procedure

Next, we explain the procedure we use to split the input of intermediate goods, demand for intermediate goods, final demand, value added, and output of each industry in Japan's manufacturing sector in the ICIO table into production for export and domestic sale.

4.2.1. Rationale for splitting output into production for export and for domestic sale

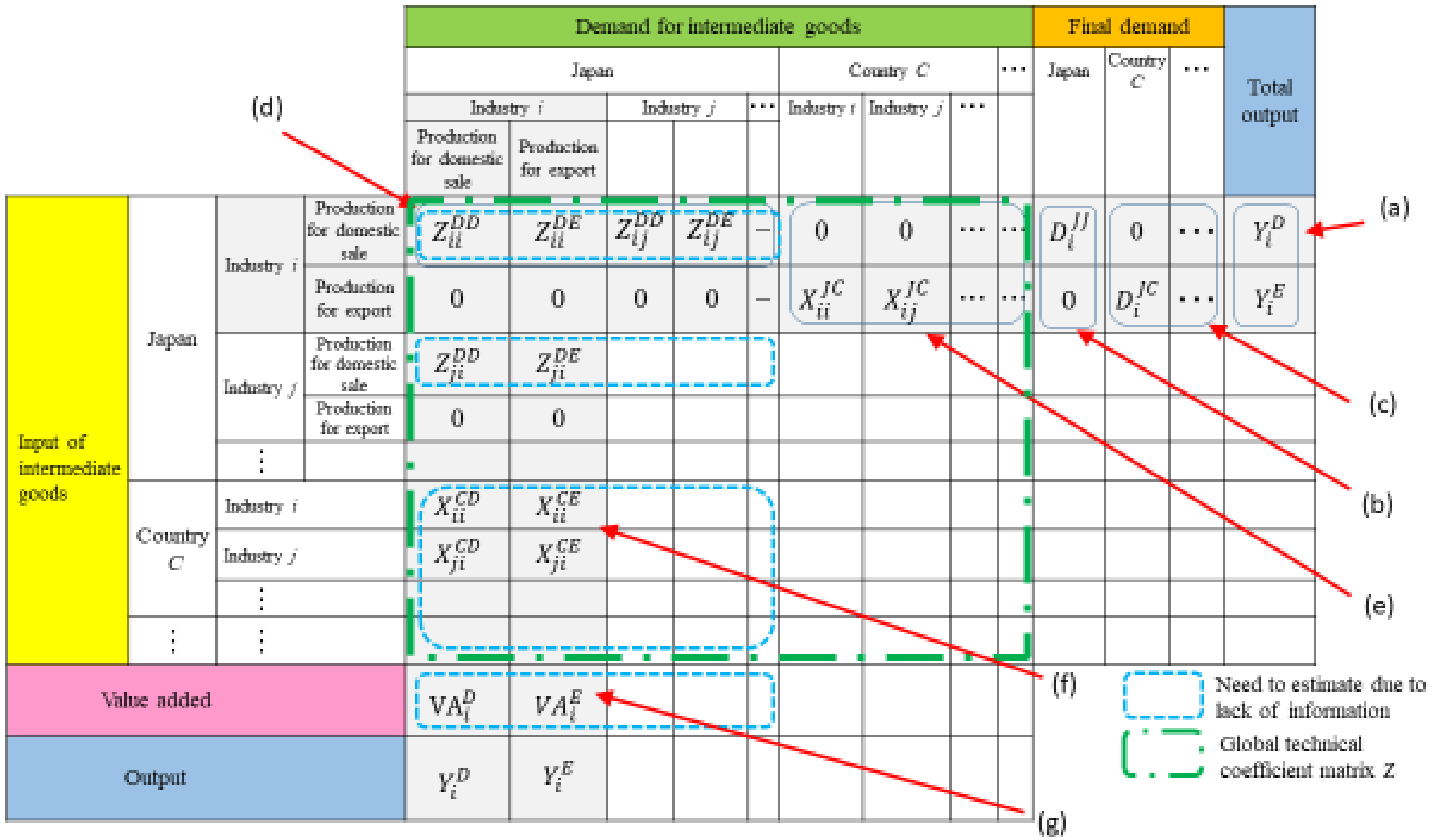
While previous studies that divide IO tables split production by industry into production of exporting and non-exporting firms, herein we split production in each industry in the Japanese manufacturing sector into production for export or domestic sale to observe factor contents of export and domestic sale.

If we had two groups of plants, one that sells only for export and another that sells only to the domestic market, we could split production in each industry into production by exporting and non-exporting plants. Unfortunately for us, plant that largely export typically sell to the domestic market as well. So we are not able to take this approach. Instead, we assume that at each plant, input vectors are identical for activities aimed at producing goods for export and for the domestic market.[50] We therefore divide the output

[50] Information on imported input intensities for exporting and non-exporting plants is not available in our data. The dataset contains information on plants' total amount of purchased intermediate goods but not on the sector and country from which these intermediate goods are purchased.

of each industry into production by plants that do export and production by plants that do not export (see Figure 4-1). Inputs for export are, thus, the input of plants that do export multiplied by the share of their sales that is sold to foreign markets. Inputs for domestic sale are estimated by summing inputs of plants that strictly do not export and adding to them the inputs of plants that do export, albeit weighted by the share of their domestic sales. We then estimate the split IO table using a quadratic programming method. The split introduces a new dimension in multi-country IO tables that proves to be highly important in the light of our analyses.

Figure 4-1 Split of Japan's manufacturing sector into production for domestic sale and production for export



4.2.2. Sequence of estimation of the split IO table

The sequence of estimation of the split IO table is as follows.

(1) We harmonize the industry classifications of the ICIO table and our micro data.

While the ICIO table uses ISIC rev.3, the ECBA uses the Japan Standard Industry Classification (JSIC, ver.11), which has more detailed categories.[51] The concordance table of ISIC rev.3 and JSIC ver.11 published by the Japanese government is used to aggregate our micro data into the 16 manufacturing industries for Japan in accordance with the ICIO table.[52]

(2) We classify the micro-data of the ECBA into the 16 manufacturing industries using the concordance table mentioned above.

(3) Before we can conduct our estimation, we need to make conjectures about the initial values of the elements in the IO table. We set the following values in the extended IO table as shown in Figure 4-1:[53]

a. *Total output*: For each of the 16 industries, we calculate production by plants that

[51] In JSIC rev.11, there are 637 industries, which are represented by three-digit codes.
[52] The ICIO table also contains data on domestic sales and exports at the industry level, and we could split the table using this data. However, we use the information from the ECBA, because the ECBA is an almost complete census and hence provides more accurate information.
[53] Note, that the numbering that follows (i.e., a, b, c, d, e, f, and g) corresponds to the numbering in Figure 4-1(b).

export and production by plants that do not export by aggregating the production and input data of the two plant groups. We then compute the shares of production for export, s_i^E, and production for domestic sale, s_i^D, in total output, and use them to split the original data in the ICIO table into, Y_i^D, and Y_i^E:

$$s_i^E = \frac{\sum_{p_i \in E_i} PE_{p_i}}{\sum_{p_i \in E_i} PE_{p_i} + \sum_{p_i \in E_i} PD_{p_i} + \sum_{p_i \in D_i} PD_{p_i}} \tag{1}$$

$$s_i^D = 1 - s_i^E \tag{2}$$

$$Y_i^E = s_i^E Y_i^O \tag{3}$$

$$Y_i^D = s_i^D Y_i^O \tag{4}$$

where PE_{p_i} stands the for production for export of plant p_i, PD_{p_i} stands for the production for domestic sale of plant p_i, E_i denotes the set of plants in industry *i* that do export, D_i denotes the set of plants in industry *i* that do not export, and Y_i^O stands for output in industry *i* in the original ICIO table.

b. *Japan's final demand*: According to our identification, output produced for export is not available for domestic use. We therefore use data for Japan's final demand from the ICIO and use this as production for domestic sale (D_i^{JJ}). Zero is recorded in the row corresponding to production for export.

c. *Foreign final demand*: Output produced for domestic sale is not available for foreign final demand. We therefore use data for Japan's production for foreign final demand from the ICIO and use them as production for export (D_i^{JC}). Zero is recorded in the row corresponding to production for domestic sale.

d. *Japanese manufacturing sector's output used as Japanese manufacturing sector intermediate input:* By definition, production for export is not used as the Japanese manufacturing sector intermediate input. Therefore, in the row for Japan's production for export, we set all values for intermediate input in Japan to zero. In the row for Japan's production for domestic sale, the original data in the ICIO table are divided into output for domestic sale used in production for export and in production for domestic sale based on the shares of production for export and for domestic sale calculated in (a):[54]

$$Z_{ji}^{DE} = s_i^E Z_{ji}^O, Z_{ii}^{DE} = s_i^E Z_{ii}^O, Z_{ij}^{DE} = s_i^E Z_{ij}^O \quad (5)$$

$$Z_{ji}^{DD} = s_i^D Z_{ji}^O, Z_{ii}^{DD} = s_i^D Z_{ii}^O, Z_{ij}^{DD} = s_i^D Z_{ij}^O \quad (6)$$

where Z_{ji}^O (Z_{ii}^O, Z_{ij}^O) represents the manufacturing output of industry *j* (*i, i*) used as intermediate input in industry *i* (*i, j*) in the original ICIO table.

e. *Japanese manufacturing sector's output used as intermediate input by other*

[54] This calculation is based on the assumption that technology is homogenous within plants producing for export and domestic sale.

countries: In the row for production for export, the original data from the ICIO are used. In the row for production for domestic sale, values are set to zero.

f. *Foreign output used as the Japanese manufacturing sector intermediate input*: The original data in the ICIO table are split into foreign output used as intermediate input in production for export and for domestic sale based on the shares calculated in (a):

$$X_{ji}^{CE} = s_i^E X_{ji}^O, X_{ii}^{CE} = s_i^E X_{ii}^O \quad (7)$$

$$X_{ji}^{CD} = s_i^D X_{ji}^O, X_{ii}^{CD} = s_i^D X_{ii}^O \quad (8)$$

where X_{ji}^O (X_{ii}^O) represents the manufacturing output of industry *j* (*i*) used as intermediate input in industry *i* (*i*) in the original ICIO table.

g. *Value added of production for export and for domestic sale of the Japanese manufacturing sector*: Value added is equal to output minus the sum of inputs. For the calculation of VA^E, the sum of inputs used is the sum of elements in the column for production for export, while for the calculation of VA^D it is the sum of elements in the column for production for domestic sale:[55]

$$VA_i^D = Y_i^D - Z_{ii}^{DD} - Z_{ji}^{DD} - X_{ii}^{CD} - X_{ji}^{CD} \quad (9)$$

[55] We do not use information on value added from the micro-level data. That would mean making additional restrictive assumptions on the distribution of value added.

$$VA_i^E = Y_i^E - Z_{ii}^{DE} - Z_{ji}^{DE} - X_{ii}^{CE} - X_{ji}^{CE} \quad (10)$$

(4) We implement quadratic programming, which balances IO tables subject to constraints and initial values.[56] As a result, we obtain the extended ICIO table with the Japanese manufacturing sector output split into production for export and domestic sale. [57]

5. Extended input–output table analysis of forward and backward participation in GVC

5.1. Indicators of forward and backward participation in GVC

We are now ready to identify how heterogeneity in production for export and domestic sale affects domestic and foreign value added embodied in Japanese exports and final demand, as well as factor input use induced by final demand. The indicators we calculate are described below.

We start by computing a global Leontief inverse matrix **L** of dimension *C*S x C*S*

[56] The purpose of this estimation is twofold. The first is to ensure that the balance conditions in the aggregated ICIO table are always satisfied, and that the estimated ICIO table is consistent with the original ICIO table. The second is to ensure that the estimated ICIO table is consistent with the structure of production for export and domestic sale. Our estimation framework closely follows Ma et al. (2015). Details of the estimation framework are in Appendix 1.

[57] After the estimation, the assumption that the intensity of intermediate input use is the same for production for export and production for domestic sale does not hold.

(where C stands for country and S stands for industry):

$$\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1} \quad (11)$$

where **A** is a global technological coefficient matrix ($C*S$ x $C*S$) in which each element is defined as $a_{ij} \equiv z_{ij}/y_j$.[58] Each element of the global value-added share of output vector **v** (1 x $C*S$) is computed as $v_j = va_j/y_j$, where va_j is the value added of sector j and y_j is the output of sector j.

To allow comparison, the indicators we use are identical to those of the OECD TiVA database.[59] Below, we provide short definitions of the indicators used.

(1) Domestic value added in exports in each industry (DVA_{JWOR})

DVA_{JWOR}, which serves as a measure of forward participation in GVCs, includes both direct exports (production for export) and indirect exports, that is, goods produced for domestic sale used as input for production for export, and is defined as follows:

$$DVA_{JWOR} = \mathbf{v}_J' \mathbf{L}_J \widehat{\mathbf{ex}}_J' \quad (12)$$

where $\mathbf{v}_J'$ is a row vector of the value added/output ratio for Japanese industries; $\mathbf{L}_J$ is a

[58] The part of the interindustry transaction matrix **Z** and the output vector **y** that corresponds to Japan's manufacturing sector is split into production for export and domestic sale, as explained in Section 3.2. See Appendix 1 for technical details.
[59] We use version 2 of the definitions of TiVA 2015 indicators. Retrieved from https://www.oecd.org/sti/ind/tiva/TIVA_2015_Indicators_Definitions.pdf on June 19, 2017. During the writing of this manuscript, a newer version has been released by the OECD, which can be found at http://www.oecd.org/sti/ind/tiva/TIVA_2016_Definitions.pdf. The calculations remain the same.

diagonal block matrix for Japan of the global Leontief inverse matrix representing total domestic gross output required for a one-unit increase in Japan's demand; and $\widehat{\mathbf{ex}'_J}$ is a diagonalized matrix of vector $\mathbf{ex}'_J$ representing Japanese industries' exports.

(2) Foreign value added in exports in each of Japan's industries (FVA_{JWOR})

FVA_{JWOR}, which serves as a measure of backward participation in GVCs, includes the direct and indirect inputs of all other countries' industries into Japan's industries' exports and is defined as follows:

$$FVA_{JWOR} = \mathbf{v}'\mathbf{L}_{J_{zero}}\widehat{\mathbf{ex}'_J} \tag{13}$$

where $\mathbf{v}'$ is a row vector of the global value added/output ratio (*C*S x 1*); $\mathbf{L}_{J\_zero}$ is a column block of the global Leontief inverse matrix corresponding to Japan, with the row block corresponding to Japan equal to zero, and $\widehat{\mathbf{ex}'_J}$ is a diagonalized matrix of vector $\mathbf{ex}'_J$ representing Japanese industries' exports.

(3) Japanese industries' domestic value-added component in world final demand ($FFD\_DVA_{J,WOR}$)

$FFD\_DVA_{J,C}$, which also serves as a measure of forward participation in GVCs, includes both the direct and indirect contribution of Japanese industries to world final demand via all global input–output linkages and is defined as follows:

$$FFD\_DVA_{JWOR} = \widehat{\mathbf{v}_J'}\mathbf{L}_{J,global}\mathbf{d}_{global,WOR} \quad (14)$$

where $\widehat{\mathbf{v}_J'}$ is a diagonal matrix of the value added/output ratio for Japanese industries on the diagonal, $\mathbf{L}_{J,global}$ is a row block of the global Leontief inverse matrix corresponding to Japan, and $\mathbf{d}_{global,WOR}$ is a vector of global final demand for goods and services from each industry in each country, excluding Japan's final demand.

5.2. Results

We now show the differences between the main indicators that arise when Japan's industries' output is split into production for export versus production for domestic sale. We start by examining the domestic and foreign value added in Japanese industries' exports. To allow a comparison, we sum up the results for *DVA*, *FVA*, and *FFD_DVA* when splitting production into that for export and for domestic sale to derive industries' total *DVA, FVA*, and *FFD_DVA* and compare these totals to the corresponding OECD TiVA statistics. Table 4-4 shows the deviation of the indicators derived from the split version of the ICIO table from those based on the original ICIO table.[60] To more clearly illustrate the results, Figure 4-2 shows the difference visually for textiles, fabricated metal

[60] See Appendix 1, Table 4-A1.

products, machinery & equipment, computer, electronic and optical equipment, electrical machinery and total manufacturing.

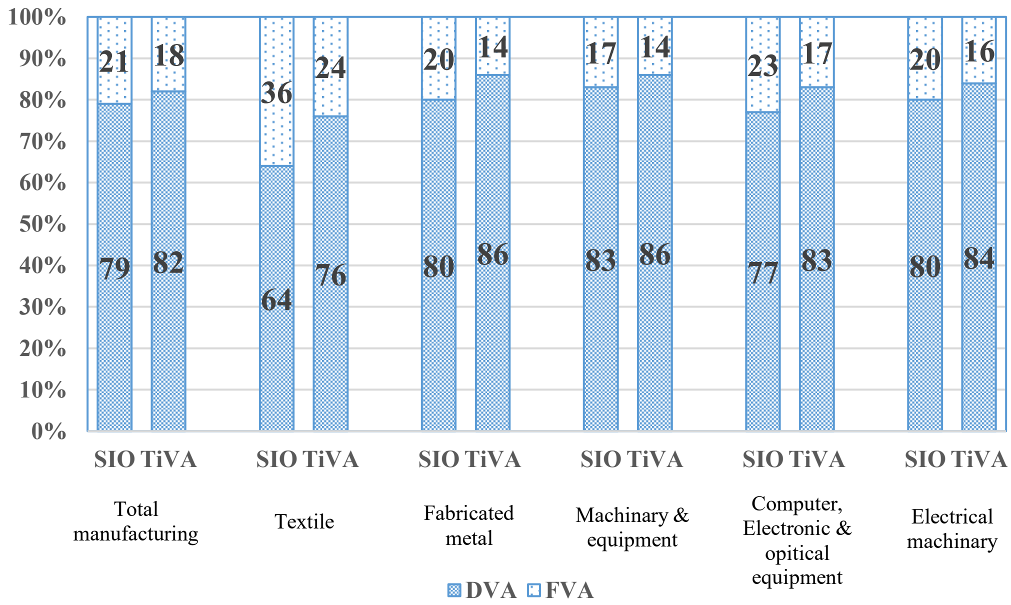
Table 4-4 Comparison of DVA, FVA, and FFD_DVA indicators between original and extended IO table

	Deviation of DVA (%)	Deviation of FVA (%)	Deviation of FFD_DVA(%)
Food products, beverages, and tobacco	-4.7	27.2	-5.7
Textiles, textile products, leather, and footwear	-16.8	39.5	-69.5
Wood and products of wood and cork	-7.2	25	11.7
Pulp, paper, paper products, printing, and publishing	-4.9	33.7	7.3
Coke, refined petroleum products, and nuclear fuel	30.3	-31.4	24.9
Chemicals and chemical products	-3.8	11.4	-13.9
Rubber and plastics products	-1.6	6.7	5.4
Other non-metallic mineral products	-4.7	24.7	-6.4
Basic metals	-5.9	18	1.7
Fabricated metal products	-7.3	35.6	-3.8
Machinery and equipment	-2.9	15.7	-28.3
Computer, electronic, and optical equipment	-7.2	28.6	-45
Electrical machinery and apparatus, nec	-5.9	27.2	-23.9
Motor vehicles, trailers, and semi-trailers	-2.1	12.2	-29.4
Other transport equipment	-5.1	24.2	-55.9
Manufacturing nec; recycling	-3.6	14.5	-11.2
Total	-4	16.5	-3.4

Note: 1 Author's calculation.

2 The deviations are calculated as {(A-B)/[(A+B)/2]}*100, where A represents the DVA (Japan's domestic value added in Japan's exports), FVA (foreign value added in Japan's exports), or FFD_DVA (Japan's domestic value added embodied in global final demand) from the split ICIO table, and B represents the DVA, FVA, or FFD_DVA from the 2016 edition of the TiVA database.

Figure 4-2 Comparison of DVA and FVA between original and extended IO table



Note 1 Author's calculation.

2 SIO stands for the result from the split ICIO table, and TiVA represents the TiVA results computed by the OECD using the non-split IO table.

3 See Table A2 for the data of each industries.

We find that the *DVA* computed from the extended ICIO table is lower in most industries as well as overall than the *DVA* computed from the original ICIO table.[61] The lower level of domestic value added means that foreign value added is higher than in the original ICIO table. Differences in the *FVA* of more than 10% are observed in many industries.[62] This implies that Japanese production for export relies more on foreign value added than estimates not taking plant heterogeneity into account suggest.

[61] Note that *DVA* is higher for the coke and petroleum industry. This industry is somewhat exceptional. In total, the number of plants is smaller in this industry and the share of exporters is relatively high (around 30%). Higher labor productivity of exporters could explain this result of a higher *DVA*.

[62] Exceptions are the rubber and plastics products and the coke, refined petroleum products, and nuclear fuel industries.

This finding indicates that Japan's forward participation in GVCs has not been as high (at least in 2011) as implied by previous studies (e.g., Fukao and Yuan, 2009). This suggests that Japanese manufacturing plants' production that is induced by foreign final demand is lower than previously argued. We infer that this result is caused by the low domestic value added/sales ratio of production for export, which implies a higher reliance on foreign inputs in production. For instance, several large assemblers (such as Toyota) purchase parts and components, and some of them come from abroad. This generates a leakage of *VA* abroad. Part of this process consists of intra-industry trade by multinationals. As GVCs proliferate, an increasing number of parts and components are being imported from abroad. The production of intermediate inputs abroad reduces the domestic value added/sales ratio, meaning that the Japanese manufacturing sector relies on backward linkages. In this context, Ito and Fukao (2010) suggest that Japanese multinationals' affiliates develop their suppliers abroad, which then provide intermediate inputs to firms in Japan. Hagino and Tokoyama (2016) also document that processing and assembly industries in Japan, many of which are export-oriented, import relatively more intermediate inputs than other industries. Note that Japan is not the only country with increased reliance on backward linkages. Timmer et al. (2014), who examine the period from 1995 to 2008, show that there was a global increase in foreign value-added shares in most industries in developed countries. Ma et al. (2014) observe a similar pattern for China. To support our argument, we compute the simple correlation between domestic value added in exports and foreign value added in exports for several industries and find that the correlation coefficient increased considerably between 1995 and 2011. For instance, in the machinery and equipment industry it rose from 0.93 in 1995 to 0.97 in 2011, in the computer, electronic, and optical equipment it increased from 0.66 to 0.86, and in the electrical machinery and apparatus industry it increased from 0.78 to 0.91. These substantial increases suggest that some manufacturing industries have indeed become more globally integrated.

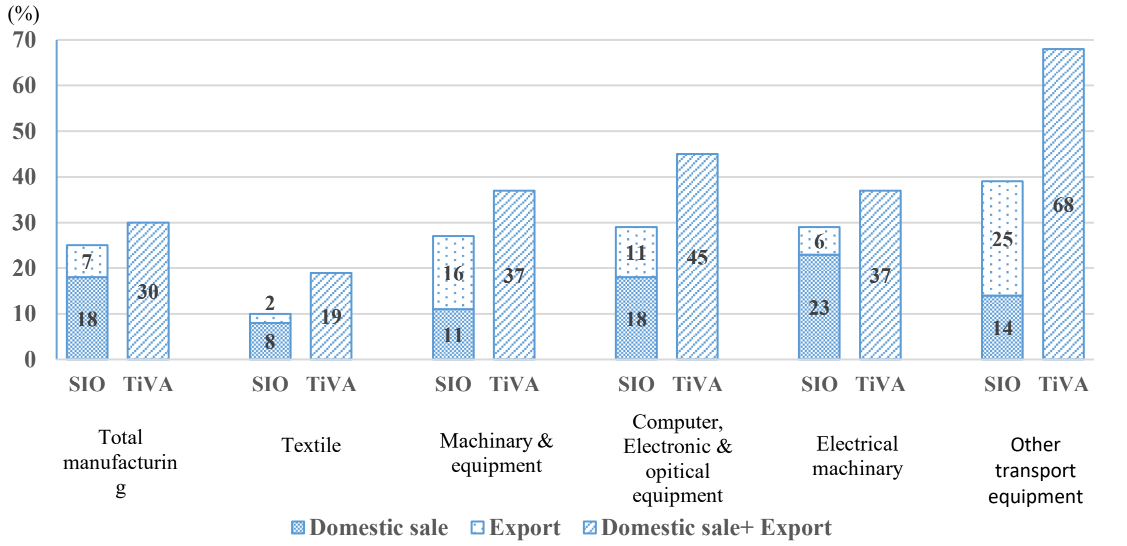
But we must note that domestic value added still represents a major part of Japanese exports. In sum, these findings imply that transnational fragmentation is greater than suggested based on measures that do not take plant heterogeneity in production for export and domestic sale into account.

Next, in the last column of Table 4-4 we compare our estimates of Japan's domestic value added embodied in global final demand to those reported in the TiVA database.[63] Again, to more clearly bring out the results, Figure 4-3 shows the difference visually for textiles, machinery & equipment, computer, electronic and optical equipment,

[63] Detailed results are provided in Appendix 1 Table 4-A1.

electrical machinery, other transport equipment, and total manufacturing. We find that our results are more than 20% lower than the TiVA results for the textiles, textile products, leather and footwear, machinery and equipment, computer, electronic and optical equipment, electrical machinery and apparatus, motor vehicles, trailers and semi-trailers, and other transport equipment industries. As is well known, plants in these industries tend to rely on outsourcing as well as outward FDI and intra-firm trade. Thus, when we consider manufacturing plant heterogeneity in production for export and production for domestic sale, we find that the *DVA* embodied in foreign final demand is lower than the results based on the ICIO table not taking such heterogeneity into account suggest. This is a surprising finding, because a widespread perception is that the Japanese manufacturing sector has much stronger forward than backward linkages, i.e., Japanese companies' value added represents an important share of foreign final demand (e.g., Fukao and Yuan, 2009). But we find that Japanese companies are strongly involved in GVCs via backward linkages as well. Thus, they rely on foreign intermediate input to a higher extent, and therefore depend less on foreign final demand, than suggested in previous studies.

Figure 4-3 Domestic value added embodied in world final demand, share in industries' total value added



Note 1 Author's calculation.
2 SIO stands for the result from the split ICIO table, TiVA represents the TiVA results computed by the OECD using non-split IO table.
3 See Table A3 for the data of each industries.

6. Skilled-labor-intensity and other factor contents of exports and domestic sale

In this section we present an extension of our analysis using matched employer–employee data to examine skilled-labor-intensity and other factor of exports and domestic sale. A correct understanding of domestic factor content participation in foreign production is of particular importance for revealing the spillovers of participation in global production networks. We use data from the ECBA and the matched employer–employee dataset using the ECBA and the BSWS constructed in Chapter 3. [64]

[64] For the detail of the data, see Chapter 3.

Our preliminary look at the data (Table 3) reveals that production for export is more capital-intensive and more skilled-labor-intensive than production for domestic sale. We also observe that there is considerable heterogeneity in production for export and domestic sale from a variety of perspectives, which leads us to conclude that to gain a better understanding of how Japan's manufacturing sector participates in GVCs it is useful to consider factor contents. We therefore extend our analysis to include this dimension.

For the purpose of our analysis, we calculated the factor input generated by world final demand via all global IO linkages, $FFD\_F_{J,C}$, which serves as a measure of forward participation in GVCs. $FFD\_F_{J,C}$ is defined as follows:

$$FFD\_F_{JWOR} = \widehat{\mathbf{f}_J'}\mathbf{L}_{J,global}\mathbf{d}_{global,WOR} \quad (15)$$

where $\widehat{\mathbf{f}_J'}$ is a diagonal matrix of factor inputs required per unit of output in the Japanese industries, $\mathbf{L}_{J,global}$ is a row block of the global Leontief inverse matrix corresponding to Japan, and $\mathbf{d}_{global,WOR}$ is a vector of global final demand for goods and services from each industry in each country, excluding, Japan's final demand.

Each element of the factor input/output share vector $\mathbf{f}_J'$ for Japan (*S x 1*) is computed as $f_j^J = \frac{FactorInput_j^J}{y_j^J}$, where y_j^J is the output of *j* sector ($j \in S$) in Japan, and

$FactorInput_j^J$ is the factor input of sector j ($j \in S$) in Japan.[65] We examine the following factor inputs: capital, regular workers, non-regular workers, and university graduates. Capital (tangible fixed assets) and regular workers are taken from the ECBA data. Other labor input is taken from the employer–employee matched data. For the purpose of our analysis, we employ only information on Japanese factor inputs.

Figure 4-4 presents the factor inputs embodied in foreign final demand in the manufacturing sector overall, the machinery and equipment industry, the computer, electronic and optical equipment industry. [66]

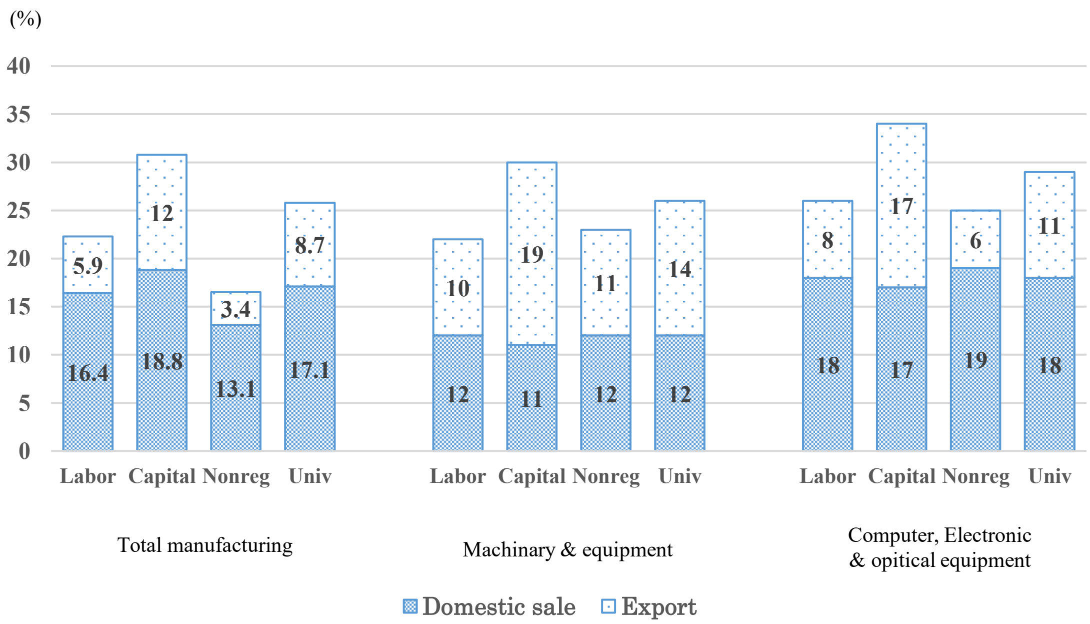
Regarding the skilled-labor-intensity shown in the last column of Table A4, the skilled-labor-intensity of production for exports increases by 2.8%, exceeding 0.6% in production for domestic sale in the manufacturing sector as a whole, Moreover, in all industries, the export sector becomes more skilled-labor-intensive than the domestic shipping sector. This finding rejects the hypothesis that the skill intensity of Japanese exports are low.

Looking at the other factor contents, we also found the following. First, in most industries capital are embodied in foreign final demand to a greater extent than labor of

[65] The approach used to calculate the factor content is explained in Appendix 2.
[66] See Appendix 1, Table 4- A4 for the detailed data.

regular and non-regular workers. Thus, most industries rely more on capital as well as high-skilled labor as factor inputs for foreign final demand production than on regular and non-regular workers. Secondly production for domestic sale contributes relatively high factor content to production for export, meaning that a significant part of production for domestic sale is used as input for production for export. Thus, production for domestic sale benefits from foreign final demand via indirect linkages. [67]

Figure 4-4 Factor inputs embodied in world final demand, share in industries' total factor input)



Note 1 Author's calculation.
2 "NonReg" stands for non-regular employees, "Univ" stands for university graduates.
3 See Table A4 for the data of each industries.

[67] Interestingly, there are a few exceptions, such as the machinery and equipment and other transport equipment industries, which are usually regarded as being capital- and high-skilled-labor-intensive. These industries do not show a high reliance on capital and high-skilled labor for production induced by foreign final demand.

In sum, we observe a high variation in factor inputs across different industries. But for most industries forward linkages are capital and skilled-labor-intensive, so that an increase in foreign demand is likely to induce a greater increase in the demand for capital and skilled workers than for unskilled workers.[68]

7. Discussion of labor share

Finally, we discuss how labor share changes depending on the ICIO split. Since the ICIO table does not have information on labor cost, it is not possible to calculate the level of the labor share based on it. [69] However, under the assumption that wages are fixed, the change in the labor share is equal to the difference of the change in employees and the change in value added.

Table 4-5 indicates the change in the labor share according to this method. The change in the labor share calculated from the split ICIO table is declining in almost all industries. This stems from the larger increase in value added compared to the increase in employees. The result is natural because firms' employment is not adjusted in the short

[68] We also examined the difference between factor inputs embodied in global final demand calculated from the split and non-split ICIO tables. We found that using a non-split IO table overestimates the level of factor inputs induced by foreign final demand. The details are available upon request.
[69] The WIOD project calculates the labor compensation of countries. According to Gourma et al. (2018), to calculate the labor compensation of Japan, they multiplied the value added from the table by the ratio of labor compensation o value added obtained from the JIP database.

term compared to firms' performance.

We also found that in all industries the labor share based on the split ICIO table is lower than that of the original ICIO table because of the lower level of growth of employees. Taking the results of the leakage of *DVA* into consideration, we can infer that the rate of increase in unskilled workers is particularly low due to the decrease in jobs for unskilled labor caused by offshoring and an increase in imports, etc.

Table 4-5 Change in the labor share in the Japanese manufacturing sector (induced by foreign demand)

	OECD TiVA Change (%)			Split IO Change (%)		
	Labor	FED_DVA	LS	Labor	FED_DVA	LS
Food products, beverages and tobacco	2.5%	2.5%	0.0%	2.1%	2.3%	-0.2%
Textiles, textile products, leather and footwear	18.7%	18.7%	0.0%	8.3%	9.1%	-0.8%
Wood and products of wood and cork	8.2%	8.3%	-0.1%	9.2%	9.3%	-0.1%
Pulp, paper, paper products, printing and publishing	15.6%	15.7%	-0.1%	16.5%	16.8%	-0.4%
Coke, refined petroleum products and nuclear fuel	15.1%	15.2%	-0.1%	14.4%	19.5%	-5.1%
Chemicals and chemical products	30.7%	30.8%	0.0%	26.1%	26.7%	-0.6%
Rubber and plastics products	32.0%	32.1%	-0.1%	30.5%	33.8%	-3.4%
Other non-metallic mineral products	25.0%	25.1%	-0.1%	19.9%	23.5%	-3.6%
Basic metals	52.9%	52.9%	-0.1%	52.7%	53.9%	-1.1%
Fabricated metal products	19.0%	19.0%	-0.1%	17.8%	18.3%	-0.5%
Machinery and equipment, nec	36.6%	36.6%	0.0%	21.7%	27.5%	-5.8%
Computer, Electronic and optical equipment	45.3%	45.4%	0.0%	26.3%	28.7%	-2.4%
Electrical machinery and apparatus, nec	36.8%	36.8%	0.0%	26.1%	28.9%	-2.8%
Motor vehicles, trailers and semi-trailers	40.7%	40.8%	0.0%	37.6%	30.3%	7.3%
Other transport equipment	68.2%	68.4%	-0.2%	33.6%	38.5%	-4.9%
Manufacturing nec; recycling	27.0%	27.1%	-0.1%	23.3%	24.2%	-0.9%
Total	29.3%	29.8%	-0.5%	21.6%	24.9%	-3.2%

Note: Author's calculation.

8. Conclusions

To view the skilled-labor-intensity of Japanese exports, this chapter adopts a method to split Japanese manufacturing output in the OECD ICIO table into production for export and domestic sale, and to construct an extended ICIO table.

Specifically, using the shares of production for export and for domestic sale in total output from the ECBA micro data, we estimated components of the extended OECD ICIO table for Japan's manufacturing sector industries. We computed trade in value added (TiVA) indicators for Japan and found that DVA and FED_DVA computed from the split IO table are lower than the results computed from the traditional input-output (IO) table. This finding implies that Japanese plants benefit less from foreign final demand and Japan's forward linkages have been weakening. We infer that this result is due to high cross-border production fragmentation as well as the large presence of Japanese multinational companies in global manufacturing and the high volume of intra-firm trade in Japan's manufacturing sector.

When, we then calculated Japanese factor inputs embodied in foreign final demand using our split ICIO table and compared the skilled-labor-intensity of exports and domestic sale. The results were compared to those obtained based on the non-split ICIO table. We observed that the share of exports was relatively higher in university graduates than in regular workers and non-regular workers. This means that exports are more capital-intensive and skilled-labor-intensive than domestic sales. For the manufacturing sector as a whole, skilled labor input induced by foreign final demand is higher in production for export than in production for domestic sale.

Based on the analysis in this chapter, which revealed exports in the Japanese manufacturing sector are more skilled-labor-intensive than domestic sales, we reconsider the question in Chapter 2 that firms that are highly dependent on export have a lower labor share. Rather that the hypothesis of the low-skilled-labor-intensity of exports, we can infer an alternative hypothesis: exporters tend to reduce labor demand overall, choose skilled-labor-intensive technology, and replace their demand for unskilled labor with demand for skilled labor. In fact, it is conceivable that exporters in the Japanese manufacturing sector focus on capital-intensive and skilled-labor-intensive operations in Japan by offshoring and GVC. This hypothesis is consistent with the negative impact of FDI on labor share (Tables 2-3 and 2-5 in Chapter 2) and the negligible effect of exporting on the wage of unskilled labor, as examined in Chapter 3.

There is high variation in the factor inputs embodied in foreign final demand among industries. Our findings suggest that distinguishing between production for export and production for domestic sale within industries provides a more complete and better picture of plant heterogeneity in the ICIO table. Moreover, the resulting TiVA indicators show a more realistic picture of the interconnected nature of countries.

Finally, we would like to touch upon the future prospects for research using MIOTs. In this chapter, the ICIO table was divided into exports and domestic sales to facilitate observation of the degree of skilled-labor-intensity, while, as explained at Section 2, dividing by exporting firm and non-exporting firm can also be employed as a method. The split of the ICIO table by export status and comparison of the results of this chapter makes it possible to confirm a difference in factor contents (technology) between production for export and domestic sale factors among the exporting firms.

Piacentini, and Fortanier. (2015) conducted a preliminary study that divided the ICIO table by firm size. The style of the split enables us to examine the differences in DVA and other variables related to the value added between large and small firms.

In this chapter, the ICIO split is performed on the assumption that the technology for export and domestic sale of exporters is the same. However, there is a possibility that production technology for exports may change depending on the export destination. For example, in the analysis using data from Colombia, Kugler and Verhoogen (2011) found that large plants and exporting plants had higher output and input prices, compared to smaller and domestic plants, implying the production of higher-quality goods by investing in high-quality intermediate goods.

If exports in wholesale industry can be extracted from the MIOT, they can be regarded as indirect exports in the manufacturing industry. Although the wholesale industry is included in the commerce industry according to the ICIO's classification, it is possible to calculate the DVA and factor contents of indirect exports, if the wholesale industry can be separated from retail and other commercial industries.

The possibility of price analysis must also be considered. If we have information on a deflator for final and intermediate goods, we can analyze which intermediate good prices affect the prices of exports and domestic sales. If a price premium between exports and domestic sales is observed, it is possible to analyze in which intermediate goods the difference is produced, that is, to which intermediate goods the price premium is distributed. Although the ICIO data currently have no data on deflators currently, a price analysis is worthwhile when the deflator is developed in the future.

Appendix 1 Estimation framework for the split IO table using quadratic programming

This appendix presents the framework for the quadratic programming we implement.

1. Set initial elements of the split IO table

We start by setting the initial value of each element of the split IO table as explained in 3.2.2. We use the following letters to denote elements in the IO table:

(a) *i* and *j* are used as industry subscripts

(b) *D* is used to denote production for domestic sale

(c) *E* is used to denote production for export

(d) *J* represents Japan

(e) *C* represents a foreign country

(f) *Z* and *X* are used for intermediate use-supply elements

(g) *VA* represents value added

(h) *Y* stands for output

(i) The *D* element in the IO table represents final demand

2. Implement quadratic programming

We need to estimate:

Z_{ij}^{DE} : Industry *i's* output for domestic sale used as intermediate input for industry *j's* production for export

Z_{ij}^{DD} : Industry *i's* output for domestic sale used as intermediate input for industry *j's* production for domestic sale

X_{ij}^{CE} : Output of industry *i* in foreign country *C* used as intermediate input in production for export in industry *j* in Japan

X_{ij}^{CD} : Output of industry *i* in foreign country C used as input in production for domestic sale in industry *j* in Japan

VA_j^E : Value added of production for export in industry *j* in Japan.

VA_j^D : Value added of production for domestic sale in industry *j* in Japan.

The estimated elements should satisfy the following constraints:

For all *i* in Japan,

$Z_{ij}^{DE} + Z_{ij}^{DD} = Z_{ij}^{O}$, where *o* refers to the "original" element (observed data) of the ICIO table before the split.

$\sum_j \left(Z_{ij}^{DE} + Z_{ij}^{DD}\right) = Y_i^D - D_i^{O,JJ}$, where $D_i^{O,JJ}$ denotes the output of industry *i* in Japan for final demand in Japan.

For all *i* in foreign country *C*,

$X_{ij}^{CD} + X_{ij}^{CE} = X_{ij}^{O,C}$

$\sum_j \left(X_{ij}^{CD} + X_{ij}^{CE}\right) = Y_i^C - D_i^{O,CJP} - \sum_C \sum_j D_i^{O,CB}$, where *B* refers to a foreign country and $B \neq C$.

For all *j,*

$$\sum_i Z_{ij}^{DD} + + \sum_C \sum_i X_{ij}^{CD} = Y_j^D - VA_j^D = \alpha_j (\sum_i Z_{ij}^{O,J} + \sum_C \sum_i X_{ij}^{O,C})$$

$$\sum_i Z_{ij}^{DE} + \sum_C \sum_i X_{ij}^{CE} = Y_j^E - VA_j^E = (1 - \alpha_j)(\sum_i Z_{ij}^{O,J} + \sum_C \sum_i X_{ij}^{O,C})$$

where α_j is the share of production for export in total production in industry j, calculated from the micro data.[70, 71]

Under these constraints, quadratic programming estimates $Z_{ij}^{DD}, Z_{ij}^{DE}, X_{ij}^{CD}$, and X_{ij}^{CE} by

[70] We assume that α_j holds after the estimation process. We also implemented the quadratic programming to estimate variables without a fixed α_j, but the solutions have implausible elements (e.g., in some industries, production for export is larger than production for domestic sale).

[71] It is also possible to use the share of value added from the micro data. However, we avoid making any assumptions on value added. We therefore use the share of total inputs and, as a result, value added va_{ij}^E and va_{ij}^N are calculated indirectly from the estimated output and total input.

minimizing the following objective function:

$$S = \sum_i \sum_j \frac{(Z_{ij}^{DE} - Z_{ij}^{*DE})^2}{Z_{ij}^{*DE}} + \sum_i \sum_j \frac{\left(Z_{ij}^{DD} - Z_{ij}^{*DD}\right)^2}{Z_{ij}^{*DD}}$$

$$+ \sum_i \sum_j \frac{(X_{ij}^{CE} - X_{ij}^{*CE})^2}{X_{ij}^{*CE}} + \sum_i \sum_j \frac{(X_{ij}^{CD} - X_{ij}^{*CD})^2}{X_{ij}^{*CD}}$$

where * denotes the initial value.

Table 4-A1 Comparison of results for Japan's domestic VA in exports (DVA), foreign VA in exports (FVA), and Japan's domestic VA embodied in global final demand (FFD_DVA) between original and extended IO table (mil. USD; current prices)

	DVA			FVA			FFD_DVA		
	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)	Split IO	OECD TiVA	Deviation (%)
Food products, beverages, and tobacco	2,540	2,662	-4.7	512	389	27.2	3,684	3,898	-5.7
Textiles, textile products, leather, and footwear	4,167	4,932	-16.8	2,319	1,555	39.5	1,531	3,160	-69.5
Wood and products of wood and cork	54	58	-7.2	18	14	25.0	903	803	11.7
Pulp, paper, paper products, printing and publishing	3,243	3,407	-4.9	570	405	33.7	13,573	12,621	7.3
Coke, refined petroleum products, and nuclear fuel	7,996	5,894	30.3	5,637	7,739	-31.4	14,849	11,557	24.9
Chemicals and chemical products	47,411	49,264	-3.8	17,222	15,369	11.4	22,178	25,515	-14.0
Rubber and plastics products	17,033	17,302	-1.6	4,148	3,879	6.7	17,919	16,974	5.4
Other non-metallic mineral products	8,968	9,403	-4.7	1,974	1,540	24.7	8,409	8,961	-6.4
Basic metals	48,930	51,886	-5.9	17,893	14,938	18.0	53,564	52,660	1.7
Fabricated metal products	6,065	6,527	-7.3	1,530	1,067	35.6	9,815	10,195	-3.8
Machinery and equipment	82,797	85,238	-2.9	16,741	14,300	15.7	33,444	44,484	-28.3
Computer, electronic, and optical equipment	103,277	110,970	-7.2	30,705	23,012	28.6	39,420	62,310	-45.0
Electrical machinery and apparatus, nec	20,101	21,333	-5.9	5,149	3,917	27.2	11,839	15,062	-24.0
Motor vehicles, trailers, and semi-trailers	100,491	102,637	-2.1	18,723	16,576	12.2	33,830	45,472	-29.4
Other transport equipment	26,742	28,149	-5.1	6,527	5,120	24.2	7,701	13,668	-55.9
Manufacturing nec; recycling	9,558	9,913	-3.6	2,624	2,269	14.5	5,903	6,601	-11.2
Total for industries	489,374	509,574	-4.0	132,290	112,089	16.5	718,308	743,034	-3.4

Note 1 Author's calculation.
2 "Deviation" is the difference between our estimates and the original TiVA estimates.

Table 4-A2 Comparison of results for Japan's DVA, FVA and share of DVA of between original and extended IO table

	Split IO				OECD TiVA			
	DVA	FVA	Total	DVA Share (%)	DVA	FVA	Total	DVA Share (%)
Food products, beverages, and tobacco	2,540	512	3,052	83.2	2,662	389	3,052	87.2
Textiles, textile products, leather, and footwear	4,167	2,319	6,486	64.2	4,932	1,555	6,486	76.0
Wood and products of wood and cork	54	18	72	74.9	58	14	72	80.5
Pulp, paper, paper products, printing, and publishing	3,243	570	3,812	85.1	3,407	405	3,812	89.4
Coke, refined petroleum products, and nuclear fuel	7,996	5,637	13,633	58.7	5,894	7,739	13,633	43.2
Chemicals and chemical products	47,411	17,222	64,633	73.4	49,264	15,369	64,633	76.2
Rubber and plastics products	17,033	4,147	21,181	80.4	17,302	3,879	21,181	81.7
Other non-metallic mineral products	8,968	1,974	10,943	82.0	9,403	1,540	10,943	85.9
Basic metals	48,930	17,893	66,823	73.2	51,886	14,938	66,823	77.6
Fabricated metal products	6,065	1,530	7,594	79.9	6,527	1,067	7,594	85.9
Machinery and equipment	82,797	16,741	99,538	83.2	85,238	14,300	99,538	85.6
Computer, electronic, and optical equipment	103,277	30,705	133,982	77.1	110,970	23,012	133,982	82.8
Electrical machinery and apparatus, nec	20,101	5,149	25,250	79.6	21,333	3,917	25,250	84.5
Motor vehicles, trailers, and semi-trailers	100,491	18,722	119,213	84.3	102,637	16,576	119,213	86.1
Other transport equipment	26,742	6,526	33,269	80.4	28,149	5,120	33,269	84.6
Manufacturing nec; recycling	9,558	2,624	12,183	78.5	9,913	2,269	12,183	81.4
Total	489,374	132,289	621,663	78.7	509,574	112,089	621,663	82.0

Note Author's calculation.

Table 4-A3 Domestic value added embodied in world final demand, share in industries' total value added

	Domestic sale	Export	TiVA
Food products, beverages, and tobacco	2.0%	0.4%	2.5%
Textiles, textile products, leather, and footwear	7.5%	1.5%	18.7%
Wood and products of wood and cork	9.2%	0.1%	8.3%
Pulp, paper, paper products, printing, and publishing	16.1%	0.7%	15.7%
Coke, refined petroleum products, and nuclear fuel	12.0%	7.5%	15.2%
Chemicals and chemical products	19.3%	7.4%	30.8%
Rubber and plastics products	25.9%	7.9%	32.1%
Other non-metallic mineral products	15.1%	8.5%	25.1%
Basic metals	45.2%	8.7%	52.9%
Fabricated metal products	16.7%	1.6%	19.0%
Machinery and equipment	11.2%	16.3%	36.6%
Computer, electronic, and optical equipment	18.0%	10.7%	45.4%
Electrical machinery and apparatus, nec	22.8%	6.1%	36.8%
Motor vehicles, trailers, and semi-trailers	24.9%	5.4%	40.8%
Other transport equipment	13.7%	24.8%	68.4%
Manufacturing nec; recycling	16.1%	8.1%	27.1%
Total	17.7%	7.1%	29.8%

Note Author's calculation.

Table 4-A4 Factor inputs embodied in global foreign final demand for products for export and domestic sale, share in industries' total factor inputs

	Labor (workers)			Capital (ten thousand yen)			Non-regular workers (workers)			University graduates (workers)			Change of univ grad intensity	
	DS	EX	Total	DS	EX	Total	DS	EX	Total	DS	EX	Total	DS	EX
Food products, beverages, and tobacco	2.0%	0.2%	2.2%	2.0%	0.4%	2.4%	2.0%	0.1%	2.1%	2.0%	0.3%	2.3%	0.0%	0.1%
Textiles, textile products, leather, and footwear	7.6%	0.8%	8.4%	7.0%	8.0%	15.0%	7.6%	0.4%	8.0%	7.5%	2.0%	9.5%	-0.1%	1.2%
Wood and products of wood and cork	9.2%	0.0%	9.2%	9.1%	0.4%	9.5%	9.2%	0.0%	9.2%	9.2%	0.0%	9.2%	0.0%	0.0%
Pulp, paper, paper products, printing and publishing	16.2%	0.4%	16.6%	16.1%	0.8%	16.9%	16.2%	0.3%	16.5%	16.1%	0.9%	17.0%	-0.1%	0.5%
Coke, refined petroleum products, and nuclear fuel	12.8%	1.8%	14.6%	12.4%	4.9%	17.2%	12.9%	1.2%	14.0%	12.7%	2.4%	15.1%	-0.1%	0.6%
Chemicals and chemical products	19.5%	6.7%	26.2%	18.6%	10.9%	29.5%	19.8%	5.1%	25.0%	19.4%	7.0%	26.4%	-0.1%	0.3%
Rubber and plastics products	27.2%	3.6%	30.7%	25.2%	10.4%	35.6%	27.6%	2.3%	29.8%	26.6%	5.7%	32.3%	-0.6%	2.2%
Other non-metallic mineral products	15.7%	4.9%	20.5%	13.0%	20.8%	33.8%	15.7%	4.4%	20.2%	15.0%	8.6%	23.6%	-0.6%	3.7%
Basic metals	46.3%	6.4%	52.8%	43.0%	13.0%	55.9%	47.2%	4.8%	52.0%	46.0%	7.2%	53.1%	-0.4%	0.7%
Fabricated metal products	16.8%	1.1%	18.0%	16.5%	3.1%	19.6%	16.8%	1.0%	17.8%	16.6%	2.3%	18.9%	-0.2%	1.1%
Machinery and equipment	12.0%	10.5%	22.5%	10.9%	18.8%	29.7%	11.9%	11.0%	22.9%	11.5%	14.0%	25.5%	-0.5%	3.5%
Computer, electronic, and optical equipment	18.5%	8.5%	26.9%	16.6%	17.3%	34.0%	18.9%	6.3%	25.2%	17.9%	11.2%	29.1%	-0.6%	2.7%
Electrical machinery and apparatus, nec	23.7%	2.6%	26.3%	22.1%	9.0%	31.1%	24.0%	1.5%	25.5%	23.5%	3.5%	27.0%	-0.2%	0.9%
Motor vehicles, trailers, and semi-trailers	22.3%	15.4%	37.7%	21.2%	19.5%	40.7%	22.7%	14.0%	36.7%	22.3%	15.5%	37.8%	0.0%	0.2%
Other transport equipment	14.6%	20.0%	34.6%	14.0%	23.2%	37.2%	16.6%	9.3%	25.9%	13.3%	27.0%	40.3%	-1.3%	7.0%
Manufacturing nec; recycling	16.2%	7.6%	23.8%	14.8%	15.7%	30.5%	17.0%	3.2%	20.2%	15.7%	10.5%	26.2%	-0.5%	2.9%
Total	16.4%	5.9%	22.4%	18.8%	12.0%	30.8%	13.1%	3.4%	16.5%	17.1%	8.7%	25.8%	0.6%	2.8%

Note 1 Author's calculation.
2 DS and EX stands for "domestic sale" and "export", respectively.

Appendix 2 Method to calculate factor inputs used for production for exports and domestic sale

The amount of an input factor in the production for exports in industry *i*, F_i^E, is is computed as follows.

$$F_i^E = \sum_{f_i=1}^{n_i} s_{f_i}^E F_{f_i}$$

where $s_{f_i}^E$ is a share of exports in total output of firm f_i and F_{f_i} is an input factor used by firm f_i.

In the same way, the amount of an input factor in the production for domestic sale in industry i, F_i^D , is calculated as follows.

$$F_i^D = \sum_{f_i=1}^{n_i} (1 - s_{f_i}^D)\ F_{f_i}$$

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