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Offshore production and skill upgrading by Japanese manufacturing firms

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Abstract

We investigate the influence of offshore production by Japanese multinationals on domestic skill intensity. Identifying relationships based on within variation in a panel of 1070 firms, we find that additional foreign affiliate employment in low-income countries raises skill intensity. The positive effect of FDI on domestic skill intensity, however, diminishes as investment shifts towards high-income countries. Increases in affiliate employment in low-income countries also raise a firm's reliance on finished goods purchases, suggesting that overseas employment affects domestic skill intensity because imports of final goods from foreign affiliates displace domestic production.

Keywords: Multinational enterprises; Outsourcing; Skills; Wages; Globalization

JEL classification: F2

1. Introduction

Over the past three decades, Japanese multinational enterprises (MNEs) have steadily increased their offshore manufacturing presence. They now possess substantial production capabilities abroad. *Time* magazine (April 22, 1996, p. 60) reports, 'Currently, for example, Japan imports 23 times as many television sets as

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it exports. They are all assembled in Japanese-owned factories in places like Malaysia and Thailand . . . By the year 1998, Toyota expects that 65% of the cars it sells around the world will be made outside Japan'. Over the corresponding period, Japanese firms have also increased the share of the wage bill attributable to nonproduction workers, suggesting a demand shift away from workers with low skills.

This paper investigates the relationship between the international production strategies of Japanese MNEs and skill upgrading in Japanese firms. We employ a 25-year panel data set for over 1000 Japanese manufacturing firms to investigate the effects of increases in foreign employment on the skill intensity of the domestic workforce. We use the nonproduction worker share of the wage bill and the firm-level average wage as proxies for skill intensity. The analysis explores differential effects on domestic skill intensity of investment in countries with different levels of per capita income. We also examine the electronics industry as a special case of extensive foreign production.

We develop predictions about how FDI affects skill intensity of the parent firm at home based primarily on alternative depictions of MNEs described in the series of articles written by Markusen, Venables, and co-authors.[1] Markusen and Maskus (1999, p. 1) state that horizontal MNEs 'replicate roughly the same activities in many locations'. Vertical MNEs, in contrast, 'geographically fragment production into stages, typically on the basis of factor intensities, locating skilled-labor intensive activities in skill abundant countries and so forth'. FDI may have different effects on skill intensity at home depending on the type of investment and the income level of the host country. The relationship we observe between FDI and skill intensity will indicate whether horizontal or vertical investment characterizes our data.

The paper contributes to a recent literature investigating the influence of globalization on the demand for skilled labour. Slaughter (2000) and Feenstra and Hanson (1996a,b) relate the nonproduction worker share of the wage bill of US industries to international activities. Slaughter demonstrates that the US industry data provide no support for a positive relationship between MNE activities and skill upgrading over the 1977–1994 period. Feenstra and Hanson, however, find that foreign outsourcing (defined by them as the substitution of imported inputs and finished goods for domestically produced goods) can account for 18.9–21.3% of the observed increase in the nonproduction worker share of the wage bill for their sample of 4-digit SIC industries in 1979–1990.[2] Feenstra and Hanson (1999) obtain somewhat stronger results. They use 4-digit industry data on the prices and quantities of outputs and inputs to relate estimated changes in factor prices to foreign outsourcing and the high-technology capital stock. They find that outsourc-

[1] See, for instance, Markusen (1984, 1995), Markusen and Venables (1997), Carr et al. (2001), Venables (1999), Markusen and Maskus (1999).

[2] These figures are reported in Feenstra and Hanson (1996c), the errata to the original publication.

ing can account for as much as three-fifths of the observed 0.59 annual increase in the nonproduction/production relative wage observed over 1979–1990.

Our study adds to the existing literature in four ways. Firstly, our 25-year sample period includes the transformation of a number of Japanese firms into major multinational enterprises. Thus, by utilizing the large firm-level variation in our data we are able to identify a strong relationship between overseas employment and the use of nonproduction workers at home. Secondly, we find that this result depends on the income per capita of the host country: skill upgrading associated with foreign investment is most evident in low-income countries. Thirdly, the relationship between offshore employment and skill intensity is robust to using changes in firm-level average wages as an alternative proxy for skill upgrading. Finally, our results show that employment in low-income countries exhibits a strong positive correlation with parent firms' purchases of finished goods. This information is consistent with the view that Japanese multinationals are outsourcing labour-intensive goods from their affiliates in low-income countries.

In the next section, we describe alternative types of FDI and how their effect on skill upgrading may vary across host countries. Section 3 presents the Japanese firm-level data we employ in our analysis. The following section introduces our econometric specification and presents the estimation results. The concluding section summarizes how well the data support the alternative depictions of FDI and comments on the extent to which FDI has contributed to observed skill upgrading within firms in Japan.

2. Alternative types of FDI and skill upgrading

The effect of overseas investment on the skill intensity of the domestic workforce will depend on the type of FDI. The theoretical literature distinguishes horizontal and vertical multinational enterprises. We adapt that terminology to describe alternative types of *investment*.

- *Horizontal* FDI: overseas investment replicates downstream activities (production of final goods) across markets. It is useful to distinguish between different horizontal investments based on the extent of activities replicated overseas:
  –*Replication*: investments that replicate *all* activities (assembly, components, product design, etc.). Thus, affiliate production abroad is made entirely from local factor services.
  –*Branching*: investments that replicate production of final goods only. Upstream activities such as component production and/or product design are concentrated in the home country. Headquarters exports these inputs to the branch factories located in the foreign markets. As discussed below, the

knowledge capital model predicts that at least some of the activities concentrated at home will be high-skill intensive.

- *Vertical* FDI: overseas investment relocates activities abroad based on comparative advantage: skill-intensive activities are placed in skill-abundant countries and vice-versa. Each activity, including final production, occurs in only one country.

Brainard (1997) explains how an MNE's decision to invest abroad depends on the relative magnitude of two opposing forces. Scale economies provide an incentive to concentrate production in single sites at home. Trade costs, in contrast, encourage firms to disperse production in proximity to customers in each market. Horizontal replication arises when trade costs are high and economies of scale are low, i.e. when the benefit of great proximity exceeds the costs of reduced plant scale.

Carr et al. (2001) develop the concept of knowledge capital, an input to production described by three principal characteristics: transportability, jointness, and skill intensity. Low transport costs allow these knowledge-based assets to be transferred easily to foreign affiliates. Jointness implies that there is no need to replicate these services as overseas production increases. Indeed, because knowledge generation involves indivisible inputs, it is very costly to replicate it. Knowledge capital combined with trade costs for final goods can give rise to branching where skill-intensive services are concentrated at home and supplied as inputs into foreign production.

Helpman (1984), Jones and Kierzkowski (1997), Arndt (1997), Feenstra and Hanson (1996a) and Venables (1999) develop models in which the production process can be divided into separate stages with different factor intensities. The ability to fragment production, coupled with high economies of scale and low trade costs, can give rise to the vertical form of FDI.

The simplest case for establishing the effects of investment on skill intensity is that of replication. Since it assumes that foreign activities are largely independent of domestic ones, there is no direct effect on domestic skill intensity. However, overseas activities may influence the *scale* of domestic operations and thereby have an indirect effect on skill intensity. For example, FDI may substitute for exports and reduce home production.

When the production function is heterothetic, scale influences skills intensity. To illustrate potential scale effects, we represent a firm's demand for high-skilled workers (H) and low-skilled workers (L) as follows:

$$H = F_{\mathrm{H}} + \nu_{\mathrm{H}} Q,$$

$$L = F_{\mathrm{L}} + \nu_{\mathrm{L}} Q.$$

F_i represents the fixed amount of labour needed for production and ν_i the labour required for each unit of output Q. The ratio of high-skilled to low-skilled workers is

$$\frac{H}{L}=\frac{F_{\mathrm{H}}+\nu_{\mathrm{H}}Q}{F_{\mathrm{L}}+\nu_{\mathrm{L}}Q}.$$

The change in the relative use of high-skilled labour with respect to a change in output is given by

$$\frac{\partial(H/L)}{\partial Q}=\frac{F_{\mathrm{L}}\nu_{\mathrm{H}}-F_{\mathrm{H}}\nu_{\mathrm{L}}}{(F_{\mathrm{L}}+\nu_{\mathrm{L}}Q)^{2}}.$$

Since the sign of this derivative depends on the term $F_{\mathrm{L}}/\nu_{\mathrm{L}}-F_{\mathrm{H}}/\nu_{\mathrm{H}}$, skill intensity may rise or fall with output. In an extreme version of the knowledge capital model, knowledge generation requires only a fixed amount of skilled workers and serves as an input to any amount of production. Thus, ν_{H} approaches zero, implying that skill intensity declines when output increases.

This depiction of production suggests that horizontal replication FDI that substitutes for exports from home may raise skill intensity by reducing the scale of home operations. However, FDI of this type should not have an effect that is independent of scale. Thus, in a regression that controls for scale, we would expect a coefficient on overseas investment that does not differ significantly from zero.

Branching FDI centralizes skill intensive activities such as knowledge generation at home while establishing lesser skilled activities involving final good production in each market (home and foreign). This should result in an increase in skill intensity at home. Suppose the overseas branch plant serves a new market (one that was not previously served by exports from home). Since this higher output requires additional skill intensive services, the firm must hire high-skilled workers and thereby increases its skill intensity. Now consider a foreign plant that produces output that displaces exports. The scale effect will induce a change in skill intensity. Moreover, even after one controls for this scale effect, skill intensity will rise due to the fact that skill intensive services produced at home will still be required as inputs for the foreign plant.

The effect of vertical FDI on skill intensity depends on the stage of production moved offshore and the relative factor abundance of the home and host countries. Investment in low-income countries — that are likely to have a relative abundance of unskilled workers — will consist primarily of low-skill intensive activities. High-income countries, on the other hand, may host high-skill intensive production. Thus, we may obtain opposite effects of FDI depending on the income level of the host country. Investment in low-income countries may cause skill upgrading whereas investment in high-income countries would be associated with skill downgrading.

Vertical FDI may be distinguished from branching by whether final goods are imported back into Japan from foreign affiliates. Under branching, production is maintained in Japan and the goods made by offshore affiliates do not enter Japan. In vertical specialization, however, economies of scale and low cost inputs abroad may induce the multinational firm to produce in a single foreign site and export to home to serve the home market. If final goods assembly is low-skill intensive, we would expect investment in low-income countries to raise offshore sourcing of final goods. Thus, by examining the relationship between FDI and offshore sourcing from affiliates, one may distinguish between the two FDI forms. Under vertical specialization, we expect a positive relationship for investment in low-income countries and we expect no relationship for branching.

Table 1 portrays how we distinguish between the different types of investment based on the effects of investment on skill intensity and offshore sourcing of finished goods. We consider different effects of FDI for host countries at varying levels of development by considering the interaction between FDI and host-country per capita income. We evaluate the 'base' effect of FDI and how that effect is moderated as the income level of the host country increases. The base effect can be interpreted as the effect of FDI in a country with a low level of income.

In the case of horizontal replication, the activities at home are independent of activities abroad. FDI should have no effects on home activities regardless of the income of the host country. Thus, the base FDI effect and the interaction term are zero. On the other hand, branching investment increases skill intensity at home and the effect should be the same whether the investment is in high- or low-income countries. Hence, the base effect is positive while the interaction term is zero. Since branching does not involve movements of final goods to the home country, it should not influence offshore sourcing.

The effect of vertical FDI on skill intensity depends on the location of the investment. It will be positive for investment in low-income countries. However, this positive effect should diminish with an increase in the income level of the host country. This implies that the interaction term is negative in the case of vertical FDI. For sufficiently high levels of income of the host country, the overall effect of FDI (the sum of the positive base effect and the negative interaction effect) may be negative implying skill downgrading. Assuming that final goods assembly is

Table 1
Predicted effects on skill intensity and offshore sourcing

	Skill intensity		Offshore sourcing	
	FDI	FDI×host income	FDI	FDI×host income
Horizontal FDI				
Replication	0	0	0	0
Branching	+	0	0	0
Vertical FDI	+	−	+	−

low-skill intensive, vertical FDI in low-income countries will result in an increase in offshore sourcing. However, this effect should fall as investment shifts towards higher income countries.

In the next section we describe the data we use to test these hypotheses portrayed in the table. In particular, we discuss in detail our measures of skill intensity and outsourcing.

3. Data

The unconsolidated financial statements of publicly traded Japanese companies provide annual data on total employment, production wages, selling, general, and administrative (SGA) wages, purchases of intermediate and final goods, and depreciable assets (buildings, machinery, and equipment). The wage figures reflect the cost of workers to the firm and include bonuses.[3] Our data set runs from 1965 to 1990. The number of firms in our sample increases over time, reaching the full 1070 in 1977.

We combine the parent firm accounting data with information on foreign affiliates listed in *Japanese Overseas Investment*, 1992–1993, which is compiled by Toyo Keizai, Inc. Based on a survey conducted in 1991, this data lists all firms more than 10% owned by Japanese parent companies. We convert this 'snapshot' data into an annual time series of each firm's overseas employment levels using information on the year each affiliate began operations or was acquired by the Japanese parent firm. We then calculate the stock of employees in a country in year t as the cumulative sum of the employment created by each affiliate established prior to year t.

This data set does not take into account investments that had ceased operations at the time of the survey. Another limitation is that employment levels are those recorded at the time of the 1991 survey. Thus, our method assumes that affiliates have static employment levels. In Appendix A, we explore alternative methods of constructing the panel of foreign affiliate employment and report how these alternative treatments affect the regression results. We consider two alternatives that allow affiliate employment to increase over time to attain the 1991 level recorded in the survey. One method assumes that employment grows at a constant rate while a second method assumes it increases in equal increments.

In many cases overseas affiliates are only partially owned by a given Japanese parent company. To generate total foreign affiliate employment in such cases, we multiply employment by the ownership share. Thus, in the case of joint ventures between two Japanese parents, employees of the affiliate are prorated between each parent based on ownership shares.

[3] Bonuses are typically paid twice a year and comprise roughly one-quarter of total compensation. Our data do not separate bonuses from regular wages.

The offshore manufacturing employment of our sample of firms grew from 63,000 in 1965 to 703,000 in 1989. Employment in the 1970s was concentrated in low-income countries such as Taiwan and South Korea and shifted towards high income-countries in Europe and North America in the 1980s. The increase in overall overseas employment accelerated in the late 1980s, coinciding with a sharp appreciation of the yen.[4] In 1989, the home employment of our sample of firms totalled about 2.7 million implying that the overseas share of worldwide employment for our sample was 20.5% that year.

Table 2 lists the 25 largest investors abroad in terms of employment. Offshore employment often exceeds home employment for these firms. Electronics dominates this list of firms, accounting for six of the top 10 and 13 of the top 25.

Table 2
The top 25 overseas employers

	Industry	Overseas		Home	Overseas
		Plants	Employees	employees	share
Matsushita Electric	Electronics	84	49,451	41,409	0.54
Sanyo Electric	Electronics	62	29,356	34,405	0.46
Honda Motor	Automobiles	71	29,050	30,022	0.49
Sony	Electronics	22	28,348	16,278	0.64
Bridgestone	Rubber	12	23,512	15,791	0.60
NEC	Electronics	28	22,639	37,721	0.38
Nissan Motor	Automobiles	14	21,745	52,808	0.29
Toshiba	Electronics	29	18,015	69,201	0.21
Minebea	Machinery	16	17,369	3646	0.83
Hitachi	Electronics	29	16,866	76,479	0.18
Dainippon Ink	Chemicals	22	15,793	6626	0.70
Toray Industries	Textiles	36	13,400	9602	0.58
Sharp	Electronics	17	12,010	18,282	0.4
Toyota Motor	Automobiles	27	11,802	67,814	0.15
Mitsubishi Electric	Electronics	28	11,753	47,693	0.20
Mitsumi Electric	Electronics	12	9493	1936	0.83
Sumitomo Rubber	Rubber	7	9426	4856	0.66
Hitachi Koki	Electronics	3	8680	2583	0.77
Asahi Glass	Glass and cement	21	8269	9295	0.47
Suzuki Motor	Automobiles	23	7180	12,616	0.36
TDK	Electronics	17	7117	7797	0.48
Toko	Electronics	5	6841	1014	0.87
Alps Electric	Electronics	12	6793	6502	0.51
Kawasaki Steel	Iron and steel	19	6660	18,562	0.26
Ricoh	Precision machinery	6	6472	10,817	0.37

[4] Aggregate Japanese data on overseas employment from other sources do not exist to our knowledge. Statistics on Approval/Notification of Overseas Investment collected by the Ministry of Finance, however, provide annual data on the (yen) value of FDI flows. We calculated cumulative sums from 1976 to 1989 and compared them to our data. The correlation of the two series is 0.92.

Matsushita, a large, diversified manufacturer that sells under labels such as Quasar and Panasonic, tops the list with nearly 50,000 employees abroad in 1989. Collectively, the 154 listed electronic firms employed 307,000 workers in foreign affiliates in 1989, over one-third of the total for our sample. Offshore workers constitute 30% of these firms' worldwide employment. Automobile makers are also prominent offshore investors; the 53 members of that industry employ 92,000 workers overseas (21% of their worldwide workforce).

In addition to foreign affiliate employment variables, the other primary variable of interest is skill intensity. We shall define skill intensity of the parent company workforce as the high-skilled worker share of the wage bill. That is, the skill intensity, denoted S_{H}, is defined as $w_{\mathrm{H}}H/(w_{\mathrm{H}}H + w_{\mathrm{L}}L)$, where H and L are employments of high and low-skilled workers and w_{H} and w_{L} are their respective wages. This measure, which has been adopted by most other studies of skill intensity, will prove convenient for the estimation stage of the analysis. We will employ two proxies for skill intensity in the analysis, the share of selling, general, and administrative pay (SGA) in the total wage bill as well as the average wage paid by the firm. Below we discuss the merits and drawbacks of these measures.

Previous researchers such as Slaughter (2000), Feenstra and Hanson (1996a,b), and Berman et al. (1994) consider nonproduction workers to be skilled and production workers unskilled. A number of arguments support this classification. Firstly, Berman et al. (1994) find that, in the aggregate, the proportions of workers that are nonproduction matches fairly closely across time with the percent of workers that population surveys show are in white-collar occupations and more educated. Secondly, Berman et al. (1997) report the results from an analysis of matched microdata performed by Troske that showed that 66% of nonproduction workers have 'some college' or more education. In contrast, 61% of production workers have a high school education or less. Finally, Sachs and Shatz (1994) link production worker intensity to indexes of the skills required in each industry. They report that 'the more skilled an industry, as measured by lower ratio of production workers to total workers, the more likely it is to have high interactive skills requirements'.

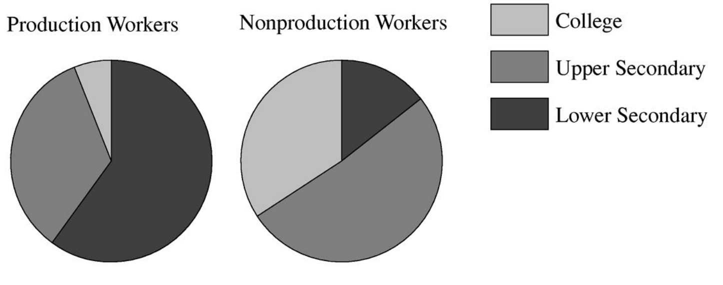
The firm-level accounting data we use in this study separates the wage bill into a component for selling, general and administrative (SGA) costs and another for production costs. This classification appears fairly close to the nonproduction vs. production worker distinction employed by government manufacturing surveys. The definition of nonproduction workers used by the US Annual Survey of Manufacturing includes professional, technical, and advertising employees as well as those involved in personnel and the servicing of products. Meanwhile production workers engage in activities such as 'fabricating, processing, assembling'.

The breakdown between SGA and production in the wage bill in our sample appears to be consistent with the composition of manufacturing employment reported in Japan's *Labor Force Survey*. In 1989, for instance, production workers represented 73% of persons employed in manufacturing. Japan's *Basic Survey on Wage Structure* reports a wage premium for male non-production workers of 1.34 in that year. This implies a 67% share of the wage bill for production workers. In our sample, they accounted for 68% of the wage bill. Thus, the accounting measures of the composition of the work force do not differ markedly from government survey measures. Hereafter we will refer to our SGA wage data as 'nonproduction' worker wages.

The data support the view that nonproduction personnel have higher education attainment than production workers in Japan. Fig. 1 shows educational attainment for production workers and other employees in the manufacturing sector. The data are from the *Basic Survey of Wage Structure* in Japan for 1980, but we had to use the 1979 *Employment Status Survey* to allocate production workers with 'upper secondary and over' education into separate upper-secondary and college subcategories.[5] Of nonproduction employees in manufacturing, 34% had some college education in 1980 as compared to 5.7% for production workers. Meanwhile, only 14% of nonproduction workers had less than a high school diploma whereas 60% of production workers in 1980 had not graduated from high school.

The preceding discussion indicates that nonproduction workers are more skilled on average than production workers. Of course, there are also highly skilled production workers and low-skilled nonproduction workers. The following algebra generates the conditions for which the high-skilled worker share is an increasing function of the nonproduction labour share. Let S_N be the share of nonproduction workers in the wage bill:

$$S_N = \frac{w_H H_N + w_L L_N}{w_H H + w_L L}.$$



Source: *Basic Survey of Wage Structure*, 1980

Fig. 1. Educational attainment of production and nonproduction workers.

[5]The *Employment Status Survey* provides educational attainment by *occupation*, without providing industry data. However, it seems likely that the occupation called 'production process workers' would be representative of production workers in manufacturing.

The variables subscripted with N are nonproduction workers while L and H are total employments at each skill level. Denoting the share of high-skilled workers in nonproduction as $h_N \equiv H_N/H$ and the share of low-skilled workers in nonproduction as $\ell_N \equiv L_N/L$, we obtain

$$S_N = (h_N - \ell_N)S_H + \ell_N. \tag{1}$$

Thus, the nonproduction share is an increasing linear function of true skill intensity as long as $h_N > \ell_N$ or, equivalently, $H_N/L_N > H/L$, i.e. nonproduction activities make more intensive use of high-skilled workers than do the firm's total activities.

The positive relationship between the nonproduction labour share and true skill intensity might break down, however, if h_N and ℓ_N vary over time. For example, consider foreign investment that moves high skill production tasks offshore (raising h_N), without affecting nonproduction activities and low skill production activities. In this case, the nonproduction share will rise due to the elimination of high skill *production* activities at home but true skill intensity (S_H) will fall since the number of high-skilled workers at home decreases.

Leamer (1994) provides another criticism of using the nonproduction share as a proxy for skill intensity. He states '...the classification of workers into 'production' and 'non-production' doesn't have much to do with 'unskilled' and 'skilled'. More appropriate data may provide very different answers'. The quote refers to the definitions of production and nonproduction workers used by the US Annual Survey of Manufactures. He points out that production workers include line supervisors and product development personnel while nonproduction includes delivery truck drivers and cafeteria workers. We cannot determine whether our accounting data make the same classification choices but it seems likely that they will include similar, if not the same, problems.

In light of these concerns, we also employ the log of the firm's average wage as a measure of skill intensity. The average wage a firm pays consists of the sum of payments to high and low-skilled workers divided by the total number of employees:

$$\hat{w} = \frac{w_H H + w_L L}{H + L}.$$

After some manipulation of this expression we obtain

$$\hat{w} = w_L/(1 - S_H(w_H - w_L)/w_H).$$

Thus the average wage depends in a monotonic way on three factors: (1) the base wage paid to low-skilled workers, w_L; (2) the wage premium for skill, that is $\sigma \equiv (w_H - w_L)/w_H$; (3) the skill composition of the firm's employees, S_H. We can express the log of the average wage paid by a firm as

$$\ln(\hat{w}/w_L) = -\ln(1 - \sigma S_H).$$

Now there are relatively few college-educated workers in Japanese manufacturing during our sample period. In 1980 those with junior college or above amounted to just 16% of employment. Meanwhile the premium to college-educated workers, σ, was only about 17%.[6] Thus, there is good reason to believe that σS_H is a small number (less than 0.03). This means that the logged firm average wage is approximately proportional to true skill intensity, that is $\ln(\hat{w}/w_L) \approx \sigma S_H$.

These calculations suggest that the log of average pay (normalized by the wages of low-skilled workers) can be used as an indicator of the skill intensity of a firm's domestic work force. The use of the firm's average wage as a skill-intensity proxy has the advantage that it does not rely on the 'nonproduction' versus 'production' distinction to identify skills. The measure certainly has its own drawbacks. Foremost among them is that average pay at an individual firm might reflect some type of quasi-rent or efficiency wage that is paid to all employees independent of skill level. We hope to control for these sources of wage variation in part by including firm-specific fixed effects. To control for macro variation in the premium for skill we also include year effects. While recognizing the potential problems with this indicator, we present average pay results with the intent of providing an alternative measure of skill intensity to verify whether Leamer's warning that different measures of skill intensity might deliver different results applies to our study.

Fig. 2 displays the trends in the nonproduction share of wages, the log of

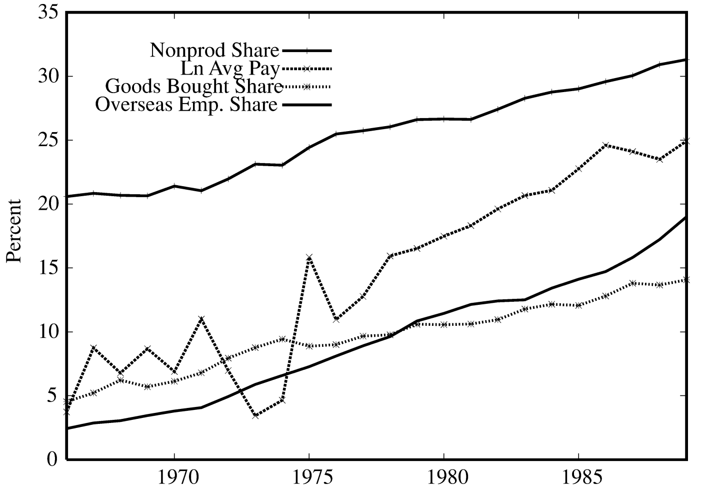


Fig. 2. Trends in skill intensity, outsourcing, and overseas employment.

[6] In Japan σ declined gradually from 24% in 1965 before stabilizing at its current level of around 17% in 1975. For the period of this study, we are unlikely to obtain a false impression of skill upgrading from rises in the skill premium.

average pay, the finished goods purchases' share of variable inputs, and the overseas employment share of total employment. The first three variables are measured as the value for the median firm for each year whereas the foreign employment share is aggregate overseas employment as a percentage of overseas plus home employment for all the firms in our sample. We normalized the average wage the firms pay by the wages of workers with just high school diplomas collected from various issues of the *Japan Statistical Yearbook*. The table shows all the variables trending upwards over time. The nonproduction share of wages rises from 0.21 in 1966 to 0.31 in 1989. Clearly, the median Japanese firm is devoting a decreasing share of the wage bill to production workers. This restructuring towards nonproduction labour is occurring *within* firms and does not simply reflect a shift in production *between* firms that rely on production labour and those that do not. The normalized average wage also rises over the period except for 1973 and 1974. It is not the case that average wages actually fell these years for the median firm. Rather, the growth of the average wage fell below the growth of wages paid to workers with high school degrees.

Fig. 2 also shows that the median firm increased its purchases of finished goods as a share of variable costs, the latter being defined as the sum of wages, materials, and finished goods purchases. This variable interests us because we intend to use it in the regressions as an indicator of outsourcing. While the data do not specify from whom the goods were purchased, they include purchases of finished goods from overseas affiliates. Having portrayed the upward trend of the variables, we now turn to disaggregated data to determine the statistical relation between *firm-level changes* in overseas employment and domestic skill intensity.

4. Specification and results

The literature on skill upgrading in US manufacturing has employed the translog cost function to examine the sources of increased demand for skilled workers. The advantage of this functional form is that it is flexible enough to allow for cross-factor substitution or complementarity as well as heterothetic production. Berman et al. (1994) (hereafter BBG) provide a discussion of this approach. Slaughter (2000) and Feenstra and Hanson (1996a,b) adopt this specification to examine the effects of international trade and investment on US industry data.

The translog cost function implies that the share of some variable factor in variable costs can be expressed as a linear function of the logs of input prices and quasi-fixed factors. Thus for high and low-skilled workers, we would have

$$S_{\mathrm{H}} = \lambda_0 + \lambda_{\mathrm{H}} \ln w_{\mathrm{H}} + \lambda_{\mathrm{L}} \ln w_{\mathrm{L}} + \lambda_{\mathrm{K}} \ln K/Q + \lambda_{\mathrm{Q}} \ln Q. \tag{2}$$

Following BBG, we consider capital to be a quasi-fixed factor, i.e. it is *predetermined* with respect to labour cost shares. Domestic output, Q, is modeled as value-added, the transformation of intermediate inputs into finished goods. Thus, in this formulation, Q is measured as sales minus the sum of materials and goods bought.[7] BBG assume that there is no exogenous variation in w_H and w_L across industries and therefore do not include wages as regressors. We maintain this assumption and allow year dummies to capture year-to-year changes in the wage levels faced by all firms (w_L and w_H).

We follow the practice of Slaughter (2000) and Feenstra and Hanson (1996a) by adding a measure of international activity to the basic translog specification consisting of year dummies, capital intensity, and firm size. Slaughter uses the ratio of overseas employment to domestic employment. When using firm-level data, there are cases where domestic employment is quite small, leading to extremely large ratios of foreign to domestic employment. Such observations can have excessive influence on the results. For that reason in most of our specifications we employ the ratio of overseas to worldwide employment, i.e. the share of a firm's total work force that are located offshore.

4.1. Results for the nonproduction share

Column (1) of Table 3 presents results for a specification that is similar to the one Slaughter (2000) fits to US industry data. The subsequent columns reflect

Table 3
A comparison of different specifications

Unit of	Dep. var.: nonproduction share of the wage bill					
observation	Industries			Firms		
Method	First differences		Industry effects		Firm effects	
Specification	(1)	(2)	(3)	(4)	(5)	(6)
Log assets/output	−2.49[a]	−1.81[a]	−1.96[a]	−7.92[a]	−4.10[a]	−3.88[a]
	(0.38)	(0.35)	(0.44)	(0.17)	(0.13)	(0.12)
Log output	−3.83[a]	−3.51[a]	−3.54[a]	0.86[a]	−3.18[a]	−3.51[a]
	(0.47)	(0.45)	(0.40)	(0.08)	(0.16)	(0.13)
Offshore empl.	−1.14	−1.81	−5.58[a]	1.11[a]	3.01[a]	11.79[a]
	(1.02)	(1.20)	(1.24)	(0.23)	(0.18)	(0.72)
Residual change	0.07	0.16	15.80[a]	6.76[a]	12.52[a]	17.03[a]
	(0.16)	(0.19)	(0.68)	(0.53)	(0.32)	(0.69)
N	1584	1584	1672	19,845	19,845	25,131
R^2	0.08	0.06	0.586	0.154	0.262	0.277
RMSE	1.008	1.183	2.745	11.782	5.58	6.263

Standard errors in parentheses with [a], [b], and [c] denoting significance at the 1%, 5%, and 10% level. Sample period runs from 1971 to 1989 except in column (6) where it is 1965–1990.

[7]In practice, BBG and Feenstra and Hanson use shipments rather than value-added.

gradually moving to a firm-level specification containing the full sample of 1070 firms and 25,131 observations.

To mimic Slaughter's regression specification, we aggregate our firm data to the industry level, first difference, and regress the nonproduction share of wages on capital intensity, scale, year dummy variables, and the ratio of overseas affiliate employment to home employment. Our use of production affiliate data as opposed to Slaughter's use of total (sales and production) affiliate employment remains as a difference between the specifications.[8] Following Slaughter, we weight the observations by the industry's share of the total manufacturing wage bill and measure output in terms of sales.

To prevent entry of firms into our sample from influencing the industry aggregates, we confine the sample to 1052 firms for whom we have financial information over the period 1971 to 1989. The panel we create comprises 1672 (1584 after first differencing) observations reflecting 88 industries over this 19-year period whereas Slaughter's US data uses 32 industries for 14 years. Our industries are comparable but somewhat more detailed than the Bureau of Economic Analysis definitions used by Slaughter.[9]

The industry results displayed in column (1) of Table 3 reproduce Slaughter's result that foreign employment does not have a statistically significant effect on the nonproduction wage share. Both scale and capital intensity, however, have a negative and significant relationship with skill intensity. These estimates differ markedly from the positive effects for both variables found in the studies of US industry-level data. A negative scale effect is consistent with the knowledge capital hypothesis that firms need not increase skill-intensive knowledge capital as output increases. The estimates also suggest that increases in capital intensity favour production workers in Japan. This result contrasts with the common result in US data that capital and skill appear to be complementary.

The subsequent columns in the table gradually alter the specification towards the one that will serve as our baseline. For the column (2) estimates, we re-run the regression without weighting by pay. The results do not change appreciably when large industries are no longer given greater weight. Next, we employ industry fixed effects. Thus, rather than using first differenced data, the results shown in column (3) consider the difference of each variable from the industry mean. We view this procedure of 'demeaning' the data as beneficial, especially in the context of our data. Unlike first differencing, demeaning allows an increase in an explanatory

[8] We did not record sales affiliate employment because the data were very incomplete and sales affiliates tended to have few employees.

[9] For example, both samples contain the Bakery Products Industry, the Agricultural Machinery Industry, the Computer and Office Equipment Industry, the Glass Industry, and the Printing Industry. However, while his sample aggregates Motor Vehicles and Equipment, we have separate entries for Automobiles and Automobile and Parts; where his data combines Audio, Video and Communication Equipment, ours separates Household Electronics and Communication Equipment.

variable in one period to influence the dependent variable in subsequent periods. This is reasonable if the effects are felt gradually over time.

The fixed effect estimates in column (3) do not change the signs of the estimates. However, the level of significance is increased. Indeed, overseas employment now appears to have a negative impact on the nonproduction share of wages at a 5% significance level. Slaughter also obtains negative affects of MNE activity on the nonproduction share for four out of five specifications using his full sample with *t*-statistics ranging from −1.065 to −1.769.

The influence of overseas investment on the nonproduction labour share changes dramatically when we employ firm-level data in the regressions as portrayed in columns (4) and (5). Column (4) assumes industry fixed effects and shows a positive and significant overseas investment effect. In column (5), we use firm fixed effects and find that FDI continues to exert a strongly positive influence. A notable difference in the column (4) and (5) regressions is the effect of scale. The positive and significant scale effect in column (4) indicates that within industries, larger firms make more intensive use of nonproduction labour. However, column (5) indicates that as firms increase scale, the nonproduction labour share falls.

Finally, column (6) shows results when we redefine two variables and expand the sample to 1070 firms and the full period 1965–1990. Firstly, to be consistent with the cost function theory, we use value-added instead of sales as the measure of domestic output, Q. Secondly, we define the offshore employment variable as the foreign affiliate share of the firm's worldwide employment. This scales the variable to lie in the interval of 0 to 1. Expressing overseas employment as a share seems natural and it has the benefit in some subsequent regressions of reducing the influence of unusual firms. These changes do not alter the results relative to column (5) much except for raising the coefficient on offshore employment.

We augment the specification to include a variable capturing differential effects of investment depending on the income of the host country. It is the interaction of the offshore employment share and per capita GDP of the host country relative to per capita GDP in Japan. For a Japanese firm that invests in multiple countries, we compute the average host-country income associated with that firm's overseas employment. To accomplish this, we weight the per capita income of each host country, Y_c, by the share of the firms' overseas employment in that country, E_{ic}/E_i. Specifically, our employee-weighted relative per capita income term is calculated as

$$y_i = \sum_{c=1}^{C} \frac{E_{ic}}{E_i} \frac{Y_c}{Y_0}, \tag{3}$$

where Y_0 represents per capita income in Japan and we suppress time subscripts.[10]

[10] The Y_c are real GDP per capita in international prices (PPP) obtained from the Penn World Tables Version 5.6.

As previously discussed, the interaction variable may distinguish between the branching and vertical form of overseas investment. In the former, the location of investment should not affect skill intensity. In the latter, skill upgrading should diminish as investment shifts towards high-income countries.[11]

Table 4 shows the results of the firm fixed effect regressions when we add the variable that measures the interaction between the offshore employment share and host-country income. Columns (1)–(3) contain results for the full set of firms whereas columns (4)–(6) confine the analysis to electronics firms. The first and fourth columns reflect the full sample period and the subsequent two columns portray results for the 1965–1979 and 1980–1990 sub-periods. As before, greater output and capital intensity are associated with a lower nonproduction labour share. The exception is the scale effect for the electronics sub-sample for the full period where a positive and significant estimate obtains. The scale effect is

Table 4
Overseas employment and the use of nonproduction workers

	Dep. var.: nonproduction share of the wage bill					
Sample	1070 Manufacturing firms			154 Electronics firms		
Period	65–90	65–79	80–90	65–90	65–79	80–90
Specification	(1)	(2)	(3)	(4)	(5)	(6)
Log assets/value-added	-3.80^a	-2.81^a	-3.42^a	-0.93^a	-1.66^a	-0.81^c
	(0.12)	(0.16)	(0.16)	(0.31)	(0.38)	(0.47)
Log value added	-3.33^a	-1.81^a	-3.91^a	0.62^c	-0.86^b	-1.97^a
	(0.13)	(0.17)	(0.21)	(0.32)	(0.39)	(0.60)
Overseas employment share	23.80^a	10.48^a	31.59^a	18.01^a	8.48^a	29.68^a
	(1.31)	(1.71)	(1.87)	(1.83)	(2.20)	(2.25)
Overseas share × income	-18.23^a	-6.68^a	-30.80^a	-13.87^a	−0.85	-22.20^a
	(1.66)	(2.49)	(2.06)	(2.73)	(3.51)	(3.28)
Residual change	16.68^a	6.97^a	7.47^a	−1.41	0.40	4.76^a
	(0.69)	(0.55)	(0.24)	(1.98)	(1.46)	(0.72)
N	25,131	13,551	11,580	3606	1933	1673
R^2	0.281	0.168	0.203	0.236	0.231	0.184
RMSE	6.248	4.756	4.299	5.488	3.903	4.163

Firm fixed effects (within) estimation. Standard errors in parentheses with [a], [b], and [c] denoting significance at the 1%, 5%, and 10% level.

[11] In the previous version of the paper, we divided all host countries into just two categories: high and low income. The cut-off criteria for being a low income country (LIC) was having less than half Japan's income. All other countries were deemed to be high income countries (HICs). The results showed skill upgrading for investment in LICs and no systematic effect for investment in HICs. When we narrowed the definition of HICs to those countries with higher incomes than Japan, the HIC estimate became almost uniformly negative and occasionally significantly so. We report these results in an unpublished appendix available at ⟨economics.ca/keith/suppapp.pdf⟩. The current approach allows for skill upgrading or downgrading based on host country income and does not require an arbitrary income cut-off.

negative and significant for electronics, however, in the two subperiods. One explanation for the contrasting results for scale is that large electronics firms became more nonproduction labour intensive over the full period independent of their overseas activities. This change is captured by different fixed effects in the two sub-periods but not when we impose a single fixed effect on the full sample.

The coefficients on the offshore employment share are positive and significant at the 1% level indicating that FDI in low-income countries raises skill intensity. However, the negative and generally significant interaction term shows that this skill upgrading effect diminishes as investment moves towards higher income countries. The relative per-capita income in the host country is 0.68 for the median investing firm in our sample in 1989. Multiplying this number by the coefficient for the interaction term, -18.23, and adding the coefficient for the base effect, 23.80, yields 11.40. This means that the overseas investment of the median firm in our sample resulted in skill upgrading. Indeed, even the 90th percentile firm, one that in 1989 had investments in countries with average income 1.25 times that of Japan, incurred slight skill upgrading due to its FDI. Skill downgrading associated with FDI, however, does emerge in our sample. There were eight firms with investment confined to the US in the 1980s. Since US per capita income averaged 1.41 times that of Japan in that decade, the regression coefficients shown in columns (3) and (6) indicate that these firms realized skill downgrading as a result of their overseas activities.

The signs of the coefficients on the FDI variables support the vertical form of FDI. Overseas investment in low-income countries may reflect the transfer of low-skill production work abroad while high-skilled employees serving the global production network remain at home. Similarly, investment in a high-income country like the United States may lead to skill downgrading as skill-intensive activities are relocated abroad.

One final item to note in Table 4 is the large residual change. Column (1) shows that for the full sample this residual amounts to a 16.7 percentage point change from 1965 to 1990. This exceeds the 10 percentage point increase in the nonproduction share observed over the period. The results show that, while the direct contribution of FDI has been to increase skill intensity, increases in firm scale have tended to reduce it.[12]

We use the estimated coefficients from column (1) to decompose the total change in the share of nonproduction workers into the part attributable to overseas employment expansion. We take differences in firm size into account by weighting implied changes by each firm's wage bill. We find that changes in overseas employment shares can explain a 0.9 percentage point increase, or about 9% of the roughly 10 percentage point increase in the share of nonproduction workers from 1970 to 1989. While this magnitude is not negligible, it falls well short of the

[12]During the 1970s increases in capital intensity also appear to have caused reductions in skill intensity; however, the median firm in the 1980s slightly reduced its capital intensity.

18.9–21.3% of the increase in the US during the 1980s that Feenstra and Hanson (1996c) attribute to outsourcing. These results suggest that the actions of Japanese multinationals constituted a significant but relatively small source of shifts in the demand for low-skilled workers during the 1970s and 1980s.

4.2. Results for the firm's average wage

Table 5 contains results for the same set of regressions that we estimated in the previous table except that a measure of the average wage replaces nonproduction share of the wage bill as the dependent variable. The new dependent variable is the average wage paid by the firm (from firm-level accounting data) normalized by the wages paid to workers with just a high school degree (from the *Employment Status Survey*). The normalization removes the effects of inflation and general productivity gains that raise the wages of all workers. The specification employs annual dummy variables that capture changes in the wage premium paid to all high-skilled workers. Hence, we hypothesize that higher average wages reflect a shift in the composition of workers towards those with high skills.

Table 5 shows negative effects of capital intensity, suggesting that capital deepening reduces the share of skilled workers. Firm-level average pay appears to increase with firm size. This is in contrast to the previous results where the nonproduction worker share fell with scale. One way to reconcile the two results is

Table 5
Overseas employment and the firm's average wage

	Dep. var.: $100\times\ln$ average wage					
Sample	1070 Manufacturing firms			154 Electronics firms		
Period	65–90	65–79	80–90	65–90	65–79	80–90
Specification	(1)	(2)	(3)	(4)	(5)	(6)
Log assets/value-added	−1.41[a]	−2.90[a]	−1.04[a]	−3.28[a]	−2.68[a]	−5.38[a]
	(0.22)	(0.37)	(0.31)	(0.55)	(0.90)	(0.81)
Log value added	7.13[a]	7.29[a]	4.71[a]	3.29[a]	2.87[a]	1.40
	(0.24)	(0.40)	(0.39)	(0.57)	(0.93)	(1.04)
Overseas employment share	26.59[a]	22.82[a]	16.87[a]	26.69[a]	30.08[a]	5.68
	(2.44)	(3.96)	(3.52)	(3.39)	(5.22)	(4.36)
Overseas share $\times$ income	−13.31[a]	−1.28	−11.15[a]	−5.06	−0.71	−18.03[a]
	(3.10)	(5.75)	(3.88)	(5.05)	(8.31)	(6.34)
Residual change	5.08[a]	2.31[c]	4.23[a]	23.77[a]	19.19[a]	10.46[a]
	(1.29)	(1.27)	(0.44)	(3.66)	(3.46)	(1.39)
N	25,131	13,551	11,580	3606	1933	1673
R^2	0.316	0.206	0.118	0.555	0.416	0.185
RMSE	11.674	11.002	8.079	10.15	9.239	8.050

Firm average pay is divided by the average wage of high school educated workers in each year. Firm fixed effects (within) estimation. Standard errors in parentheses with [a], [b], and [c] denoting significance at the 1%, 5%, and 10% level.

that increases in size cause the firm to use a higher skill intensity on the factory floor. Thus, the share of nonproduction workers might decline at the same time as the overall share of high-skilled workers increases. The positive wage-scale relationship is also consistent with the hypothesis that firms that grew experienced success in the form of higher firm-level quasi-rents that they shared with workers in the form of higher bonuses (which are a component of average pay).

The estimates of the coefficient on offshore employment indicate that investment in low-income countries raises average wages. This result is consistent with FDI leading to a higher skill mix in Japan. As in the nonproduction wage share regressions, the coefficient on offshore employment interacted with host-country income is negative, although it is insignificantly different from zero in three out of the six specifications. Apart from the column (6) estimates, the magnitude of the estimate of the interaction term is small relative to that for the foreign investment share. Thus, even investment in high-income countries like the United States is associated with higher wages in Japan.

The estimated FDI effects in the column (6) specification, the sub-sample of electronic firms for 1981–1990, differ somewhat from those in the other specifications: the base offshore employment estimate is insignificant whereas the coefficient on the interaction term is strongly negative and significant. These differences are entirely attributable to one firm's investment. Crown Corporation is an audio equipment maker that opened a large production plant in China. Crown increased its nonproduction share from 13% in 1987 to 31% in 1988, the year the China plant began operations. It also increased its purchased goods share of variable costs from 33% to 84% in that year. Thus, the firm seems to be a perfect example of shifting production offshore and importing finished goods from its foreign affiliate. However, perhaps due to timing issues, the accounting data record a 24% decline in average wages in 1988. If this firm is removed from the sample, the coefficient on offshore employment in the column (6) specification is 64.82 (with a standard error of 5.17) and the coefficient on the interaction term is −66.23 (standard error of 6.29).

The wage regressions support the findings in the nonproduction wage share regressions that investment in low-income countries is associated with skill upgrading in Japan. Both sets of results show this effect diminishing as investment shifts towards high-income countries.

4.3. Results for the share of goods bought

To investigate the effects of FDI on purchases of final goods by the parent firm, we turn to a four variable factor translog specification that includes the purchases of finished goods (G). Denote expenditures on materials as $w_M M$ and expenditures on finished goods bought from other firms as $w_G G$. Total variable costs of domestic production are given by $C = w_L L + w_H H + w_M M + w_G G$. The translog cost function yields the goods bought cost-share equation as

$$S_G = \frac{w_G G}{C} = \gamma_0 + \sum_i \gamma_i \ln w_i + \gamma_K \ln K/Q + \gamma_Q \ln Q. \tag{4}$$

In this specification, output (Q) should now be measured as total sales including goods purchased from other firms (outsourcing).[13]

Table 6 displays results when we repeat the previous specifications but employ the finished goods' share of variable costs as the dependent variable. The coefficient on the assets/sales variable indicates that capital substitutes for purchased goods. Conversely, the second row results reveal that sales increases raise the purchased goods share. This pattern emerges for all firms and the subset of electronics firms.

The estimated coefficients on the foreign employment share variable and its interaction with host-country income reveal that investment in low-income countries strongly increases the purchased-goods share of total variable costs. However, this effect diminishes for investment in higher income countries. These results suggest that a portion of purchased goods are being imported by Japanese MNEs from their foreign affiliates in low-income countries. They are consistent with vertical FDI where assembly is done in low-wage affiliates with final goods

Table 6
Overseas employment and outsourcing of final goods

	Dep. var.: goods bought as a share of variable costs					
Sample	1070 Manufacturing firms			154 Electronics firms		
Period	65–90	65–79	80–90	65–90	65–79	80–90
Specification	(1)	(2)	(3)	(4)	(5)	(6)
Log assets/sales	-6.50^a	-5.45^a	-5.36^a	-4.34^a	-5.42^a	-4.44^a
	(0.17)	(0.24)	(0.23)	(0.51)	(0.76)	(0.72)
Log sales	2.17^a	2.16^a	2.36^a	5.47^a	6.46^a	7.19^a
	(0.19)	(0.28)	(0.32)	(0.52)	(0.78)	(0.93)
Overseas employment share	33.13^a	15.99^a	53.16^a	43.43^a	31.40^a	54.83^a
	(1.78)	(2.50)	(2.56)	(2.79)	(3.99)	(3.31)
Overseas share × income	-32.71^a	-9.14^b	-41.95^a	-39.05^a	-28.41^a	-38.72^a
	(2.26)	(3.63)	(2.82)	(4.16)	(6.36)	(4.80)
Residual change	3.90^a	0.76	3.40^a	-8.62^a	-8.55^a	-3.07^a
	(0.96)	(0.84)	(0.32)	(3.07)	(2.79)	(1.06)
N	25,222	13,636	11,586	3608	1935	1673
R^2	0.161	0.116	0.157	0.2	0.19	0.251
RMSE	8.516	6.948	5.869	8.359	7.086	6.076

Firm fixed effects (within) estimation. Standard errors in parentheses with [a], [b], and [c] denoting significance at the 1%, 5%, and 10% level.

[13]Using sales instead of value-added increases the sample slightly from 25,131 to 25,222 due to observations where negative value-added resulted in missing values for ln Q.

being shipped back to Japan.[14] The positive effect of FDI on finished goods purchases is not consistent with branching FDI where final production serves local demand only.

5. Conclusion

The dramatic growth of overseas production by Japanese MNEs has the potential to explain the observed rise in the skill intensity of Japanese manufacturing. We use a large panel set of Japanese manufacturing firms to investigate the effects of offshore employment on skill composition in Japan. A fairly consistent set of results emerges across different specifications and samples. The rise in the share of nonproduction workers and the average wage can be explained in part by investment in production facilities in low-income countries. We also find that increases in scale and capital intensity tend to raise the production workers' share of the wage bill.

Our findings differ markedly from those of Slaughter (2000) who finds that the nonproduction worker share of wages in the US has an insignificant relationship with MNE activity and a positive one to scale and capital intensity. In regressions similar to his using first-differenced, industry-level data, we do not find significant FDI effects, although scale and capital intensity continue to be negative and significant. This suggests that one source of the difference between the two FDI estimates is our use of firm-level data. We note, in addition, that we consider production employment whereas Slaughter evaluates activity of all affiliates including distributors. This probably results in stronger skill upgrading effects.

Our empirical results provide evidence consistent with vertical specialization. FDI in low-income countries appears to raise skill intensity at home but this effect falls as investment shifts towards high-income countries. For high enough host-country income levels, FDI can result in skill downgrading. This is consistent with low-skill activities being transferred to low-income countries and high-skill activities to high income countries. The positive relationship between investment in low-income countries and purchases of finished goods suggests that Japanese affiliates in these countries are assembling goods that are shipped back to the parent firm at home.

We find aspects of multinationals activity that have not been detected in the existing empirical literature. As mentioned previously, Slaughter's study of US multinationals cannot link overseas activity to skill upgrading. While Feenstra and Hanson (1996b) find that outsourcing is positively associated with skill intensity,

[14] Since finished goods include purchases from both domestic and foreign sources, we cannot be certain that this positive correlation represents imports of finished goods. Another interpretation is that the correlation reflects firms with technologies that allow them to outsource through foreign employment and contracting with local firms.

they do do not link outsourcing to multinationals. Maskus and Markusen's (1999) empirical tests reject their vertical FDI model. Our results add to the literature by compiling evidence that vertical specialization by multinationals contributes to skill upgrading. However, most of the apparent skill upgrading in Japanese manufacturing remains unexplained by changes in the observable characteristics of the firms.

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Appendix A. Calculation of offshore employment panel

Japan Overseas Investment lists each affiliate's employment level in 1991 and year of establishment. Denoting the former as E_T and the latter as t°, we need to estimate employment levels E_t for $t^{\circ} \leq t < T$. We have experimented with three different assumptions about the temporal pattern of E_t.

1. Athena assumption (AA): affiliates are 'born' at their final size. Thus, we have $E_t = E_T$ for all $t > t^{\circ}$.
2. Constant growth assumption (CGA): after an initial creation of employment E_0 at time $t = t^{\circ}$, affiliates grow at a constant rate g. Thus, $E_t = E_T(1+g)^{-(T-t)}$ for all $t \geq t^{\circ}$. The growth rate we assume is $g = 0.1$.
3. Equal increments assumption (EIA): affiliates expand to their final size in a series of equal steps. Thus, we have $E_t = E_T(t - t^{\circ})/(T - t^{\circ})$ for all $t > t^{\circ}$.

In the main text of the paper we report results using AA. Using EIA or CGA instead reallocates offshore employment to later periods. Thus, it reduces offshore employment shares in the 1970s.

Table A.1 reports the coefficients on the variables of interest, offshore employment shares, under alternative computations of foreign employment. This table includes the results from columns (2) and (3) of Tables 4–6 (which use the Athena assumption) for reference purposes. We do not report the coefficients on the scale and capital intensity variables as well as the residual change as they do not depend in any noteworthy way on the assumption used to calculate employment.

First note that the alternative assumptions have little impact on the fit of the regressions as shown by the R^2. Moreover, a similar pattern of effects emerges when we replace AA with EIA and CGA. Specifically, the coefficient estimates on

Table A.1
Alternate measures of offshore employment levels

Model	(1)	(2)	(3)	(4)	(5)	(6)
Assumption	AA	CGA	EIA	AA	CGA	EIA
Period	1965–1979			1980–1990		
Dependent variable	SGA costs as share of wage bill					
Overseas employee share	10.48[a]	23.73[a]	15.00[a]	31.59[a]	34.33[a]	41.95[a]
	(1.71)	(4.18)	(4.26)	(1.87)	(1.91)	(2.19)
Overseas share × income	−6.68[a]	−14.39[b]	−5.61	−30.80[a]	−36.54[a]	−44.97[a]
	(2.49)	(7.13)	(7.96)	(2.06)	(2.39)	(2.94)
R^2	0.168	0.169	0.167	0.203	0.205	0.209
Dependent variable	log average pay					
Overseas employee share	22.82[a]	60.96[a]	56.82[a]	16.87[a]	14.31[a]	14.30[a]
	(3.96)	(9.66)	(9.84)	(3.52)	(3.60)	(4.14)
Overseas share × income	−1.28	−23.34	−19.74	−11.15[a]	−11.60[b]	−10.51[c]
	(5.75)	(16.50)	(18.39)	(3.88)	(4.50)	(5.54)
R^2	0.206	0.207	0.208	0.118	0.117	0.117
Dependent variable	Goods bought share of variable costs					
Overseas employee share	15.99[a]	40.71[a]	36.02[a]	53.16[a]	49.79[a]	62.38[a]
	(2.50)	(6.10)	(6.21)	(2.56)	(2.63)	(3.01)
Overseas share × income	−9.14[b]	−34.48[a]	−37.51[a]	−41.95[a]	−46.62[a]	−60.92[a]
	(3.63)	(10.42)	(11.63)	(2.82)	(3.28)	(4.02)
R^2	0.116	0.117	0.115	0.157	0.151	0.157

Firm fixed effects (within) estimation. Standard errors in parentheses with [a], [b], and [c] denoting significance at the 1%, 5%, and 10% level.

overseas employment share are positive while the estimates for the overseas share–income interaction variable are negative. The former are always highly significant (P-values below 0.001) whereas the latter estimates are usually significant. Thus, the alternative methods for calculating offshore employment yield similar results: investment in low-income countries raises the nonproduction share of pay, the log of average pay, and the share of variable costs attributable to final goods purchases but this positive effect diminishes as investment shifts towards high-income countries.

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