Offshore Production and Skill Upgrading by Japanese Manufacturing Firms*

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June 25, 2000

Abstract

We investigate the influence of offshore production by Japanese multinationals on labour in Japan. Identifying relationships based on within variation in a panel of 1070 Japanese firms, we find that additional foreign affiliate employment is associated with greater use of nonproduction labour at home relative to production labour. Firms that shift production overseas also tend to increase their average wages and purchased goods. These effects are strongest when the offshore production occurs in low income countries.

JEL classification: F2

Keywords: multinational enterprises, outsourcing, skills, wages, globalization

*This draft may be rough in places. Comments and corrections are very welcome. An earlier version of this paper was titled "Offshore Production and the Home Employees of Japanese Manufacturers." We appreciate the helpful comments of Robert Feenstra, Zadia Feliciano, and Matthew Slaughter. We thank Meng Zhang for research assistance.

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Over the past three decades, Japanese multinational enterprises (MNEs) have steadily increased their offshore manufacturing presence. They currently possess significant production capabilities abroad. *Time* magazine (1996) reported, "Currently, for example, Japan imports 23 times as many television sets as 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." As has been the case for the United States, the movement of manufacturing abroad has generated concerns about potential adverse consequences on workers. Indeed, 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. We assess the differential impacts of investment in low income countries and high income countries on the composition of manufacturing employment. We also examine the electronics industry as a special case of extensive foreign production.

We develop predictions about how FDI will effect skill intensity of the parent firm at home based primarily on alternative depictions of MNEs described in the series 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,

[1] See, for instance, Markusen (1984, 1995), Markusen and Venables (1997), Carr, Markusen, and Maskus (1998), Venables (1999), Markusen and Maskus (1999).

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 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 (1996b) relate the nonproduction worker share of payroll of U.S. industries to international activities. Slaughter finds that various measures of MNE activities cannot be linked to observed 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 17.5–29.0 percent of the observed increase in the in the nonproduction worker share of payroll for their sample of 4-digit SIC industries in 1979–1990. In their follow-up, 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 outsourcing can account for as much three-fifths of the observed 0.59 annual increase in the nonproduction/production relative wage observed over 1979–1990.

Brainard and Riker (1997) employ U.S. firm-level MNE data to test whether domestic and foreign affiliate labour are complements or substitutes. They find modest substitution of affiliate employment for home employment but that affiliate employment in one low-wage country is a strong substitute for affiliate employment in another low-wage country. Blomstrom, Fors, and Lipsey (1997) use a cross-section of U.S. and Swedish MNEs and regress home employment on foreign production. They find that, controlling for home production levels, additional foreign production is associated with less domestic employment for U.S. firms but more home employment for Swedish firms. In the case of the U.S., foreign production in less developed countries appears to substitute more for home employment than does foreign employment in industrialized countries.

Our study adds to the existing literature in four ways. First, our 25-year sample period includes the transformation of a number of Japanese firms into major multinational enterprises. Thus, we can utilize the large firm-level variation in our data to identify the relationship between overseas employment and skill intensity at home. Second, we consider differential impacts of overseas investment in high and low income countries. Third, our accounting data allow us to assess the effect of overseas investment on the parent firm's purchases of finished goods. This information helps to distinguish between alternative types of MNEs. Finally, we use the average wage as a measure of the skill intensity of the parent firms' workforce in addition to the nonproduction worker share of the wage bill to respond to concerns about the degree of linkage between nonproduction status and skill.

In the next section, we describe alternative types of FDI and how their effect on skill upgrading may vary across host countries. Section 2 presents the Japanese firm-level data we employ in our analysis and shows patterns in the data over the period of study. 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.

1 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 of 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 production to be located in proximity to customers in each market. Horizontal replicating FDI 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, Markusen, and Maskus (1998) 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,b) and Venables (1999) develop models inw which the production process can be divided into separate stages produced 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 will be 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

$$
\begin{aligned}
H &= F_H + \nu_H Y \\
L &= F_L + \nu_L Y
\end{aligned}
$$

As shown, production requires both a fixed and variable amount of each type of labour. The ratio of high skilled to low skilled workers is

$$\frac{H}{L} = \frac{F_H + \nu_H Y}{F_L + \nu_L Y}.$$

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

$$\frac{\partial(H/L)}{\partial Y} = \frac{F_L \nu_H - F_H \nu_L}{(F_L + \nu_L)^2},$$

and its sign depends on the term $\frac{F_L}{\nu_L} - \frac{F_H}{\nu_H}$. Skill intensity may rise or fall with output. In the context of the knowledge capital model, if high-skilled activities require only a fixed amount of skilled workers and serve as an input to any amount of production, ν_H would approach zero, implying that skill intensity declines when output increases.

This depiction of production demonstrates that horizontal FDI that substitutes for exports from home will raise skill intensity through 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 normally 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. 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 input for the foreign plant.

The effect of vertical FDI on skill intensity depends on the stage of production moved offshore. This will depend on 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 for FDI in low and high income countries. Investment in the former will cause skill upgrading whereas investment in the latter would be associated with skill downgrading.

The preceding discussion indicates that both vertical FDI and branching FDI can lead to skill upgrading independent of scale effects. The two forms of FDI may be distinguished by whether 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 induce the multinational firm to produce in a single foreign site and export to home to serve the home market. Thus, we by examining the relationship between FDI and offshore sourcing from affiliates, one could distinguish between the two FDI forms. Under vertical specialization, we expect a positive relationship and we expect no relationship for branching.

Table 1: Predicted effects on skill intensity of each type of investment

Investment in:	Low Income Countries		High Income Countries	
	Skill Intensity	Offshore Sourcing	Skill Intensity	Offshore Sourcing
Horizontal FDI				
Replication	0	0	0	0
Branching	+	0	+	0
Vertical FDI	+	+	−	+

Table 1 displays the signs we expect for the effect that FDI has in low income countries (LICs) and high income countries (HICs) on skill intensity and offshore sourcing for each of the alternative FDI forms after we control for the impact of FDI on the scale of home production. All coefficients should be zero in the case of horizontal replication FDI. By design, the activities at home are independent of activities abroad. Branching will increase skill intensity at home. However, such investment should not influence the purchased goods of the parents. The effect of vertical FDI on skill intensity depends on the location of the investment. Investment in LICs should lead to skill upgrading whereas there may be skill downgrading in conjunction with investment in HICs. Vertical FDI will result in an increase in goods purchased from affiliates.

2 Data

The financial statements of publicly traded Japanese companies provide annual data on total employment, total production payroll, and selling, general, and administrative (SGA) payroll as well as information on the value of depreciable assets. 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 Kezai, 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 levels of each affiliate established prior to year t. Thus, we cannot account for 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 implicitly assumes that affiliates have static employment levels.

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 times the ownership share. Thus, in the case of joint ventures between two Japanese parents, employees of the affiliate are allocated between each parent based on ownership shares.

Figure 1 displays the total amount of foreign affiliate employment in high income countries and low income countries for our sample of firms for the years 1965–1989. We define LICs as countries with per-capita real incomes of less than one-half that of Japan; HICs are all other countries. The figure shows that foreign employment rose steadily over the period and was about equally divided between LICs and HICs. Investment in LICs exceeded that of HICs in the 1970s but the 1980s saw a surge in Japanese affiliate employment in HICs. Figure 2 focuses on 1052 firms for which we have data from 1971 to 1989 and shows employment abroad and at home for these firms. Employment abroad rises over time while employment at home falls, leaving these firms' overall employment roughly constant over this period. In 1989, foreign employment for these relatively large manufacturing firms stood at 697,000 while home employment totalled about 2.7 million.

Table 2 shows the industry composition of overseas employment. The 154 electronic firms employed 307,000 workers in foreign affiliates in 1989, over one-third the total for our sample as a whole. The second and third biggest investors by industry were Automobiles and Machinery. The final column of the table shows the share of employment in the industry accounted for by foreign affiliate employment which often exceeds 20% and ranges as high as 42% in the case of Rubber.[2]

Table 3 lists the 25 largest investors abroad in terms of employment. Electronics dominates

[2]The rubber industry comprises 20 firms. The high overseas affiliate share reflects major acquisitions by Bridgestone (Firestone) and Sumitomo Rubber (Dunlop).

Figure 1: Affiliate Employment in Low-Income and High-Income Nations

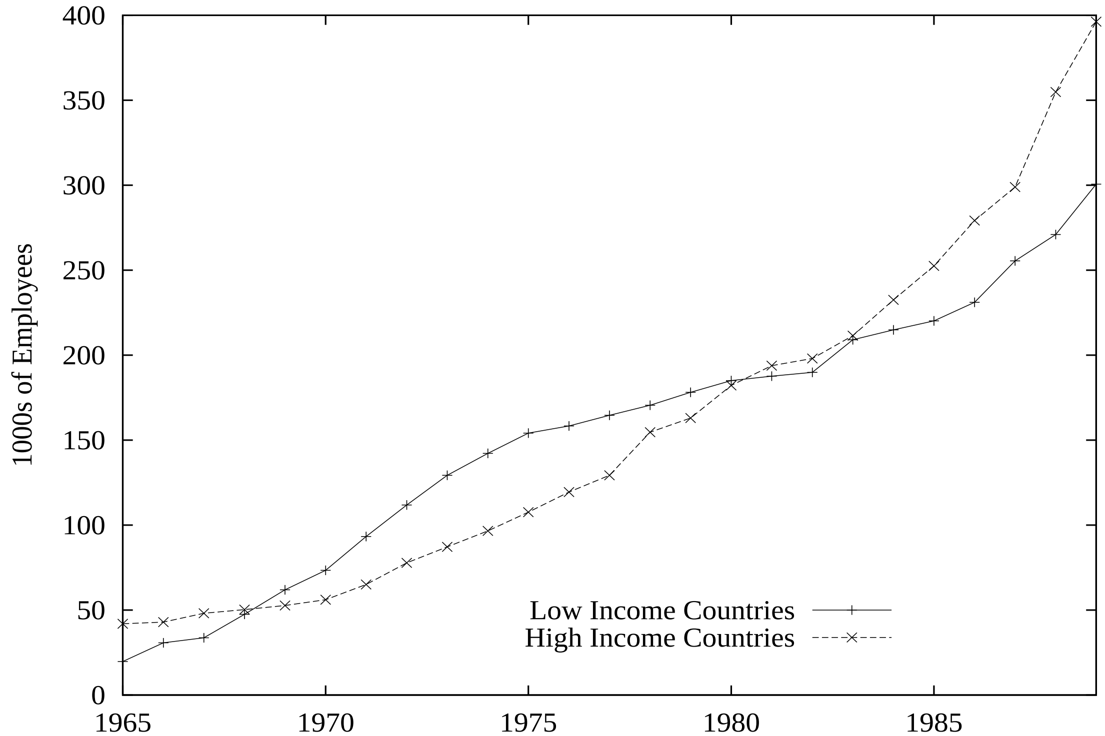
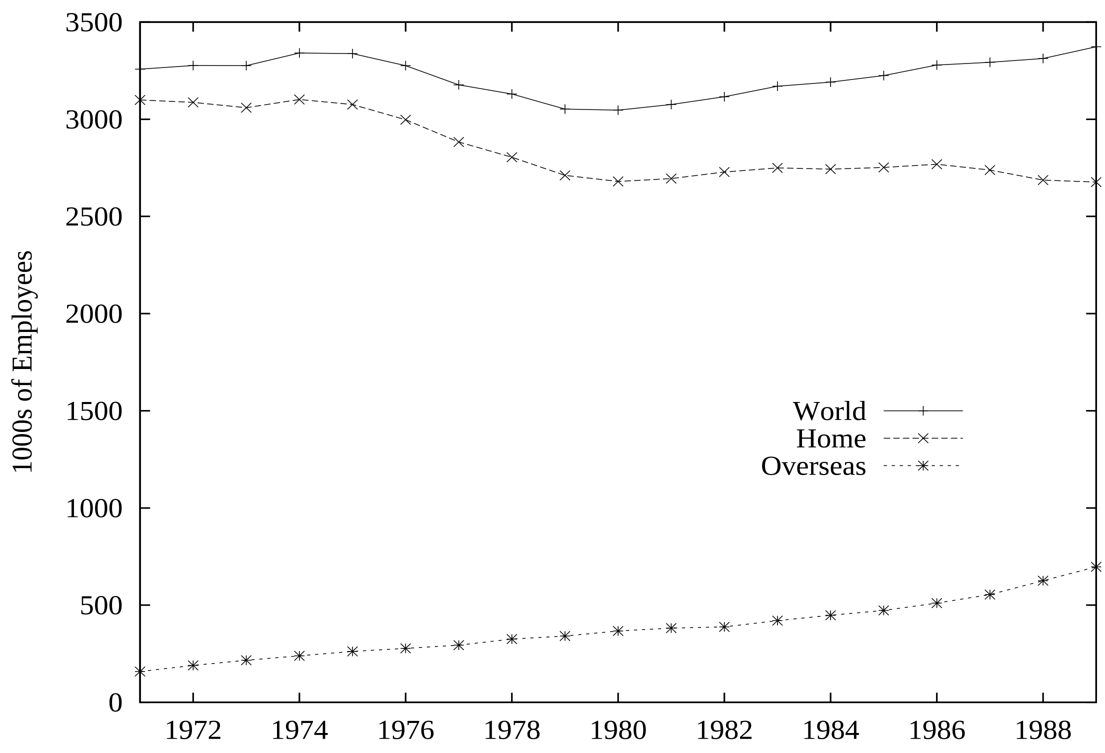


Figure 2: Employment at Home and at Overseas Affiliates for 1052 Japanese Manufacturers



this list of firms, accounting for 4 of the top 5 and 13 of the top 25. 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.

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 $w_H H/(w_H H + w_L L)$, 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.

Partitioning workers in an industry or firm according to skill levels poses great difficulties. Skill is often defined in terms of worker education levels. Alternatively, one may focus on occupational type, distinguishing "white-" and "blue-collar" jobs. Previous researchers such as Slaughter (2000), Feenstra and Hanson (1996a,b), and Berman, Bound and Griliches (1994) have use the nonproduction worker share of wages, labeling nonproduction workers as skilled and production workers as unskilled. To support the use of this division, the following arguments have been put forward.

1. Berman, Bound, and Griliches (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.

2. Berman, Bound, and Machin (1997) report the results from an analysis of matched microdata performed by Ken 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.

3. Sachs and Shatz (1994) link production worker intensity to indexes of the skills required

Table 2: World Employment by Industry

	Firms	Overseas	Home	Share Overseas
Electronics	154	307253	733868	.30
Automobiles	53	91602	364114	.20
Machinery	158	46850	210772	.18
Chemicals	133	44887	214639	.17
Textiles	80	41052	128827	.24
Rubber	20	34786	49021	.42
Precision Machinery	30	26538	79487	.25
Non-Ferrous Metals	90	24198	128059	.16
Iron and Steel	59	17743	216001	.08
Foods	93	17726	150330	.11
Glass and Cement	57	16178	78986	.17
Shipbuilding	10	10757	90480	.11
Other Manufacturing	40	9107	73792	.11
Pharmaceuticals	34	6390	84367	.07
Pulp and Paper	31	2447	50910	.05
Other Transportation	18	1494	20158	.07
Petroleum	10	109	15337	.01

Table 3: The Top 25 Overseas Employers

		Overseas		Home	Overseas
	Industry	**Plants**	**Emp.**	**Emp.**	**Share**
Matsushita Electric	Electronics	84	48178	41409	.54
Sanyo Electric	Electronics	62	29719	34405	.46
Sony	Electronics	22	28866	16278	.64
Honda Motor	Automobiles	71	23759	30022	.44
NEC	Electronics	28	22639	37721	.38
Bridgestone	Rubber	12	22137	15791	.58
Nissan Motor	Automobiles	14	21766	52808	.29
Toshiba	Electronics	29	18015	69201	.21
Minebea	Machinery	16	17369	3646	.83
Hitachi	Electronics	29	16966	76479	.18
Dainippon Ink & Chem.	Chemicals	22	15586	6626	.70
Toray Industries	Textiles	36	13249	9602	.58
Toyota Motor	Automobiles	27	12654	67814	.16
Sharp	Electronics	17	12290	18282	.40
Mitsubishi Electric	Electronics	28	11732	47693	.20
Mitsumi Electric	Electronics	12	9493	1936	.83
Sumitomo Rubber	Rubber	7	9418	4856	.66
Hitachi Koki	Electronics	3	8680	2583	.77
Asahi Glass	Glass and Cement	21	8269	9295	.47
Suzuki Motor	Automobiles	23	7195	12616	.36
TDK	Electronics	17	6876	7797	.47
Toko	Electronics	5	6841	1014	.87
Alps Electric	Electronics	12	6793	6502	.51
Kawasaki Steel	Iron and Steel	19	6660	18562	.26
Ricoh	Precision Machinery	6	6472	10817	.37

> 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 distinction appears fairly close to the one employed by government manufacturing surveys. The definition of nonproduction workers used by the U.S. 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 the SGA and production payrolls 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. In our sample, they accounted for 68% of the wage bill (the firm data provides total employment but does not specify the number of employees in SGA and production). To reconcile these two numbers, the relative wage of non-production workers would have to be 1.27. Japan's *Basic Survey on Wage Structure* reports a wage premium for male non-production workers of 1.34 in 1989. These numbers suggest that accounting measures of the composition of the work force do not differ markedly from government survey measures. Hereafter we will refer to out SGA wage data as "nonproduction" worker wages.

We have found support the view that nonproduction personnel have higher skills than production workers in Japan. Figure 3 shows educational attainment for production workers and salaried employees. 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 "up-

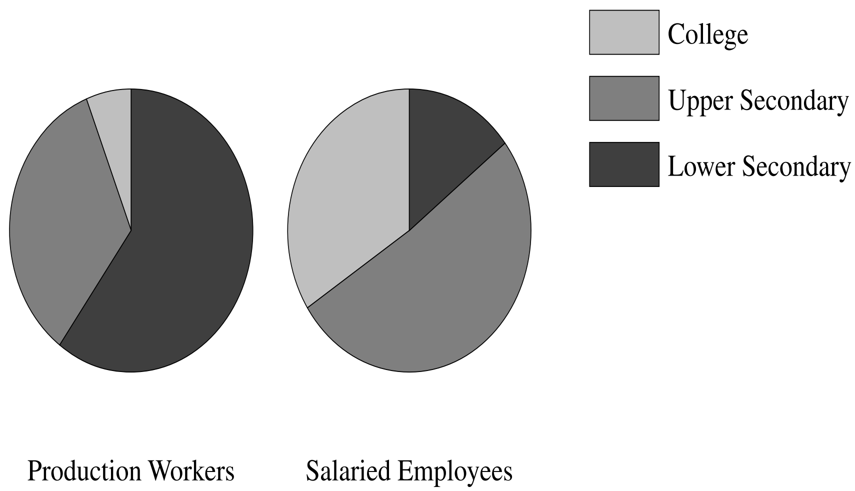


Figure 3: Educational Attainment of Production and Non-production workers

per secondary and over" education into separate upper-secondary and college subcategories.[3] Of salaried 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 will be 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 (SGA) in the wage bill:

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

where $L_N + L_P = L$ and $H_N + H_P = H$. Denoting the share of high-skilled workers in non-

[3]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.

production as $h_N \equiv H_N/H$ and the share low-skilled in non-production 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.

We have demonstrated that there are strong arguments for using the nonproduction share of wages as a proxy for skill intensity. This approach, however, is not without its detractors. Leamer (1994) states "But in the data used by Lawrence and Slaughter 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." Leamer was referring to the definitions of production and nonproduction workers used by the U.S. Annual Survey of Manufactures. He pointed out that production workers includes line supervisors and product development personnel while nonproduction included delivery truck drivers and cafeteria workers. We have no way of knowing if our accounting data make the same classification choices but it seems likely that they will include similar, if not the same, problems.

It could be the case that foreign investment affects skill intensity on the factory floor differently than it does nonproduction employees. For example, an investment may move skilled-intensive production tasks offshore. In this case, the nonproduction share may rise due to the elimination of skill-intensive production at home but the skill-intensive worker share of wages may fall since the number of high skilled workers at home decreases. In light of these concerns, we employ the log of the firm's average wage as a alternative 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

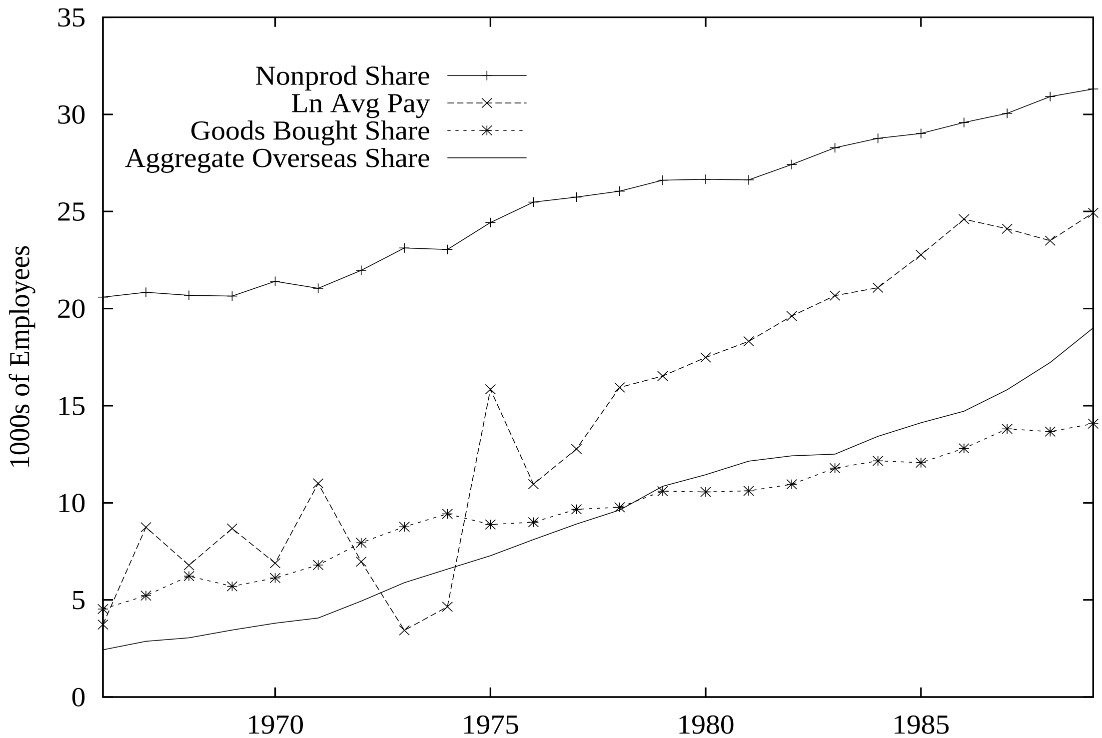
$$\ln(\hat{w}/w_L) = -\ln(1 - \sigma S_H).$$

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%[4] 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 for the skill intensity of the domestic work force. The use of the firm's average wage as a skill-intensity measure 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

[4] 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.

Figure 4: Trends in Skill Intensity, Outsourcing, and Overseas Employment



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 effects and 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.

Figure 4 displays the trends in the nonproduction share of wages, the log of 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. To remove overall trends in wages over the period, we normalized the average wage the firms pay by the wages of workers without 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 .21 in 1966 to .31 in 1989. Clearly, the median Japanese firm is devoting an 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 without high school degrees.

Figure 4 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. While the data do not specify from whom these goods were purchased, they include purchases of finished goods from foreign 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.

3 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, Bound and Griliches (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, and it is used by Slaughter (1995) and Brainard and Riker (1997) to test whether U.S. foreign affiliate employment substitutes or complements U.S. domestic employment.

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

$$S_H = \lambda_0 + \lambda_H \ln w_H + \lambda_L \ln w_L + \lambda_K \ln K/Q + \lambda_Q \ln Q. \tag{2}$$

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.[5] 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). BBG estimate the coefficients using long differences whereas we employ firm fixed effects.

We follow the practice of simply adding a measure of international activity to the basic specification consisting of year dummies, capital intensity, and firm size. Slaughter uses the ratio of overseas employment to domestic employment but for most of our specifications we will use the ratio of overseas to worldwide employment, i.e. the share of a firm's total work force that are located offshore. For industry-level data, this distinction is not very important but once we go to firm-level data, there are cases where domestic employment is quite small, leading to extremely large ratios of foreign to domestic employment.

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

3.1 Results for the nonproduction share

We begin by employing a specification that is similar to the ones fit to U.S. data in Slaughter (2000). Namely, 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. 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 U.S 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.[6]

The industry results displayed in column (1) of Table 4 replicate 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 U.S. 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.

The subsequent columns in the table gradually alter the specification towards the one that

[6]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.

Table 4: A Comparison of Different Specifications

	Dep. Var.: Nonproduction Pay as a Share of the Wage Bill					
Unit of 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)
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)
Offshore Employment	-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)
N	1584	1584	1672	19845	19845	25131
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

Note: Standard errors in parentheses with [a], [b] , and [c] denoting significance at the 1%, 5%, and 10% level.

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 higher 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 (i.e. the data are "demeaned"). We view this procedure as having some benefits, especially in the context of our data. Demeaning allows an increase in a variable 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 fiver percent 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)–(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 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. First, to be consistent with the cost function theory, we use value-added instead of sales as the measure of domestic output in $\ln Q$ and the denominator in the capital intensity variable, $\ln K/Q$. Second, we define the offshore employment variable as the foreign affiliate share of the firm's worldwide employment. This scales the variable to be within 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 alter the results relative to column (5) much except for raising the coefficient on offshore employement.

Table 5 shows the results of the firm-fixed effect regressions when we separate the overseas employment share into the share of employment in high income countries (HICs) and low income countries (LICs). 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 1966–1979 and 1980–1989 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 subsample for the full period where a positive and significant estimate obtains. The scale effect is negative

Table 5: Overseas employment and the use of nonproduction workers

	Dep. Var.: Nonproduction Pay as a Share of Wage Bill					
Sample:	1070 Manufacturing Firms			154 Electronics Firms		
Specification:	(1)	(2)	(3)	(4)	(5)	(6)
Log Assets/Value-Added	-3.80[a]	-2.81[a]	-3.42[a]	-0.94[a]	-1.61[a]	-0.75
	(0.12)	(0.16)	(0.16)	(0.31)	(0.38)	(0.47)
Log Value Added	-3.34[a]	-1.81[a]	-3.91[a]	0.74[b]	-0.66[c]	-1.93[a]
	(0.13)	(0.17)	(0.21)	(0.32)	(0.39)	(0.60)
Employee Share in LICs	19.30[a]	9.41[a]	27.58[a]	15.51[a]	10.99[a]	27.21[a]
	(1.01)	(1.25)	(1.68)	(1.38)	(1.50)	(2.04)
Employee Share in HICs	2.89[a]	1.70	-4.81[a]	2.35	2.31	3.79
	(1.11)	(1.73)	(1.47)	(1.76)	(2.11)	(2.99)
Residual Change	16.70[a]	6.96[a]	7.50[a]	-1.85	0.04	4.59[a]
	(0.69)	(0.55)	(0.24)	(1.98)	(1.46)	(0.72)
N	25131	13551	11580	3606	1933	1673
R^2	0.281	0.168	0.203	0.238	0.236	0.185
RMSE	6.249	4.755	4.3	5.481	3.891	4.162

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

and significant for electronics, however, in the two subperiods. One explanation for these results is that large electronics firms became more nonproduction labour intensive over the full period independent of their overseas activities. This change is captured by the fixed effect in the two sub-periods but not when a single firm fixed is assumed as in the full sample specification.

The coefficients on the employment share in LICs are positive and significant at the 1% level whereas the results for the HIC share are mixed. Most HIC effects are insignificant with a significant positive estimate recorded for the full same of all firms and a significant negative for the electronics subsample for the 1980s period. The positive and significant estimates for LICs support both the branching and vertical types of FDI. Overseas investment in LICs may reflect the transfer of unskilled intensive production abroad with high skilled inputs serving the global production network remaining at home. The mixed results for HIC investment make it difficult to draw unambiguous conclusions. One view is that such investment may be mostly the replicating type that does not influence home skill intensity. Much investment in the U.S.

is in the form of acquisitions where firms inherit self-sufficient operations which may be largely independent of the parent.

The estimated coefficients from column (1) may be used 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 firms' payroll. We find that changes in overseas employment shares can explain a .8 percentage point increase, or about 8% of the roughly 10 percentage point increase in the share of non-production workers from 1970 to 1989. While this magnitude is not negligible, it falls well short of the 17.5–29% of the increase in the U.S. during the 1980s which Feenstra and Hanson (1996b) 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.

3.2 Results for the firm's average wage

Table 6 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. Since the specification employs annual dummy variables capturing any changes in the wage premium to high skilled workers, higher average wages reflect a shift in the composition of workers towards those with high skills. As before, we also remove fixed firm effects.

Table 6 shows negative effects of capital intensity, again indicating that capital deepening favours production workers. Wages appear to increase with firm size. This is in contrast to the

Table 6: Overseas employment and the firm's average wage

	Dep. Var.: 100 X Ln Average Pay					
Sample:	1070 Manufacturing Firms			154 Electronics Firms		
Specification :	(1)	(2)	(3)	(4)	(5)	(6)
Log Assets/Value-Added	-1.37[a]	-2.87[a]	-1.03[a]	-3.12[a]	-2.61[a]	-6.33[a]
	(0.22)	(0.37)	(0.31)	(0.57)	(0.90)	(0.92)
Log Value Added	7.22[a]	7.35[a]	4.73[a]	3.36[a]	3.12[a]	0.62
	(0.24)	(0.40)	(0.39)	(0.60)	(0.93)	(1.16)
Employee Share in LICs	27.81[a]	27.22[a]	17.51[a]	28.00[a]	33.35[a]	1.32
	(1.89)	(2.88)	(3.15)	(2.56)	(3.55)	(3.96)
Employee Share in HICs	6.00[a]	12.61[a]	2.10	17.39[a]	22.64[a]	-9.78[c]
	(2.08)	(4.01)	(2.76)	(3.26)	(5.01)	(5.79)
Residual Change	4.91[a]	2.23[c]	4.24[a]	23.25[a]	18.73[a]	10.32[a]
	(1.29)	(1.26)	(0.44)	(3.66)	(3.46)	(1.39)
N	25131	13551	11580	3606	1933	1673
R^2	0.317	0.207	0.118	0.556	0.417	0.182
RMSE	11.665	10.998	8.076	10.142	9.231	8.064

Note: 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.

previous results where the nonproduction worker share fell with scale. One way to reconcile the two results is that size cause the firm to use a higher skill intensity on the factory floor. The positive wage-scale relationship is also consistent with the hypothesis that firms which grew experienced success in the form of higher firm-level quasi-rents which they shared with workers in the form of higher wages.

The results for offshore employment in LICs corroborates the findings in the previous table that investment in low income countries increases skill intensity at home. A positive and significant estimate obtains for all specifications except for the second period (1981–1990) for the electronics sub-sample. However, if one firm is removed, Crown Corporation, an audio equipment maker that opened a large production plant in China in 1988, the coefficient rises to 49.72 with a t-statistic of 10.65 for the electronic sub-sample in the later period. Crown increased its nonproduction share to 31% from 13% in 1988, the year the plan 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 classic example of shifting production offshore and importing finished goods from its foreign affiliate. However, the accounting data records a fall in average wages of 24% in 1988. The negative relationship between LIC investment and average wages in 1988 for Crown causes the coefficient for LICs to become insignificant for electronics in the 1980s.

As before, the results are somewhat mixed for the offshore employment in HICs. In four out of six specifications, the estimate is positive and significant albeit with a much smaller magnitude than the estimates for LIC investment. However, a negative estimate obtains for the electronic sub-sample in the 1981–1990 period that is significant at the 10% level. This estimate is consistent with vertical specialization where skill-intensive production activities are shifted to advanced countries.

3.3 Results for the share of goods bought

The positive effect of investment in LICs supports the branching form of FDI. However, a positive LIC affect is also consistent with vertical FDI. Thus, at this point we cannot conclude whether it is primarily branching or vertical specialization that underlies the results for investment in low income countries. To discriminate between the two forms, 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 equations as

$$S_G = \frac{w_G G}{C} = \gamma_0 + \sum_{i=1}^{4} \gamma_i \ln w_i + \gamma_K \ln K/Q + \gamma_Q \ln Q, \quad (3)$$

Table 7: Overseas employment and outsourcing of final goods

	Dep. Var.: Goods Bought as a Share of Variable Costs					
Sample:	1070 Manufacturing Firms			154 Electronics Firms		
Specification :	(1)	(2)	(3)	(4)	(5)	(6)
Log Assets/Sales	-6.51[a]	-5.45[a]	-5.36[a]	-4.16[a]	-5.14[a]	-4.26[a]
	(0.17)	(0.24)	(0.23)	(0.51)	(0.76)	(0.71)
Log Sales	2.08[a]	2.14[a]	2.37[a]	5.58[a]	6.65[a]	7.19[a]
	(0.19)	(0.28)	(0.31)	(0.52)	(0.77)	(0.93)
Employee Share in LICs	22.62[a]	12.39[a]	48.63[a]	36.17[a]	27.37[a]	51.42[a]
	(1.38)	(1.82)	(2.29)	(2.10)	(2.71)	(2.99)
Employee Share in HICs	-1.40	7.95[a]	2.86	-0.40	-4.75	7.69[c]
	(1.52)	(2.54)	(2.00)	(2.69)	(3.83)	(4.34)
Residual Change	4.10[a]	0.78	3.45[a]	-9.10[a]	-8.64[a]	-3.32[a]
	(0.96)	(0.84)	(0.32)	(3.06)	(2.77)	(1.06)
N	25222	13636	11586	3608	1935	1673
R^2	0.158	0.116	0.158	0.205	0.202	0.257
RMSE	8.529	6.949	5.866	8.331	7.035	6.055

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

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

Table 7 displays the 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 variables reveal that a higher share of LIC employment strongly increases the purchased-goods share of total variable costs. The coefficients are somewhat higher for the electronics industry sub-sample.

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 being shipped back to Japan.

The positive effect of FDI on finished goods purchases is not consistent with branching FDI where final production serves local demand only. The effect of investment in high income countries on the purchase of finished goods is mostly insignificant. It is positive and significant at the 1% level for all firms in the 1965–1980 period and positive and significant at the 10% level for electronics in the 1980s. Thus, there is only mild evidence that investment in HICs increase purchases of final goods.

4 Conclusion

The tremendous growth of in overseas production by Japanese MNEs has the potential to explain the observed rise in the skill intensity of manufacturing. We use a large panel set of Japanese manufacturing firms to investigate the effects of foreign employment of Japanese MNEs on skill composition in Japan. A consistent set of results emerge across different specifications and samples. The rise in the share of nonproduction worker payroll in the total wage bill and the average wage can be partly explained by investment in low income countries. The results contrast with those of Slaughter who finds no significant relationship between MNE activity and the nonproduction worker share of wages. We also find that increases in scale and capital intensity tend to favour production workers relative to nonproduction workers, results opposite to those from studies using U.S. industry data.

Our empirical results portray evidence of all three FDI forms posited in the MNE literature. The positive effect of investment in low income countries on skill intensity is consistent with branching as well as vertical FDI. Further support for the vertical form is the positive relationship between investment in LICs and the finished goods purchases share of variable costs. The generally insignificant results for investment in high-income countries supports replicating FDI.

There remains a large increase in our skill intensity measures that cannot be explained by changes in the observable characteristics of the firms. In summary, the expansion of offshore production by Japanese MNEs contributes significantly to a shift in labour demand in Japan towards skilled workers. However, other factors account for the majority of the shift.

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