DISCUSSION PAPERS IN ECONOMICS

Working Paper No. 08-09

The Impact of Foreign Production Activities: Firm-Level Evidence from Taiwan's Multinationals

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October 2008

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Abstract

A prominent phenomenon characterizing the increasing level of globalization is that many firms move some or all of their production activities abroad for different reasons. One of the main concerns is that the domestic industries will be hollowed out, and only the most skilled labor will survive. On the other hand, some people argue that firms' foreign production activities may be a complement to domestic production and even raise the domestic employment level. Must foreign production activities result in job-exportation?

Using firm-level data from Taiwan, this paper finds that while increasing the proportion of foreign output has a negative impact on both the domestic manufacturing and R&D workers, most of the negative impact on R&D workers is nullified when the foreign production activities are carried out in developing countries. Nevertheless, this is not the case for manufacturing workers. Since over three quarter of the Taiwanese multinationals engage in foreign production activities in developing countries, the empirical results suggest that there exists a geographical fragmentation of R&D and manufacturing activities.

Keywords: Multinational; Outward FDI; Job-exportation

J.E.L. Classification numbers: F14; F16; F23

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1 Introduction

A prominent phenomenon characterizing the increasing level of globalization is that many firms move some or even all of their production activities abroad for different reasons. One of the main concerns is whether the domestic industries will be hollowed out when the production activities are moved abroad. Many people in more developed countries are worrying about losing their jobs because the cheaper foreign labor will prompt firms to relocate more production activities outside their home countries.

For instance, in Germany, workers fear that cheaper labor in the new eastern EU member countries will attract companies to invest there and shut down domestic plants. In the United States, giant companies such as General Electric, IBM, and United Technologies have recently taken many of their operations overseas. It seems that those multinationals are exporting jobs rather than goods (BusinessWeek, 2006; 2008). Besides the anecdotal evidence, earlier empirical studies have found that the outward foreign direct investment (FDI) can have negative impacts on domestic output and employment.[1]

However, more recent studies also find that the effect of outward FDI can be quite mixed. For example, if the foreign affiliate uses more inputs (the inputs could be services or intermediate goods, etc.) produced by the parent firm, there could be a positive impact on some specific type of domestic employment. At the same time, the impact can vary across different labor categories, industries, and countries.[2]

Recent research on the foreign activities of U.S. multinationals has explicitly taken into account the role of trade in intermediate inputs between a firm and its foreign affiliate (Feenstra and Hanson, 2001; Hanson, Mataloni, and Slaughter, 2001; 2005). These studies find that trade in intermediate inputs is also one of the important elements that determines the factor demands and factor prices.

[1] See Singh (1977), Frank and Freeman (1978), and Glickman and Woodward (1989).
[2] See Lipsey (1994), Mariotti, Mutinelli, and Piscitello (2003), and Molnar, Pain, and Taglioni (2007).

Besides the evidence from a large economy, like the U.S., what happens in a small economy elsewhere? Hsieh and Woo (2005) find that outsourcing from Hong Kong to China has positive and negative impact on the demand of skilled and non-skilled labor in Hong Kong, respectively. In contrast, this paper takes Taiwan as an example and studies the impact of the multinationals' foreign production activities on domestic employment.

The case of Taiwan is of interest for the following reasons. First, Taiwan is an active participant in foreign production activities. As shown in Table 1-1, when considering the Asian newly industrialized or developing economies, Taiwan has been among the top-ranking countries in terms of both the outward FDI flow and stock since the 1990s, which is comparable to Singapore and just behind Hong Kong (UNCTAD, 2007).[3] Second, although there have been many studies investigating relevant issues in Taiwan, perhaps due to the lack of data until recent years, very few of them consider the role of trade in intermediate inputs between a firm and its foreign affiliate.[4]

When studying the impact of outward FDI, one often compares some characteristics or performances of firms with outward FDI to those without it. This paper, on the other hand, will just focus on multinationals (those firms who have already undertaken outward FDI) and answer the following question: will the multinationals' foreign production activities inevitably result in job-exportation?

This paper finds that the outcome depends on the location of the firms' foreign affiliates and the proportion of the foreign output. More specifically, while increasing the proportion of foreign output has a negative impact on the domestic manufacturing labor, the impact on those employees who engage in R&D activities is not (statistically) significant. On the other hand, while engaging in foreign production activities in developing countries has a positive impact on those employees in the domestic R&D sector, the impact on domestic manufacturing labor is not significant.

[3] In fact, part of the outward FDI by Hong Kong is either Taiwanese investment or Chinese capital from China, or round-tripping. See Hsiao and Hsiao (2004) and UNCTAD (2001).

[4] The only exception is Sung (2007), who uses Taiwan's data for 2001 to study firms' foreign production activities on domestic manufacturing and R&D employees.

The empirical evidence suggests that, first, in recent years, the geographical fragmentation of R&D and production activities is a prevailing phenomenon for those Taiwanese multinationals with affiliates in developing countries. Those multinationals often hire more skilled labor domestically to provide some services like R&D as input for the foreign affiliates. Second, the impact of trade in intermediates on domestic employment is insignificant. This could suggest that in Taiwan, the positive impact on the domestic skilled labor might come from providing intangible input like R&D related services rather than from producing tangible intermediates for the foreign affiliates. The paper is organized as follows: Section 2 discusses the implications of the theory of multinational firms; Section 3 reviews the relevant research on Taiwan; Section 4, 5 and 6 present the data, model and the results, respectively; and Section 7 concludes the paper.

Table 1-1 Outward FDI Flow and Stock in Asia

Unit: Millions of the U.S. dollars

	flows			stock		
Outward FDI	2004	2005	2006	1990	2000	2006
East Asia	62924	49836	74099	49032	509636	923403
China	5498	12261	16130	4455	27768	73330
Hong Kong	45716	27201	43459	11920	388380	688974
Korea, Republic of	4658	4298	7129	2301	26833	46760
Taiwan	**7145**	**6028**	**7399**	**30356**	**66655**	**113910**
Other East Asia countries	-93	48	-18	0	0	429
Japan	30951	45781	50266	201441	278442	449567
South Asia	2247	2579	9820	423	2503	14198
India	2179	2495	9676	124	1859	12964
Other South Asia countries	68	84	144	299	644	1234
South-East Asia	14212	11918	19095	9220	84045	171396
Indonesia	3408	3065	3418	86	6940	17350
Malaysia	2061	2972	6041	753	15878	27830
Singapore	8074	5034	8626	7808	56766	117580
Other South-East Asia countries	669	847	1010	573	4461	8636
West Asia	8078	13413	14053	7504	13861	42973
Kuwait	2526	5142	7892	3662	1677	4616
United Arab Emirates	2208	3750	2316	14	1938	11830
Other West Asia countries	3344	4521	3845	3828	10246	26527

Sources: Annex Table B.1 and B.2 in UNCTAD (2007).

2 Implications of the Theory of Multinational Firms

Multinationals are often broken down into two categories: the horizontal multinationals which produce similar goods or services in different countries, and the vertical multinationals which geographically fragment the production stages. Firms choose to be horizontal multinationals to expand their businesses when the benefit of doing so (avoiding the trade cost) outweighs the corresponding cost (establishing and running the foreign affiliates). Alternatively, the vertical multinationals try to internationally utilize the cheaper factors used intensively for some stages of production, provided that the cost of doing so (for example, trade cost, administrative expenses, etc.) does not dominate.[5]

It is quite plausible that for both types of multinationals, the foreign affiliates use the headquarters services as input provided by the parent firm, which means that horizontal multinationals could also fragment their production processes. Markusen et al. (1996) and Markusen (1997) present the knowledge capital model, which combines both the horizontal and vertical motives for firms' FDI activities.[6] It predicts that horizontal firms will be the dominant type of multinationals if the countries are similar in size and relative endowments and the transport costs are high. In contrast, vertical multinationals headquartered in the home country will prevail if the home country is small and skilled-labor-abundant and the trade cost is not too high.

Many Taiwanese firms have had their products produced abroad for the past decade, especially in other developing countries like China. According to the knowledge capital model, one would predict that these multinationals would become the vertical firms that keep the skilled-labor-intensive jobs (like R&D) in Taiwan while gradually shifting the relatively labor-intensive production processes

[5] Earlier theoretical frameworks for the vertical and horizontal multinationals can be found in Helpman (1984) and Markusen (1984), respectively.

[6] The three major assumptions for the model are: first, the location of knowledge-based assets may be fragmented from production, and the cost of supplying the services of the assets to the foreign affiliates is low. Second, knowledge-based assets are skilled labor intensive relative to final production. Third, knowledge-based services can be utilized simultaneously by multiple production facilities, i.e., they have a (partial) joint input characteristic. See Markusen et al. (1996), Markusen (1997), and Carr (2001).

(like assembly) to China since the trade costs between Taiwan and China are not overly high since 1990.[7] Furthermore, many Taiwanese firms sell the products produced by their affiliates in China not simply back to Taiwan, but also to the third countries. Thus, while skilled labor could benefit from the expansion of the multinationals' businesses, the non-skilled labor would be substituted for by the cheaper foreign labor.

The rising proportions of Taiwanese multinational's foreign outputs are confirmed in Table 2-1. For example, in 1999, the share of the export produced domestically for electronic parts and components is 90.86%, while that for computer communication and video and radio electronic products is 76.41%. However, in 2007, these shares drop to merely 56.33% and 16.41%, respectively.

Theoretically, the rising proportion of foreign output could be accomplished without sacrificing the level of domestic output. If this is the case, the domestic manufacturing employment might not suffer. On the other hand, if firms do keep their R&D activities within the home country while increasing the proportion of the foreign output, those employees in R&D sectors would not be hurt.

This means that for the case in Taiwan, if the vertical multinationals become more and more prevalent, according to the prediction of the knowledge capital model, empirically, the rising proportion of foreign output would have a negative impact on domestic manufacturing employees. However, it should not be the case for employment in the domestic R&D sector.

[7] Taiwanese government opened up the import from China in 1988, and opened up the export and FDI to China in 1990. Although before 2002, the trade and FDI between Taiwan and China are still indirect (Before 2002, officially, the destination of the export cannot be China), which are often through Hong-Kong, the trade costs between Taiwan and China are not prohibitively high at all since the sum of the distance from Taiwan to Hong-Kong and from Hong-Kong to China is still relatively short compared to other trade partners, and there are no abnormally high duties involved in these activities. Note that even after the direct trade and FDI are allowed since 2002 (i.e., officially, the source of import and destination of export could be China), nevertheless, most trade between Taiwan and China is yet through Hong-Kong since Taiwan and China are still negotiating the shipping navigation issues. See the details in MOEA (2005; 2008).
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Table 2-1 Sectoral Shares of the Overseas Sales Produced Domestically

	1999	2000	2001	2002	2003	2004	2005	2006	2007
S01	95.56%	95.57%	95.51%	93.06%	92.07%	90.03%	91.10%	98.43%	98.75%
S02	92.76%	89.42%	86.21%	86.04%	82.98%	81.00%	79.73%	78.86%	80.00%
S03	77.81%	76.55%	67.93%	74.30%	78.80%	72.00%	71.76%	78.59%	80.21%
S04	85.74%	79.84%	79.88%	78.22%	72.61%	85.42%	88.75%	88.42%	81.55%
S05	78.81%	75.52%	64.85%	69.25%	63.56%	59.41%	57.81%	64.50%	73.13%
S06	98.34%	98.50%	98.20%	98.10%	97.07%	79.00%	72.51%	66.90%	74.35%
S07	91.71%	88.34%	87.18%	90.29%	90.15%	87.10%	84.38%	84.40%	86.25%
S08	90.99%	91.65%	88.46%	88.81%	94.80%	95.76%	92.74%	94.57%	94.12%
S09	95.53%	95.05%	92.68%	91.15%	91.81%	88.23%	84.64%	86.24%	86.04%
S10	94.05%	94.17%	83.32%	84.62%	89.98%	74.62%	68.69%	71.67%	76.26%
S11	76.41%	74.50%	73.88%	65.95%	55.02%	39.61%	27.57%	24.25%	16.41%
S12	90.86%	91.86%	86.75%	84.89%	79.73%	70.35%	62.91%	64.02%	56.33%
S13	83.70%	80.82%	75.05%	68.52%	65.02%	61.14%	51.90%	47.48%	47.70%
S14	97.83%	96.05%	94.33%	93.79%	95.88%	94.63%	94.54%	94.06%	95.45%
S15	77.54%	70.99%	64.53%	67.59%	52.88%	61.26%	53.05%	51.84%	52.68%
S16	85.13%	83.33%	81.18%	78.90%	73.50%	66.24%	60.47%	57.66%	56.09%

Definition:

S01: Food, Beverage, and Tobacco Manufacturing
S02: Textile Mills, Apparel Clothing Accessories & Other Textile Product Manufacturing
S03: Leather Fur & Applied Product Manufacturing
S04: Wood & Bamboo Products Manufacturing
S05: Furniture & Fixtures Manufacturing
S06: Chemical Material and Chemical Product Manufacturing
S07: Rubber Products and Plastic Products Manufacturing
S08: Non-Metallic Mineral Products Manufacturing
S09: Basic Metal Industries and Fabricated Metal Products Manufacturing
S10: Machinery & Equipment Manufacturing & Repairing
S11: Computer Communication & Video & Radio Electronic Products
S12: Electronic Parts & Components
S13: Electrical Machinery Supplies & Equipment Manufacturing & Repairing
S14: Transport Equipment Manufacturing and Repairing
S15: Precision Optical Medical Equipment Watches & Clocks Manufacturing
S16: Other Industrial Products Manufacturing

Source: Taiwan Economic Statistical Databank System developed by Taiwan Economic Data Center (TEDC).

3 Relevant Research and Industry-level Information of Taiwan

Earlier research on issues regarding the activities of Taiwanese multinationals often classified the outward FDI into expansionary and defensive categories.[8] The former and the latter could result in horizontal and vertical firms, respectively. Using Taiwan's data from 1986 to 1994, Chen and Ku (2000) find that either types of outward FDI (expansionary and defensive) are neutral to domestic employment. They argue that the trend of manufacturing employment decline during that period seems to be driven by the structural change toward the capital-intensive industries.

To determine the types of outward FDI, the aforementioned research compares the wage rate in the host country and that in the home country (or some other benchmark level). If the former is higher than the latter, the outward FDI is regarded as expansionary, or it is classified as defensive if the wage rate in the host country is lower than that in the home country.[9] However, recently, many Taiwanese firms investing in China, where the wage rate is much lower than that in Taiwan, are not just seeking cheaper labor, but are also accessing the market there or meeting the customers' needs, etc. (MOEA, 2002; 2003; 2004). Thus, it would be dubious for these investments to be classified as defensive simply because the wage rate in the host country is lower.

Another issue is that the firms' motivations to invest in low-wage countries are often mixed.[10] Classifying each firm's outward FDI to be one of the two mutually exclusive parts might oversimplify the whole story. For example, Hanson, Mataloni, and Slaughter (2001) find the fact that U.S. multinationals were shifting activities towards low-income countries is consistent with vertical FDI where factor-cost differences matter, and also with horizontal FDI since many of these host countries were characterized by growing markets.

Recently, the survey on Taiwanese multinationals' foreign activities conducted by the Ministry of

[8] For example, see Chen and Chen (1995).

[9] In Taiwan, the practice is appropriate before the early nineties because most outward FDIs to low-wage countries then were to seek cheap labor (Chun, 1996).

[10] Chen and Ku (2000) argue that when investing in low-wage countries, the cost-saving motivation often dominates, which is just the case mentioned in the previous footnote.

Economic Affairs (MOEA) of Taiwan asks firms about their motives behind investing abroad. This allows the researchers to consider the coexistence of expansionary and defensive motives. Based on this database for 2001, Hsu and Liu (2002) find that the defensive and expansionary motives do have negative and positive impacts on a firm's domestic production scale, respectively, while Sung (2007) finds that when firms move the production activities to China, there will be a negative impact on employees in the manufacturing sectors.

MOEA's survey provides the firm-level evidence for researchers. However, until now, the relevant studies based on MOEA's database are all but cross-sectional. In contrast, to get more extensive information, this paper uses the panel data analysis. Although the MOEA's database covers 2000 to 2006, in this paper, only three years (from 2001 to 2003) will be selected due to the data availability issues on some variables.

To study the impact of firms' foreign production activities on domestic employment, this paper first analyzes the industry-level data from the Taiwan Economic Data Center (TEDC) before investigating the firm-level data from MOEA.[11] The manufacturing sector from 1999 to 2007 is classified into 24 industries. The available data include the number of skilled labor, non-skilled labor, output, and the foreign production ratio for each industry.[12]

Table 3-1 shows both the (industry) random effect and fixed effect regressions of the log of non-skilled labor on foreign production ratio and other independent variables. In both types of regressions, the year fixed effect has been controlled for to account for those unobserved year-specific factors that might correlate with the regressors. Furthermore, the setting of (industry) random effect is not rejected by Hausman test. Random effect setting allows us to observe the

[11] The database from TEDC is named the Taiwan Economic Statistical Databank System, which is also known as the AREMOS Economic Statistical Databanks.

[12] The skilled labor includes supervisor, professional, and technician, while the non-skilled labor is just the complement of skilled labor. The raw data for calculating the foreign production ratios (or domestic production ratios shown in Table 2-1) are based on commodities rather than industries. Since the author has to combine some industries when mapping the commodities into the industries, there are only 16 rather than 24 industries in Table 2-1. Finally, when mapping the 16 industries back to the 24 industries, there are no data available for: 1) Pulp Paper and Paper Products Manufacturing; and 2) Printing and Related Support Activities. In these two cases, the foreign production ratio in terms of the average industrial level will be used.

coefficients for industry dummies.

The results show that when the foreign production ratio increases by 1%, on average, the domestic non-skilled labor employment will decrease by 0.19%. The signs of the coefficients of the industry dummies are as expected, although they are not significant. Finally, Table 3-1 also shows that when the industry's output increases by 1%, on average, the non-skilled employees will increase by 0.42%.

Similarly, Table 3-2 shows the case for skilled labor. The (industry) random effect setting is again survived. A quite interesting finding is that in contrast to the case for non-skilled labor, when the foreign production ratio increases by 1%, the skilled labor employment will increase by 0.19%.

The above results suggest that Taiwanese multinationals' foreign production activities might have quite different impacts on different categories of labor.

Table 3-1 The Impact on Manufacturing Employees (Industry-level Linear Regression)[13]

Dependent variable : Lnonskl (Natural log of non-skilled employees) Number of industries = 24 ; Period = 9 ; Number of observations = 216				
	Random effect (GLS)		Fixed effect	
Loutput (Natural log of output)	0.4158 (0.0247)	***	0.4137 (0.0250)	***
met (Industry dummy-Met[14])	0.7749 (0.4845)		-	
inf (Industry dummy-Inf[15])	0.6205 (0.5395)		-	
liv (Industry dummy-Liv[16])	-0.0299 (0.4029)		-	
fpr (Foreign production ratio $\in [0, 1]$)	-0.1937 (0.0595)	***	-0.1920 (0.0599)	***
R^2 (within)	0.7307		0.7307	
R^2 (between)	0.5444		0.5183	
R^2 (overall)	0.5458		0.5179	
Test statistic for Hausman test (H_0: Random effect is true)	$0.3185<\chi(2)_{0.25}$	[p-value>0.25]	-	

***(**;*): Significant at 1% (5%; 10%) level. The output is in terms of 2001 price. For the fixed effect regression, the industry fixed effect and the year fixed effect have been controlled for respectively. The year fixed effect is still being controlled for in the (industry) random effect regression.

Table 3-2 The Impact on R&D Employees (Industry-level Linear Regression)

Dependent variable : Lskl (Natural log of skilled employees) Number of industries = 24 ; Period = 9 ; Number of observations = 216				
	Random effect (GLS)		Fixed effect	
Loutput (Natural log of output)	0.2847 (0.0222)	***	0.2811 (0.0223)	***
met (Industry dummy-Met)	0.6402 (0.5283)		-	
inf (Industry dummy-Inf)	1.0393 (0.5880)	*	-	
liv (Industry dummy-Liv)	-0.2633 (0.4395)		-	
fpr (Foreign production ratio $\in [0, 1]$)	0.1893 (0.0533)	***	0.1926 (0.0533)	***
R^2 (within)	0.6082		0.6082	
R^2 (between)	0.4941		0.5362	
R^2 (overall)	0.4944		0.5311	
Test statistic for Hausman test (H_0: Random effect is true)	$1.7359<\chi(2)_{0.25}$	[p-value>0.25]	-	

13 The model is: $\ln(\text{nonskl}_{it}) = \alpha_i + \beta \ln(\text{output}_{it}) + \gamma \text{ fpr} + \delta \text{ dummies}_{\text{industry}} + \xi \text{ dummies}_{\text{year}} + \varepsilon_{it}$. Here, $\partial \ln \text{nonskl}_{it} / \partial \text{fpr}$ and $\partial \ln \text{nonskl}_{it} / \partial \ln \text{output}_{it}$ are both elasticities since $\text{fpr} \in [0,1]$ is a share.

14 These industries include: 1) Metal; 2) Machinery; and 3) Transportation equipment.

15 These industries include: 1) Computer; 2) Electronic parts and components; and 3) Electrical machinery.

16 These industries include: 1) Food; 2) Tobacco; 3) Textile; 4) Apparel; 5) Wood and bamboo product; 6) Furniture and fixture; and 7) Non-metallic mineral products manufacturing.

4 Data

This paper uses the data from the survey on Taiwanese multinationals in the manufacturing industry conducted by MOEA. In the survey, each firm was asked to provide the information including: 1) the employment status (shortage, balance, or surplus) of domestic manufacturing and R&D sectors; 2) the relationship between parent firm and foreign affiliate; 3) total sales; 4) total assets; 5) domestic and foreign investments; 6) domestic and foreign R&D expenditures; 7) the location of its main foreign affiliate; 8) the proportion of foreign output; 9) the motivation to engage in foreign production; and 10) the global employees (sum of domestic and foreign employees), etc.

There are, however, some deficiencies in MOEA's survey. For instance, although there is information about each firm's global employees, it cannot be broken down into: 1) domestic and foreign employees; and 2) skilled and non-skilled labor. Thus, this paper has to use the shortages in domestic manufacturing and R&D employees as dependent variables. Since in general, R&D employees are more skilled than manufacturing employees, in this paper, the former will be treated as skilled workers while the latter are non-skilled workers. Nevertheless, these two variables are only available from 2001 to 2003.

Using the employment status as the dependent variable would inevitably raise some concerns. For example, a multinational's shortage in skilled labor might reflect the sectoral competition of hiring skilled labor between manufacturing and service sectors. On the other hand, since a multinational's surplus in non-skilled labor often accompanies with its (global) business expansion rather than contraction, surplus of non-skilled labor seems to correlate with a firm's shrinkage in domestic production activities better.

Another data issues are: 1) the exact proportion of foreign output for each firm is only available from 2003 to 2006; and 2) the information about whether there is trade in intermediates between the parent firm and its foreign affiliate is not available from 2003 onward; and 3) each firm's total assets are not available for 2003.

As a result, this paper only uses the data from 2001 to 2003. Furthermore, to approximate each firm's proportion of foreign output for 2001 and 2002, this paper uses the industry-level data from TEDC's database (See Table 2-1).[17] Finally, this paper assumes that the status of intra-firm trade for each multinational in 2003 is the same as that in 2002, and each firm's total assets for 2003 is estimated by summing its net assets (after depreciation) of 2002 and its investment of 2003.[18]

Other remaining issues are, first, in the survey, firms that do respond to the questionnaire in a particular year but fail to do that later might still survive. This means that treating them as exiting the market at some time is inappropriate. Second, even for those firms who do respond to the survey annually, some of them might not provide complete information, and it causes the issue of missing values.

To simplify things, this paper will just extract observations without missing values in the dependent and independent variables from the MOEA's survey. As a result, there will be 692, 678, and 666 multinationals with domestic manufacturing sectors in 2001, 2002, and 2003, respectively, and there will be 658, 654, 643 multinationals with domestic R&D sectors in these three respectively years.[19] The above treatment, however, means that this paper could still suffer from the sample selection bias. The output from these multinationals in the sample constitutes about a quarter of the total industrial output every year, as shown in Table 4-1.

[17] For example, to inference each firm's proportion of foreign output in 2002 (denoted by fpr_2), this paper uses the following formula: fpr_2 = (FPR[2]/FPR[3])*fpr_3. Here, fpr_3, which is available from MOEA's survey, is the firm's proportion of foreign output in 2003. FPR[2] (FPR[3]) is the industrial level share of the export produced abroad in 2002 (2003), which comes from the database of Taiwan Economic Journal and is just the complement information shown in Table 2-1. In some rare cases, if the survey classifies the firm into a different industry in 2002 compared to that of 2003, then FPR[2] will be used as a proxy to fpr_2.

[18] Each year, only the depreciation rate of the whole manufacturing industry (4.55% in 2002) is available. The calculation is based on: 1) the macroeconomic database (depreciation), and 2) the National Wealth Statistic (capital stock) from the Directorate General of Budget Accounting and Statistics of Taiwan.

[19] 633 firms with domestic manufacturing sectors are observed over the 3 years, while 583 firms with domestic R&D sectors are observed over the same period, and 522 firms with both manufacturing and R&D sectors are observed over the same period.

Table 4-1 Share of the Sum of the Sample Output

Year	Sales (NT$ 1 billion in 2001 price)		[C] = [A]/[B]	Number of firms [D]
	Sample [A]	Manufacturing total [B]		
2001	2463.59 (2484.00)	8404.60	29.31% (29.56%)	692 (658)
2002	2263.51 (2284.71)	9079.42	24.93% (25.16%)	678 (654)
2003	2696.47 (2618.16)	9657.51	27.92% (27.11%)	666 (643)

Figures with and without parenthesis are from the sample with firms with domestic manufacturing and R&D sectors, respectively (Except column [B]).

5 Model

Since the employment status is classified into shortage, balance, or surplus, there are two different ways of analyzing the dependent variable y_{it}. Let us denote firm i's shortage in manufacturing (or R&D) employees in year t by y_{it}^* (y_{it}^* is unobservable). When $y_{it}^* > 0$, it has an incentive to hire more employee. Otherwise, it might want to lay off some employees (or at least not to hire more employees). Thus, one can apply the binary choice model with the following correspondence:

$$y_{it} = \begin{cases} 1 & \text{(shortage)} & \text{if and only if} & y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} > 0 \\ 0 & \text{(balance or surplus)} & \text{if and only if} & y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \leq 0 \end{cases} \tag{1}$$

The drawback of (1) is that it cannot distinguish the employment status "surplus" from "balance". As a result, one can set up the following three-alternative ordered model:

$$y_{it} = \begin{cases} 1 & \text{(shortage)} & \text{if and only if} & \gamma_0 < y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \leq \gamma_1 \\ 0 & \text{(balance)} & \text{if and only if} & \gamma_{-1} < y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \leq \gamma_0 \\ -1 & \text{(surplus)} & \text{if and only if} & \gamma_{-2} < y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \leq \gamma_{-1} \end{cases} \tag{2}$$

In (2), $\gamma_{-2} = -\infty$ and $\gamma_1 = \infty$. Also, note that $\gamma_{-1} < \gamma_0$, which means that there is a range for y_{it}^* which corresponds to the status "balance". However, this characteristic could be the drawback of applying the ordered model in this case.[20] Since the binary choice model and the three-alternative ordered model have their own advantage and limitation, in this paper, both of them will be adopted.

In both models, x_{it} is the $K \times 1$ vector of independent variables, while α_i represents the unobserved individual specific effect. Based on section II, the independent variables should include at least the proportion of foreign output and the location of the foreign affiliate. (In order to utilize

[20] This is because usually, the balance (equilibrium) status of employment level for a firm corresponds to a single number.

the cheaper foreign labor, the multinationals might want to assemble their products in developing countries.) Luckily, they are both part of the available information. Other independent variables include: 1) total sales or total assets; 2) sum of domestic and foreign employees; 3) domestic and foreign investments; 4) domestic and foreign R&D expenses; 5) dummy variables for years; 6) dummy variables for industries; 7) motivation to be a multinational; and 8) whether the foreign affiliate uses the intermediates provided by the parent firm (and vice versa).

For a discrete choice model with panel data, pooled estimation fails to account for the individual specific effect. In a nonlinear model, this can lead to inconsistent estimates of β.[21] To solve this issue, the fixed effect and random effect models are proposed. However, not every fixed effect model can have a consistent estimator due to the incidental parameters problem (Neyman and Scott, 1948). For instance, there is no consistent estimator for a fixed effect probit model (Hsiao, 1986; Wooldridge, 2002).

Similarly, most fixed effect logit models are inconsistent. One exception is within the class of binary choice logit models. Anderson (1973) and Chamberlain (1980) suggest the conditional likelihood approach and apply it on the binary choice logit model. They demonstrate that the corresponding estimator is consistent. However, since this approach excludes those observations with $y_{it} = 1$ or $y_{it} = 0$ all the time, it is less efficient.[22]

Alternatively, in a random effect model, α_i is treated as a random disturbance term under the specified distribution. Since the logit model inherits more restriction from the multivariate logistic distribution, the probit model is more popular when considering the random effect model (Maddala, 1987). The random effect probit model assumes $\alpha_i \sim IN(0, \sigma_\alpha^2)$, $u_{it} \sim IN(0, \sigma_u^2)$, and both of them are mutually independent as well as independent of x_{it}.[23] By conditioning on the individual specific random disturbance term α_i, the joint density function can be decomposed, which simplifies the joint

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[21] See p.787 in Cameron and Trivedi (2005).
[22] Since discarding those observations could result in greater standard errors and thus insignificant estimates especially when the sample size is not that large (Allison, 2008).
[23] See Heckman and Willis (1976).

probability and makes the log-likelihood function only involve a single integration over α_i. Thus, the corresponding estimator becomes computationally feasible.[24]

In short, since: 1) for the binary choice model, when applying the fixed effect estimation in MOEA's data, the conditional likelihood approach will discard about two-thirds of the observations, which is a great loss of efficiency; 2) for the three-alternative ordered model, the random effect probit model is the most appropriate setting as explained above; and 3) for both models, this paper has included the dummy variable for different industries and that for different years to control for the industry-specific and year-specific fixed effects, respectively. Thus, this paper will adopt the random effect probit estimation to estimate both models (1) and (2).

[24] See Butler and Moffitt (1982).

6 Empirical Results

To find whether the multinationals' foreign production activities result in job-exportation, this section uses the MOEA's survey from 2001 to 2003 to investigate the impacts on domestic manufacturing and R&D employees, respectively. The definitions of the variables are shown in Table 6-1.

Table 6-2 shows that: 1) the average foreign production ratio (i.e., proportion of foreign output to global output) is around one third and demonstrates an increasing trend; 2) more and more Taiwanese multinationals engage in foreign production activities in developing countries (77% of them do so in 2001 and that proportion increases to 81% in 2003); 3) multinationals in the sample are large firms in terms of the number of global employees.[25]

Table 6-3 reveals that: 1) firms are more likely to report shortages in R&D employees rather than shortages in manufacturing employees; and 2) firms with higher foreign production ratios are more likely to report "surplus" in their domestic manufacturing employees (i.e., there exists a negative correspondence between foreign production ratio and domestic manufacturing employment), while for firms with domestic R&D employees, the extent of this negative correspondence (in terms of percentage change) is much smaller.

Let us consider the impact on domestic manufacturing employees first. This paper includes the 692, 678, and 666 multinationals which have domestic manufacturing sectors in 2001, 2002, and 2003, respectively. Thus, there will be 2036 observations in the imbalanced panel. In Table 6-4, models M-1 and M-2 are random effect probit estimations with binary choice settings, while M-3 and M-4 apply the random effect probit estimations with three-alternative ordered settings. Year dummies have been included to control for the year fixed effect through M-1 to M-4.

The main findings are as follows. First, in M-1 and M-2, the coefficients of the industry dummy

[25] According to MOEA's classification, large enterprises are those with 200 or more employees.

f_liv are not significant, which implies that the multinationals in "light industries" are less likely to report shortages in manufacturing employees than those in "heavy industries" or high-tech sectors.[26] In M-3 and M-4, none of the coefficients of industry dummies are significant. Nevertheless, although the coefficients of f_inf and f_liv in M-3 and M-4 are all negative, the coefficients of f_liv are larger in terms of absolute values. These findings suggest that the situation of job-exportation is more likely to happen to multinationals in light industries.

Second, the coefficients of the variable f_fpr are negative and significant in M-1 and M-2 (in M-3 and M-4, they are negative but not significant). These findings suggest that increasing the proportion of foreign output, as expected, has negative impact on domestic manufacturing employees. This confirms the common worry about job-exportation in the manufacturing sectors.

Third, when the multinationals increase the domestic investment, it could have a positive impact on domestic manufacturing employees, as suggested by the positive and significant coefficients of the variable i_dom in M-1 and M-2. (In models M-3 and M-4, they are positive but not significant.)

Fourth, to control for the size of the multinational, this paper uses either total sales (M-1 and M-3) or total assets (M-2 and M-4). The corresponding coefficients are all negative, while only the coefficient of f_tas in M-2 (binary choice model) is significant. This sample evidence suggests that in Taiwan, larger multinationals might be less likely to hire new manufacturing employees.

Finally, the coefficients for the variables v_tpi and v_fpi are both insignificant, which suggests that whether there is trade in intermediates does not significantly affect the domestic employment in manufacturing sectors. Nevertheless, these results might reflect the deficiency of the data since both v_tpi and v_fpi are only binary-value variables.

Let us investigate the impact on domestic R&D employees. This paper includes the 658, 654, and 643 multinationals which have domestic R&D sectors in 2001, 2002, and 2003, respectively. Thus,

[26] In this paper, light industries include the following industries: 1) Food; 2) Tobacco; 3) Textile; 4) Apparel; 5) Wood and bamboo product; 6) Furniture and fixture; and 7) Non-metallic mineral products manufacturing. Heavy industries include: 1) Metal; 2) Machinery; and 3) Transportation equipment industries. High-tech sectors include: 1) Computer; 2) Electronic parts and components; and 3) Electrical machinery industries.

there will be 1955 observations in the imbalanced panel. In Table 6-5, models R-1 and R-2 are random effect probit estimations with binary choice settings, while R-3 and R-4 apply the random effect probit estimations with three-alternative ordered settings. Year dummies have been included to control for the year fixed effect through R-1 to R-4. The main findings are as follows.

First, in Taiwan, smaller multinationals might be more active in R&D activities, as suggested by the negative and significant coefficients for f_sal and f_tas in models R-1 and R-2. (In models R-3 and R-4, the coefficients are negative but not significant.)

Second, multinationals in high-tech sectors are most likely to report shortages in R&D employees. This shows that although compared to other manufacturing sectors, multinationals in high-tech sectors have, on average, even higher foreign production ratios (as shown in Table 2-1), these multinationals are still looking for more skilled labor domestically. This could suggest that multinationals in high-tech sectors are more likely to carry out different production stages in different countries.

Third, although shifting production activities abroad also has a negative impact on domestic R&D employees, most of this negative impact will be nullified if multinationals also engage in foreign production activities in developing countries, as suggested by the coefficients of the variable for foreign production ratio (f_fpr) and the interaction term of f_fpr and dummy for developing countries (f_ing). These results are quite consistent from the estimates of R-1 through R-4 and could suggest a geographical fragmentation of manufacturing and R&D activities.

Other results are quite similar for the case of manufacturing employees. For example, the coefficients for trade in intermediates are still insignificant. This could suggest that in Taiwan, most skilled employees are engaging in providing R&D related services rather than producing tangible intermediates for the foreign affiliates. Of course, these results might reflect the deficiency of the data as in the cases for models M-1 through M-4 for manufacturing employees.

In short, the above findings provide some evidence that multinationals tend to fragment the production activities such that the more skilled labor intensive activities, like R&D, are kept in

Taiwan, while other production activities are gradually moved abroad. These findings conform to the implication from the knowledge capital model, which predicts that for a small and skilled-labor abundant country (in a relative sense) like Taiwan, the vertical multinationals headquartering at home and producing abroad would be the prevalent type of organization provided that the trade cost is not too high.

Table 6-1 Definition of the Variables

Dependent variable		
d_man	:	Model 1: = 1 if the firm has a shortage in domestic manufacturing employees; = 0 otherwise. Model 2: = -1 if the firm has a surplus in domestic manufacturing employees; = 0 if the firm's domestic manufacturing employment status is balance; = 1 if the firm has a shortage in domestic manufacturing employees.
d_rea	:	Model 1: = 1 if the firm has a shortage in domestic R&D employees; = 0 otherwise. Model 2: = -1 if the firm has a surplus in domestic R&D employees; = 0 if the firm's domestic R&D employment status is balance; = 1 if the firm has a shortage in domestic R&D employees.
Independent variables		
f_sal	:	Total sales
f_tas	:	Total assets
f_met	:	= 1 if the firm belongs to Metal, Machinery, or Transportation Equipment industry = 0 otherwise
f_inf	:	= 1 if the firm belongs to Computer, Electronic Parts and Components, and Electrical Machinery industry = 0 otherwise
f_liv	:	= 1 if the firm belongs to Food, Tobacco, Textile, Apparel, wood and bamboo product, Furniture and Fixture, Non-Metallic Mineral Products Manufacturing industry = 0 otherwise
f_ing	:	= 1 if the foreign affiliate locates at a developing country (China, Indonesia, Malaysia, Philippine, Thailand, Vietnam, and Other South Asia countries) = 0 otherwise
f_fpr	:	Proportion of foreign output (Foreign output / Total output)
m_exp	:	= 1 if the firm has the market expansion motivation to engage in foreign production = 0 otherwise
m_cos	:	= 1 if the firm has the cost-saving motivation to engage in foreign production = 0 otherwise
i_fdi	:	Amount of foreign investment
i_dom	:	Amount of domestic investment
r_for	:	R&D expenditures by the foreign affiliate
r_dom	:	R&D expenditures in the home country
v_tpi	:	= 1 if the foreign affiliate uses intermediates produced by parent firm in Taiwan = 0 otherwise
v_fpi	:	= 1 if the parent firm uses intermediates produced by foreign affiliate = 0 otherwise
γ_{-1}	:	Lower bound of the interval for y_{it} which corresponds to the "balance" status
γ_0	:	Upper bound of the interval for y_{it} which corresponds to the "balance" status

Table 6-2 Summary Statistics

		2001	2002	2003
Statistics for firms with domestic manufacturing sectors. Figures without (with) the parenthesis are the means (standard errors).				
	Number of observations	692	678	666
d_man	($\underline{s} = 1$; b or $\bar{s} = 0$)[27]	0.1012(0.3018)	0.0855(0.2799)	0.1607(0.3675)
	($\underline{s} = 1$; $b = 0$; $\bar{s} = -1$)	-0.0145(0.4657)	-0.0029(0.4175)	0.0976(0.4632)
f_tas	(billion NT$)	5.4425(28.3819)	4.7059(19.0206)	4.9245(19.5711)
f_sal	(billion NT$)	3.5601(25.0884)	3.3385(14.0921)	4.0488(19.4777)
f_met	(yes = 1; no = 0)	0.2645(0.4414)	0.2684(0.4435)	0.2733(0.4460)
f_inf	(yes = 1; no = 0)	0.3584(0.4799)	0.3599(0.4803)	0.3694(0.4830)
f_liv	(yes = 1; no = 0)	0.1850(0.3886)	0.1814(0.3856)	0.1622(0.3689)
f_ing	(yes = 1; no = 0)	0.7789(0.4153)	0.7994(0.4007)	0.8138(0.3895)
f_fpr	(proportion)	0.3379(0.3719)	0.3313(0.3684)	0.3615(0.3943)
m_exp	(yes = 1; no = 0)	0.6734(0.4693)	0.6519(0.4767)	0.6682(0.4712)
m_cos	(yes = 1; no = 0)	0.6402(0.4803)	0.6209(0.4855)	0.1021(0.3030)
i_fdi	(billion NT$)	0.1595(1.0684)	0.1625(1.0526)	0.1133(0.7946)
i_dom	(billion NT$)	0.9017(6.5905)	0.6733(3.7277)	0.2067(1.6157)
r_for	(billion NT$)	0.0053(0.0307)	0.0064(0.0361)	0.0089(0.0797)
r_dom	(billion NT$)	0.0600(0.4115)	0.0652(0.4073)	0.0662(0.2880)
v_tpi	(yes = 1; no = 0)	0.1503(0.3576)	0.1298(0.3363)	0.1306(0.3372)
v_fpi	(yes = 1; no = 0)	0.0665(0.2493)	0.0487(0.2153)	0.0495(0.2172)
Global employees (1000 people)		1.2222(9.3691)	0.6015(1.3107)	0.8369(2.0924)
Statistics for firms with domestic R&D sectors.				
	Number of observations	658	654	643
d_rea	($\underline{s} = 1$; b or $\bar{s} = 0$)	0.3252(0.4688)	0.3058(0.4611)	0.3235(0.4682)
	($\underline{s} = 1$; $b = 0$; $\bar{s} = -1$)	0.3055(0.5021)	0.2890(0.4894)	0.3173(0.4790)
f_tas	(billion NT$)	5.7120(29.0805)	4.8640(19.3411)	4.6084(16.5216)
f_sal	(billion NT$)	3.7751(25.7181)	3.4934(14.3369)	4.0718(18.7571)
f_met	(yes = 1; no = 0)	0.2401(0.4275)	0.2431(0.4293)	0.2473(0.4318)
f_inf	(yes = 1; no = 0)	0.4149(0.4931)	0.4021(0.4907)	0.4199(0.4939)
f_liv	(yes = 1; no = 0)	0.1687(0.3748)	0.1636(0.3702)	0.1400(0.3472)
f_ing	(yes = 1; no = 0)	0.7690(0.4218)	0.7936(0.4050)	0.8103(0.3924)
f_fpr	(proportion)	0.3442(0.3768)	0.3559(0.3830)	0.3940(0.4044)
m_exp	(yes = 1; no = 0)	0.6657(0.4721)	0.6391(0.4806)	0.6563(0.4753)
m_cos	(yes = 1; no = 0)	0.6429(0.4795)	0.6361(0.4815)	0.1089(0.3117)
i_fdi	(billion NT$)	0.1690(1.0968)	0.1670(1.0707)	0.1106(0.7886)
i_dom	(billion NT$)	0.9411(6.7560)	0.6884(3.7934)	0.1967(1.5897)
r_for	(billion NT$)	0.0057(0.0315)	0.0068(0.0367)	0.0097(0.0811)
r_dom	(billion NT$)	0.0640(0.4217)	0.0686(0.4144)	0.0676(0.2788)
v_tpi	(yes = 1; no = 0)	0.1520(0.3593)	0.1300(0.3365)	0.1306(0.3373)
v_fpi	(yes = 1; no = 0)	0.0608(0.2391)	0.0489(0.2159)	0.0513(0.2208)
Global employees (1000 people)		1.3016(9.6096)	0.6414(1.3447)	0.8932(2.0789)
1 US$	=	35.00 NT$	34.75 NT$	33.98 NT$

27 $\underline{s}$ = shortage; b = balance; $\bar{s}$ = surplus.

Table 6-3 Means of Dependent Variables Conditional on Different Foreign Production Ratios

	2001	2002	2003
Number of observations with domestic manufacturing sector	692	678	666
$\text{d\_man}\mid[\text{f\_fpr} \leq \text{f\_fpr}_{\text{median}}]$	0.0170	0.0268	0.1586
$\text{d\_man}\mid[\text{f\_fpr} > \text{f\_fpr}_{\text{median}}]$	-0.0472	-0.0322	0.0288
Number of observations with domestic R&D sector	658	654	643
$\text{d\_rea}\mid[\text{f\_fpr} \leq \text{f\_fpr}_{\text{median}}]$	0.3091	0.3013	0.3622
$\text{d\_rea}\mid[\text{f\_fpr} > \text{f\_fpr}_{\text{median}}]$	0.3018	0.2778	0.2719

Table 6-4 The Impact on Manufacturing Employees

Dependent variable : d_man ; Number of firms (in 2001; 2002; 2003) = (692; 678; 666) Random effect probit with: (1) Binary choice (M-1 and M-2); (2) Three-ordered (M-3 and M-4)				
Model:	M- 1	M- 2	M- 3	M- 4
f_sal	-0.0128		-0.0050	
	(0.0107)		(0.0037)	
f_tas		-0.0235 *		-0.0038
		(0.0124)		(0.0028)
f_met	0.5485 ***	0.5417 ***	0.0623	0.0579
	(0.2030)	(0.2027)	(0.1261)	(0.1261)
f_inf	0.3722 *	0.3674 *	-0.0095	-0.0113
	(0.1985)	(0.1986)	(0.1208)	(0.1207)
f_liv	0.2757	0.2864	-0.0550	-0.0534
	(0.2244)	(0.2245)	(0.1382)	(0.1381)
f_ing	-0.1032	-0.0980	-0.1145	-0.1199
	(0.1924)	(0.1923)	(0.1307)	(0.1306)
f_fpr	-0.7063 *	-0.7023 *	-0.3182 [p = 0.2080]	-0.3262 [p = 0.1970]
	(0.4203)	(0.4198)	(0.2528)	(0.2527)
f_fpr × f_ing	0.3272 [p = 0.4670]	0.3067 [p = 0.4950]	0.0363 [p = 0.8950]	0.0392 [p = 0.8870]
	(0.4497)	(0.4496)	(0.2749)	(0.2748)
m_exp	-0.1926	-0.1892	-0.0695	-0.0698
	(0.1175)	(0.1175)	(0.0802)	(0.0802)
m_cos	0.0731	0.0754	-0.0704	-0.0708
	(0.1311)	(0.1314)	(0.0871)	(0.0871)
i_fdi	-0.0889	-0.0172	-0.0456	-0.0338
	(0.1119)	(0.1212)	(0.0600)	(0.0619)
i_dom	0.0441 **	0.0671 **	0.0157	0.0172
	(0.0204)	(0.0262)	(0.0122)	(0.0124)
r_for	2.5792	1.7756	0.9552	0.2490
	(2.5212)	(1.8054)	(1.0265)	(0.8999)
r_dom	-0.6591	-0.4185	-0.0320	-0.0093
	(0.5481)	(0.5866)	(0.1432)	(0.1475)
v_tpi	-0.0046	-0.0001	0.0884	0.0917
	(0.1707)	(0.1707)	(0.1135)	(0.1136)
v_fpi	0.0618	0.0671	0.1717	0.1796
	(0.2536)	(0.2541)	(0.1751)	(0.1749)
γ_{-1}			-1.8200 ***	-1.8300 ***
			(0.1709)	(0.1708)
γ_0			1.4147 ***	1.4047 ***
			(0.1694)	(0.1692)
Log-likelihood =	-656.8940	-655.1272	-1239.3660	-1239.5357
LR test for $H_0: \beta = 0$ p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001

***(**;*): Significant at 1% (5%; 10%) level. Year dummies (not shown above) have been included.

Table 6-5 The Impact on R&D Employees

Dependent variable : d_rea ; Number of firms (in 2001; 2002; 2003) = (658; 654; 643)
Random effect probit with: (1) Binary choice (R-1 and R-2); (2) Three-ordered (R-3 and R-4)

Model:	R- 1	R- 2	R- 3	R- 4
f_sal	-0.0151 *		-0.0040	
	(0.0077)		(0.0031)	
f_tas		-0.0143 **		-0.0047
		(0.0065)		(0.0030)
f_met	0.3441 *	0.3362 *	0.2840 *	0.2770 *
	(0.1789)	(0.1791)	(0.1541)	(0.1541)
f_inf	0.6310 ***	0.6329 ***	0.4994 ***	0.4970 ***
	(0.1687)	(0.1690)	(0.1440)	(0.1440)
f_liv	-0.0625	-0.0448	-0.0762	-0.0736
	(0.2005)	(0.2009)	(0.1704)	(0.1704)
f_ing	0.0988	0.0929	0.0612	0.0570
	(0.1750)	(0.1748)	(0.1530)	(0.1528)
f_fpr	-0.8238 **	-0.8533 **	-0.7023 **	-0.7118 **
	(0.3483)	(0.3478)	(0.2899)	(0.2899)
f_fpr × f_ing	0.6396 *	0.6511 *	0.5557 *	0.5596 *
	(0.3710)	(0.3708)	(0.3123)	(0.3123)
m_exp	-0.0471	-0.0444	-0.0628	-0.0611
	(0.1024)	(0.1025)	(0.0912)	(0.0913)
m_cos	0.1174	0.1227	0.0167	0.0178
	(0.1074)	(0.1076)	(0.0962)	(0.0962)
i_fdi	-0.1431	-0.1235	-0.1229 *	-0.1048
	(0.0950)	(0.0969)	(0.0679)	(0.0688)
i_dom	0.0353 *	0.0462 **	0.0116	0.0145
	(0.0207)	(0.0229)	(0.0139)	(0.0140)
r_for	3.3005 *	1.7349	1.1792	0.6422
	(1.7440)	(1.2890)	(1.1000)	(1.0295)
r_dom	-0.3757	-0.2878	0.0009	0.0438
	(0.3096)	(0.3198)	(0.1522)	(0.1582)
v_tpi	-0.0330	-0.0308	-0.0103	-0.0058
	(0.1448)	(0.1451)	(0.1287)	(0.1288)
v_fpi	-0.1712	-0.1560	-0.1309	-0.1235
	(0.2257)	(0.2268)	(0.2019)	(0.2020)
γ_{-1}			-2.9582 ***	-2.9722 ***
			(0.2294)	(0.2295)
γ_0			0.8653 ***	0.8554 ***
			(0.1944)	(0.1942)
Log-likelihood =	-1086.0948	-1085.3720	-1152.4499	-1231.7708
LR test for $H_0: \beta = 0$ p-value	= 0.0003	= 0.0002	= 0.0001	= 0.0029

***(**;*): Significant at 1% (5%; 10%) level. Year dummies (not shown above) have been included.

7 Conclusion

While the relocation of production processes by multinationals might yield higher productivity, there is a serious concern that it could also hurt domestic non-skilled workers. This has been confirmed by many studies on more developed countries; however, little research has focused on less developed countries. This paper tries to bridge this gap by using the data about Taiwanese multinationals, which are also active participants in foreign production activities.

Before the empirical research, this paper borrows the theoretical considerations from the knowledge capital model, which infers that for a small and skilled labor abundant country like Taiwan, the vertical multinational, which is domestically headquartered and produces abroad, would be the prevalent type of organization, provided that the trade cost is not a dominant factor (As mentioned in Section 2, trade cost between Taiwan and China is not overly high since 1990). Based on this argument, skilled workers could survive or even benefit from the division of labor while non-skilled labor could suffer in the meantime. The prima facie evidence from the industry-level regression does suggest that in Taiwan, the non-skilled labor intensive jobs are more likely to be carried out abroad, while the skilled labor intensive jobs tend to be done domestically.

The above argument is further confirmed by the firm-level survey data for the Taiwanese multinationals. More specifically, this paper finds that while there is no significant evidence showing that less skilled workers, like manufacturing employees, would be harmed if multinationals engage in foreign production activities in developing countries, they do suffer from the multinationals' increasing proportion of foreign output.

For more skilled workers like those in the R&D sectors, this paper finds that although shifting production activities abroad also has a negative impact on domestic R&D employees, most of this negative impact will be nullified if multinationals also engage in foreign production activities in developing countries.

Since over 75% of Taiwanese multinationals engage in foreign production activities in developing countries, the above findings suggest that non-skilled employees are more likely to be harmed compared to the situation of skilled employees, which provides some evidence of the division of labor suggested by the knowledge capital model.

More extension and refinement of this kind of study could be done in the future. For example, although this paper does consider whether the parent firm produces the intermediates for the foreign affiliate (and vice versa), due to the limitations of the data, the exact trade volume in these intermediates is not considered. Obviously, more accurate data on trade in intermediates would allow researchers to make better estimates.

Furthermore, in this paper, the sample is composed of relatively large multinationals. However, there are also many smaller firms that are headquartered domestically and moving their production activities abroad. Although the empirical evidence of this paper suggests that larger multinationals are less likely to hire new manufacturing labor, some anecdotal evidence from Taiwan shows that for the smaller multinationals not considered in this paper, the proportion of foreign output could be higher and thus the negative impact on domestic manufacturing employees could be stronger. If that is the case, this paper would underestimate the aforementioned negative impact.

Another point is that the only available dependent variable is simply the firm's assessment of its employment status. However, besides the issue that there could be other causes that might result in shortage or surplus of a firm's employment, as mentioned in Section 4, it is also plausible that a firm which reports the status "balance" for a specific kind of employee has already laid off or recruited some employees ex ante. Apparently, using the exact number of employees as the dependent variable would yield better estimates.

Finally, in Taiwan, despite the promising economic growth figures in recent years, many people have kept complaining that their salaries are almost stagnant. It seems that the economic improvement is only enjoyed by a small group of people, especially the most skilled employees who work in the high-tech sectors. In fact, this can be verified by the worsening income distribution in

Taiwan during recent years.

Many empirical studies for other countries have found that the multinationals' foreign production activities could have a negative impact on the wage rates of domestic employees.[28] Thus, in addition to studying the impact on domestic employment, the impact on wages is also worth investigating. However, although there are industry-level wage data for different categories of employees, there are no firm-level counterparts in MOEA's survey. More comprehensive surveys shall definitely benefit future studies.

[28] For example, see Feenstra and Hanson (1996; 2001), Hsieh and Woo (2005), and Goldberg and Pavcnik (2007).

Appendix

A-01 Random Effect Probit Estimation with Binary Choice Model

Let us consider the following binary choice model with x_{it} being the $K \times 1$ vector of independent variables and α_i representing the unobserved individual specific effect

$$y_{it} = \begin{cases} 1 & \text{(shortage)} & \text{if and only if} & y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} > 0 \\ 0 & \text{(balance or surplus)} & \text{if and only if} & y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \le 0 \end{cases} \quad \text{(A01)}$$

In a random effect probit setting, α_i is a random disturbance term under a normal distribution. By integrating over that distribution, α_i can be cancelled out. Let us follow the assumption by Heckman and Willis (1976) such that in (A01): 1) $\alpha_i \sim IN(0, \sigma_\alpha^2)$; 2) $u_{it} \sim IN(0, \sigma_u^2)$; and 3) both of them are mutually independent as well as independent of x_{it}.[29] Let us reformulate (A01) as:

$$y_{it} = \begin{cases} 1 & \text{(shortage)} & \text{if and only if} & y_{it}^* = x_{it}'\beta + \epsilon_{it} > 0 \\ 0 & \text{(balance or surplus)} & \text{if and only if} & y_{it}^* = x_{it}'\beta + \epsilon_{it} \le 0 \end{cases} \quad \text{(A02)}$$

where $\epsilon_{it} = \alpha_i + u_{it} \sim N(0, \sigma^2)$ with $\sigma^2 = \sigma_\alpha^2 + \sigma_u^2$. The joint probability becomes:

$$P(y_{i1}, y_{i2}, y_{i3}) = \int_{a_{i1}}^{b_{i1}} \int_{a_{i2}}^{b_{i2}} \int_{a_{i3}}^{b_{i3}} f(\epsilon_{i1}, \epsilon_{i2}, \epsilon_{i3}) d\epsilon_{i3} d\epsilon_{i2} d\epsilon_{i1} \quad \text{(A03)}$$

where $a_{it} = -x_{it}'\beta$ and $b_{it} = \infty$ if $y_{it} = 1$ and $a_{it} = -\infty$ and $b_{it} = -x_{it}'\beta$ if $y_{it} = 0$. Following the approach proposed by Butler and Moffitt (1982), when conditioning on the random disturbance term α_i, the joint density function in (A03) can be decomposed into (A04) since $\epsilon_{it}|\alpha_i$ and $\epsilon_{is}|\alpha_i$ $(t \neq s)$ are independent:[30]

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29 See Maddala (1987).

30 Note that the variances of $\epsilon_{it}|\alpha_i$ and $\epsilon_{is}|\alpha_i$ only come from the contributions of u_{it} and u_{is}, respectively, and u_{it} and u_{is} are independent by assumption.

$$f(\epsilon_{i1}, \epsilon_{i2}, \epsilon_{i3}) = f(\alpha_i) f(\epsilon_{i1}, \epsilon_{i2}, \epsilon_{i3} | \alpha_i) = f(\alpha_i) f(\epsilon_{i1} | \alpha_i) f(\epsilon_{i2} | \alpha_i) f(\epsilon_{i3} | \alpha_i) \tag{A04}$$

This implies (A03) can be expressed as:

$$\begin{aligned} P(y_{i1}, y_{i2}, y_{i3}) &= \int_{-\infty}^{\infty} f(\alpha_i) \int_{a_{i1}}^{b_{i1}} f(\epsilon_{i1} | \alpha_i) d\epsilon_{i1} \int_{a_{i2}}^{b_{i2}} f(\epsilon_{i2} | \alpha_i) d\epsilon_{i2} \int_{a_{i3}}^{b_{i3}} f(\epsilon_{i3} | \alpha_i) d\epsilon_{i3} \, d\alpha_i \\ &= \int_{-\infty}^{\infty} \prod_{t=1}^{3} [F(b_{it} | \alpha_i) - F(a_{it} | \alpha_i)] \, f(\alpha_i) \, d\alpha_i \end{aligned} \tag{A05}$$

Thus, the log-likelihood function becomes:

$$\ln L = \sum_{i=1}^{N} \ln\left\{ \int_{-\infty}^{\infty} \prod_{t=1}^{3} [F(b_{it} | \alpha_i) - F(a_{it} | \alpha_i)] \, f(\alpha_i) \, d\alpha_i \right\} \tag{A06}$$

A-02 Random Effect Probit Estimation with 3-Alternative Ordered Model

Let us consider the following three-alternative ordered model:

$$y_{it} = \begin{cases} 1 & \text{(shortage) if and only if} \quad \gamma_0 < y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \leq \gamma_1 \\ 0 & \text{(balance) if and only if} \quad \gamma_{-1} < y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \leq \gamma_0 \\ -1 & \text{(surplus) if and only if} \quad \gamma_{-2} < y_{it}^* = \alpha_i + x_{it}'\beta + u_{it} \leq \gamma_{-1} \end{cases} \tag{A07}$$

Note that in the above expression, $\gamma_{-2} = -\infty$ and $\gamma_1 = \infty$. Let us follow the assumption by Heckman and Willis (1976) such that in (A07): 1) $\alpha_i \sim IN(0, \sigma_\alpha^2)$; 2) $u_{it} \sim IN(0, \sigma_u^2)$; and 3) both of them are mutually independent as well as independent of x_{it}. Let us denote the probability that firm i chooses alternative j = J (J= $-1; 0; 1$) in year t by $P(y_{it} = J)$ and reformulate (A07) as:

$$y_{it} = \begin{cases} 1 & \text{(shortage) if and only if} \quad \gamma_0 < y_{it}^* = x_{it}'\beta + \epsilon_{it} \le \gamma_1 \\ 0 & \text{(balance) if and only if} \quad \gamma_{-1} < y_{it}^* = x_{it}'\beta + \epsilon_{it} \le \gamma_0 \\ -1 & \text{(surplus) if and only if} \quad \gamma_{-2} < y_{it}^* = x_{it}'\beta + \epsilon_{it} \le \gamma_{-1} \end{cases} \quad \text{(A08)}$$

where $\epsilon_{it} = \alpha_i + u_{it} \sim N(0, \sigma^2)$ with $\sigma^2 = \sigma_\alpha^2 + \sigma_u^2$. Then, we have:

$$P(y_{it} = J) = F(\gamma_J - x_{it}'\beta) - F(\gamma_{J-1} - x_{it}'\beta) \quad \text{(A08)}$$

where $F(\cdot)$ is the c.d.f. of ϵ_{it}. Note that for the same firm, the choices of different years are correlated since ϵ_{i1}; ϵ_{i2}; ϵ_{i3} are correlated because of the presence of α_i. Thus, we need to use the approach proposed by Butler and Moffitt as in the binary choice case. Let us consider the conditional joint probability $P(y_{i1}, y_{i2}, y_{i3}|\alpha_i)$. Since $\epsilon_{i1}|\alpha_i$; $\epsilon_{i2}|\alpha_i$; $\epsilon_{i3}|\alpha_i$ are independent, we have:

$$P(y_{i1}, y_{i2}, y_{i3}|\alpha_i) = \prod_{t=1}^{3} P(y_{it} = j|\alpha_i) \quad \text{(A08)}$$

After integrating over α_i, we have:

$$P(y_{i1}, y_{i2}, y_{i3}) = \int_{-\infty}^{\infty} [\prod_{t=1}^{3} P(y_{it} = j|\alpha_i)] f(\alpha_i) d\alpha_i \quad \text{(A09)}$$

Thus, the log-likelihood function becomes:

$$\ln L = \sum_{i=1}^{N} \ln\left\{\int_{-\infty}^{\infty} [\prod_{t=1}^{3} P(y_{it} = j|\alpha_i)] f(\alpha_i) d\alpha_i\right\} \quad \text{(A10)}$$

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