Foreign Ownership and Energy Efficiency in Thailand's Local Manufacturing Plants

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Abstract

This paper examines the correlations of between shares of foreign multinational enterprises (MNEs) in Thai manufacturing industries and energy efficiency in local Thai plants using data on medium-large plants from the industrial census for 2006. At the industry level, descriptive statistics suggested that MNE presence was negatively correlated with energy intensities in local plants. However, after accounting for the influences of plant-level factor usage and technical characteristics, correlations between MNE presence and energy intensities in local plants were generally positive. In other words, the econometric evidence presented here suggests that MNE presence generally leads local plants to be less energy intensive. However, this result is not robust and depends critically on the sample of industries examined, the level of aggregation used when defining MNE shares, and the variable (labor or output) used to measure MNE shares.

Keywords: multinational enterprise, energy efficiency, spillover, Thailand, manufacturing
JEL Categories: F23, L60, O53, Q40
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1. Introduction

This paper asks whether the extent of foreign multinational enterprise (MNE) presence in Thailand's manufacturing industries is correlated with energy efficiency in medium-large, local plants covered by the Thai manufacturing census for 2006. In this context, energy efficiency is defined as the ratio of purchased energy (electricity and fuel) to gross output, and does not consider energy produced by plants or abatement efforts. Answering this question is important because energy consumption is usually the largest ultimate source of portion of air pollution generated by manufacturing plants. Greater energy conservation generally implies increased energy efficiency and is an important way to limit or reduce related pollution, especially in developing economies like Thailand where environmental regulations are relatively lax and pollution abatement efforts relatively limited. Moreover, much of the more advanced energy saving technology in the world is controlled by MNEs and it is thus possible that the presence of foreign MNEs can affect how local plants or firms in host economies use energy through so-called intra-industry spillovers.

The paper first reviews literature analyzing productivity spillovers of MNEs and its implications for analysis of energy efficiency in local plants (Section 2). Second, it describes the database used and simple, industry-level correlations of foreign shares of labor and output to energy intensities (ratios of energy expenditures to output) in local plants (Section 3). It then analyzes whether correlations of MNE shares to local plant energy intensities persist after accounting for scale, other factor use, and plant-level technical characteristics that may energy intensities (Section 4). Section 5 concludes and indicates avenues of future research.

2. Energy Efficiency, Pollution Havens, and Environmental Impacts of MNEs

In recent years, theoretical analyses have highlighted the role of what have been called knowledge-based, intangible assets (terminology from Markusen 1991) in MNEs. The key goals of many theoretical analyses are to explain why the MNE chooses to invest abroad when it (at least) initially has several cost disadvantages compared to local firms, and why the MNE chooses to spread out production across countries rather than concentrate it in one location. Most observers agree that MNEs tend to possess relatively large amounts of technological knowledge and networks, marketing expertise and networks, especially international ones, and generally have relatively sophisticated and capable management.[1] The first two characteristics are evidenced by relatively high research and development (R&D) intensities (ratios to total sales), relatively large proportions of patent applications and approvals, relatively high advertising-sales ratios, and relatively high dependence on international trade (generally on both exports and imports). Correspondingly, when asking what makes a firm decide to assume the extra costs of investing in a foreign country (compared to the costs of local firms in the host), Dunning (1988) asserted that a firm must first have “ownership advantages” such as those afforded by possession of relatively large amounts intangible assets, as well as “location advantages” and “internalization advantages” before investing.[2]

The important implication is that, if one accepts the idea that MNEs have relatively large amounts of knowledge-based, intangible assets, MNEs will tend to be relatively efficient producers compared to non-MNEs, at least in some respect. They are also a potentially important source of spillovers that foster higher productivity in local firms. In this context, spillovers refer to the effects that foreign MNE presence has on local plants. These spillovers operate through at least three major channels.

The first channel is direct linkages between MNEs and local plants. Most often these are backward linkages created when MNEs source raw materials, parts, or services from local plants. In many cases, local plants are not able to produce the required materials, parts or

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[1] Caves (2007) and Dunning and Lundan (2008) provide thorough literature reviews. The work of Markusen (2002) has also been influential.

[2] Dunning’s OLI (ownership-location-internalization) paradigm has been influential, but others (Buckley and Casson 1992, Casson 1987, Rugman 1980, 1985) emphasize that the concept of internalization alone can explain the existence of the MNE and its characteristics.

services of acceptable quality and/or meet the logistic requirements of the MNE. And in many of these cases, MNEs will work closely with local suppliers to help them increase production capacity, improve quality, and meet the logistic requirements involved. The MNE may source inputs from local firms in the same industry or in different industries. In other cases, MNEs may create forward linkages to local firms by supplying intermediate goods (materials, parts, services) or final goods of superior quality. Here again MNEs may find it profitable to help the local firms involved improve their production processes or marketing efforts to better take advantage of the goods or services provided by the MNE. The literature and casual observation suggest that spillovers backward linkages are probably more common than forward linkages in most cases.

The second channel is labor mobility. MNEs often require workers that are relatively skilled and often seek to recruit them from local firms. Moreover, the relative shortage of skilled labor (middle-level technicians and managers) has created one of the most severe constraints affecting Southeast Asian economies, including Thailand. Thus, not only do MNEs attempt poach relatively scare, skilled workers from local plants, but local plants often try to poach workers from MNEs. Another group of workers work for an MNE and then realize their experience has given them the skills to become an entrepreneur and start their own firm. In some instances, the firms created by ex-MNE employees end up supplying parts, materials, and/or services to their old MNE employers. Here again, the spillovers can be either intra- or inter-industry, though they are probably more likely to be intra-industry, to the extent that skills are industry specific.

The third major channel is a demonstration or competition effect. The entry or expansion of foreign MNEs usually increases the competitive pressure on local plants producing goods or services that compete with those produced by the MNE. The increased competitive pressure can motivate local firms to increase their own competitiveness in various ways such as developing or upgrading technology, cutting input costs, or expanding marketing efforts.

This effect is predominantly intra-industry in nature, provided that industry definitions are broad enough to include competing firms or plants in the same industry.[3]

Much of the existing research on spillovers focuses on intra-industry productivity spillovers. In other words, these studies examine the effect MNE presence has on the productivity of local firms in the industry where the MNE operates. More recent studies have also examined inter-industry spillovers through forward and backward linkages. Several reviews emphasize that empirical evidence regarding productivity spillovers has been mixed (Görg and Stobl 2001; Fan 2002; Görg and Greenaway 2004; Lipsey and Sjöholm 2005; Pessoa 2007).[4] Previous studies of Asian economies also suggest that estimates of spillovers vary substantially depending on the economies and industry groups studied, the measure of foreign presence used (i.e., whether foreign shares are measured in terms of employment, output, or fixed assets, for example), and estimation methodology. In general, estimates of spillovers are larger when cross sectional methodologies are used, but recent studies generally use fixed effects estimators when panel data are available.[5]

The most comprehensive studies of spillovers in Thailand are cross section studies for the first census year, 1996, because studies using the 2006 census data are yet to appear. There are intermittent surveys for other years (e.g., 1998, 1999, 2000, 2002) but samples are much smaller than

[3] The presence of multi-product firms and plants, including many MNEs, creates substantial divergence between theory, which often assumes single-product, single-plant firms, and statistical compilations, which usually classify multi-product plants and firms by their largest product or service. In Thailand, there are several, large multi-product plants and multi-plant firms, both local and MNE, which makes this divergence of particular concern. Correspondingly, relatively narrow industry definitions (e.g., 4- or 5-digit level) probably create important outliers among these important, large, multi-product firms or plants.

[4] A recent meta-analysis by Mebratie and van Bergeijk (2013) argues that accounting for firm heterogeneity in terms of R&D and exporting changes many ambiguous results and provides stronger evidence of positive spillovers.

[5] In general, fixed effects panel estimates are preferred because they control for unobserved characteristics among local plants or firms and because they are less vulnerable simultaneity problems that may arise if MNEs are attracted to high productivity industries. However, fixed effects estimates address the question of how changes in foreign shares are related to changes in local firm or plant productivity, not the static question of whether large or small foreign presence affects productivity in local plants or firms.

in the census years and it is not possible to panelize the Thai industrial census and survey data. As will be detailed below, the Thai censuses also suffer from substantial duplication problems that make it difficult to estimate foreign presence (Ramstetter 2012) or spillovers reliably. For 1996, cross section, industry-level results from Kohpaiboon (2006a, 2006b) and firm-level results from Ramstetter (2004, 2006) suggested positive productivity spillovers from MNEs. Kohpaiboon's results suggested that spillovers were relatively strong in industries with relatively low protection. However, despite finding positive productivity spillovers, evidence from Ramstetter and several other studies reviewed in that paper indicated that productivity differentials between MNEs and local plants were generally insignificant. In contrast, Movshuk and Matusoka-Movshuk (2006) found evidence of positive wage spillovers in 1996 and evidence that significant and positive wage differentials between MNEs and non-MNEs were more common than corresponding productivity differentials. Using a more limited sample of manufacturing firms in 2001-03, Kohpaiboon (2009) finds positive horizontal spillovers in industries where import protection is relatively low. Sajarattanochote and Poon (2009) examine the geography of technology flows among a sample of MNEs in the Greater Bangkok area, finding evidence of limited regional spillovers to first- and second-order neighbors and large variation in technology transfers depending on nationality, sector, size, and age of the MNEs involved.

Some of the earliest research on spillovers from MNEs in Asian hosts examined Indonesia, because manufacturing surveys and censuses are rich and easily obtainable. For example, cross section evidence for 1980 and 1991 from Blomström and Sjöholm (1999) and Sjöholm (1997, 1999a, 1999b) indicated that productivity spillovers tended to be positive, and that spillovers tended to be relatively strong in industries where competition among local plants was relatively intense and within regions with diversified industrial structures; there was also some evidence that spillovers were relatively large in industries with large technological gaps between MNEs and local plants, but it was inconsistent, while the degree of foreign ownership, and geographical proximity did not affect the extent of spillovers. Subsequent, more rigorous, panel analysis for 1990-1995 (Takii 2005, 2006) revealed evidence positive intra-industry spillovers that were more prevalent in industries with small technical gaps and where minority foreign MNEs had relatively large shares. Similarly, Blalock and Gertler (2008) found strong evidence of productivity gains, greater competition, and lower prices among local firms in markets that supplied foreign entrants in 1988-2006. Suyanto et al. (2009) analyze spillovers chemical and pharmaceutical plants in 1998-2000, using a stochastic frontier approach and a generalized Malmquist output-oriented index to decompose productivity growth. Their results show positive productivity spillovers from FDI that are larger with higher competition and in local plants with R&D. Results from Lipsey and Sjöholm (2004, 2006) and Sjöholm and Lipsey (2006) also suggest the existence of positive wage spillovers; i.e., they indicate that local plants tended to pay relatively high wages in industries with large foreign presence. Their results also suggested that foreign takeovers led to higher wages in target plants, but that targeted firms were not necessarily high-wage plants before the takeover.

More recently, a number of studies also indicate positive productivity spillovers in China, but the details are again varied. Using industry level data, Buckley et al. (2007) find a curvilinear relationship with foreign direct investment from HMT (Hong Kong, Macau and Taiwan) firms, but not for other (Western) firms, which is most pronounced for low-technology host industries. In contrast, using a firm-level panel for 1998-2005, Lin et al (2009) find that HMT firms generated negative horizontal spillovers, while non-HMT firms tended to create positive horizontal spillovers. They also find strong and robust vertical spillover effects on both state-owned firms and non-state firms. Liu's (2008) evidence for 1995-1999 suggest that intra-industry spillovers are negative in the short term but positive in the long term, and that backward linkages seem to be the most important channel through which spillovers occur. Xu and Sheng's (2012) results for 2000-2003 indicate that positive spillovers arise from forward linkages where domestic firms purchase high-quality intermediate goods or equipment from foreign firms in upstream sectors, and that the extent of spillovers varies greatly among domestic firms. Meanwhile, Du et al (2012) find that non-HMT MNE presence had positive effects on all individual firm level productivity in 1998-2007, while HMT presence did not. They also find weak evidence of positive horizontal externalities and evidence of positive productivity spillovers to domestic firms via backward linkages to local suppliers in downstream as well as forward linkages to their local buyers in the upstream sectors. On the other hand, Galina and Long (2011) use over 6000 specifications that take into account forward and backward linkages, but fail to find evidence of systematic and positive productivity spillovers.

For Malaysia, Khalifah and Adam (2009) analyze a balanced panel for 2000-2004 using a simplified Cobb-Douglas specification (assuming constant returns to scale) and samples of all manufacturing plants combined. They find that productivity spillovers were positive when MNE presence is measured as the share of value added or fixed assets, but insignificant or negative when MNE presence is measured as the share of employment. Spillovers are also found to depend on the foreign ownership shares. Haji Ahmad (2010, Ch. 6) uses the same data set, a translog specification, and both balanced and unbalanced panels, again finding that evidence of significant spillovers was rare. Her results also examined several groups of manufacturing industries, finding that the results varied greatly depending on the industry group examined.

For Vietnam, Nguyen, T.T.A. et al (2006) examine four channels of potential spillovers, labor turnover, technology diffusion and transfer, production linkages, and competition. Their cross section, Cobb-Douglas estimates indicated that “there is little evidence of positive spillover effects at the firm level”, though there are also “no signs of negative spillover effect either” (p. 56). In contrast, Pham’s (2008) cross section, Cobb-Douglas estimates generally suggested positive spillovers that were largest in Hanoi and Ho Chi Minh City, and from MNEs that were not wholly-foreign. Combining firm-level data for 2000-2005 with the 2000 input-output table, Nguyen, P.L. (2008) estimates cross section Cobb Douglas functions finding that both horizontal and vertical spillovers were generally positive, and largest in more advanced regions and in more sophisticated local firms. In analysis using an unbalanced panel of the same data, Nguyen, N.A. et al. (2008) finds that backward, vertical spillovers were positive in manufacturing, while horizontal spillovers were positive in services. Le and Pomfret (2011) also use a similar approach to estimate spillovers in an unbalanced panel of all industrial firms (including mining and utilities) for 2000-2004, finding positive backward spillovers in manufacturing but negative horizontal spillovers, which were relatively strong on private firms, domestic-oriented firms, firms without R&D, and firms in low technology industries.[6] Translog estimates for 2000, 2002, and 2004 from Ramstetter and Phan (2008) also suggest the existence of positive spillovers from MNEs to private firms in cross sections, but Ramstetter and Phan (2013) find no significant spillovers in unbalanced panels. In sum, these results generally suggest some degree of positive spillovers, especially in cross sections, but results vary markedly depending on specification, sample, and productivity measures, and evidence from panel analysis is relatively weak.[7]

In the same way that MNE presence may affect the productivity of local firms, it is also possible to conjecture that MNE presence may affect energy efficiency in those local firms. Indeed, greater energy efficiency might be one of the more important advantages of MNEs over local firms, as Eskeland and Harrison (2003) demonstrated from Coˆte d'Ivoire, Mexico, and Venezuela. A related study suggests that similar results are not common in Thai industries in 2006 (Ramstetter and Kohpaiboon 2012), but it is still interesting to see if foreign presence is correlated with energy intensities in local plants.

3. The Data, Energy Expenditures and Intensities in Local Plants, and Foreign Shares

As described in Ramstetter and Kohpaiboon, 2012 (Table 1), this study uses the plant-level data for 2006 underlying the Thai industrial census conducted in 2007 and excludes a large number of

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[6] The use of the 2000 input-output table in these studies may be unrealistic because of large changes in Vietnam's industrial structure during 2000-2005, for example.

[7] Ramstetter and Phan (2008), Nguyen, N.A. et al. (2008), Nguyen, T.T.A. et al. (2006) use value-added-based estimates of productivity, while Le and Pomfret (2008) and Nguyen, P.L. (2008) use a sales-based measure. Value added data must be compiled from product-level data and omit some portions of sales, but the coverage of the value added samples seems reasonably good for 2000, 2002, and 2004 (Ramstetter and Phan 2008, Table 1, Appendix Tables 1a-1p).

small plants with 19 or fewer workers.[8] The excluded plants are disproportionately local, have unusually large shares of unpaid workers, and relatively low output per worker or paid worker. Some of the excluded plants clearly had the potential to be affected by spillovers from MNEs, but most were probably not affected by MNE presence in any way. Correspondingly, the analysis below focuses on a sample of medium-large plants, defined as those with 20 or more workers. This focus also has the advantage of removing the vast majority of extreme observations (likely outliers) from the sample and facilitating comparisons with similar studies of Indonesia.[9]

In addition, records for a number of medium-large plants that reported implausibly small values for key variables were also deleted. For example, of the 22,934 plants with 20 or more workers, 4,169 plants had output per worker of less than 50,000 baht, value added per worker of less than 10,000 baht, or initial fixed assets per worker of less than 10,000 baht per worker (Table 1). These cutoffs are all less than 3.3% of corresponding averages for all medium and large plants and comparable nation-wide estimates (including small plants) from either the industrial census or alternative sources. They are also substantially smaller than per capita GDP in the country in 2006 (119,634 baht or US$3,158; National Economic Social and Development Board 2011b). Plants with extremely low values of these key variables are also predominantly local (98 percent) and are excluded from the sample to avoid distorting ownership comparisons and reduce the influence of outliers.

Among the remaining 18,765 medium-large plants, there are many apparent duplicates in the data set that need to be eliminated to avoid double counting. For example, if one checks 11 key measures of output, expenses, capital, labor, and the foreign ownership share[10], there were 4,828 duplicate records of all 11 variables. The vast majority of these records (87 percent) had different location

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[8] See Ramstetter and Kohpaiboon (2012, pp. 8-12, 21, 28-37), for more details on the data.

[9] This cutoff is somewhat higher than that used in official NSO compilations (15 or more workers) but is qualitatively similar. Indonesian data only cover plants with 20 or more workers.

[10] The variables were: (a) output, (b) sales of goods produced, (c) intermediate consumption, (d) purchase of materials and parts, (e) electricity and fuel costs, (f) initial fixed assets, (g) ending fixed assets, (h) female workers, (i) male workers, (j) female operatives, (k) male operatives, and (l) foreign ownership shares.

information but identical performance information. This suggests that a large number of plants belonging to multiplant firms and operating in different locations reported the identical firm-level information, as in the 1996 census (Ramstetter 2004, 2006).[11] Duplicates were primarily local plants (93 percent) but duplicates accounted for sizeable portions of the MNE samples as well.[12] In order to avoid double counting, maximize sample size, and coverage of large, multiplant firms, which are the focus of this study, the 4,828 duplicates were dropped, leaving one record from each set of duplicates in the data set. This solution, although probably the best feasible, is far from satisfactory because it results in a database that mixes up firm- and plant-level information. Perhaps the most obvious difficulty this causes is the distortion of location information after duplication is eliminated. In economies like Thailand where there are many multi-plant firms, this also complicates the interpretation of compilations from the data because results from plant-level data and those from firm-level data can differ markedly.

After dropping plants with extreme values and duplicates, there were 13,937 plants remaining in the dataset, 14 percent of which were MNEs. MNE shares of workers (31 percent) and output (45 percent), were much larger, reflecting MNEs' tendency to have substantially more workers per plant or output per plant than local plants, even in this sample of medium-large plants (Ramstetter and Kohpaiboon, Table 1). Similarly, the fact that MNE shares of value added and fixed assets (42 and 44 percent, respectively) exceeded MNE shares of employment suggests that MNEs had relatively high average labor productivity and capital intensity, than local plants in this sample. On the other hand, the share of MNEs in electricity and fuel expenditures (43 percent) was quite similar to shares of value added and output. In other words, energy intensities, measured as the ratio of electricity and fuel expenditures to gross output or value added, were on average rather similar in MNEs and local plants.

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[11] Cross checking of duplicates with a data set on large firms compiled from Business On-Line (2008) suggests several cases in which plants recorded firm-level information in large firms.
[12] For example, duplicates accounted for 21 percent of heavily foreign plants with 20 or more workers and 11 percent of minority foreign plants.

In this paper the primary concern is with energy expenditures and energy intensities (ratios of energy expenditures to output) in local plants in this sample. In the left column, Table 1 first shows energy expenditures by these local plants, which were concentrated in 15 industries defined at the two- or three-digit level. Plants in another six two-digit industries (tobacco, leather & footwear, wood, publishing, oil and coal products, miscellaneous manufacturing) were not included because of their small size or peculiar characteristics. These 15 industries accounted for 92 percent of energy expenditures by all local manufacturing plants in this sample. Electronics-related machinery was the largest consumer, but the mean energy intensity was relatively low in this industry (4.4 percent, compared to 5.8 percent for plants in all 15 industries combined and 5.5 percent in all sample plants). In other words, this industry was a large consumer of energy primarily because of its large size, not because plants used energy relatively intensively. The reverse pattern was observed in the next three largest energy using industries, food (7.6 percent), textiles (6.7 percent), and non-metallic mineral products (7.9 percent), while energy intensities were again relatively low in the fifth and sixth largest industries (4.6 percent in both chemicals and non-electric machinery). These six industries accounted for 56 percent of all energy purchased by local plants.

Table 1 also shows shares of MNE plants in measured in terms of labor or output. Output shares (45 percent in all manufacturing, 44 percent in the 15 large energy using industries) were substantially larger than labor shares (31 and 33 percent, respectively), reflecting relatively high output per worker in MNEs. Output shares were largest in other transport equipment (78 percent), electronics-related machinery (70 percent), motor vehicles (63 percent), and general machinery (56 percent) and labor shares were similarly large in electronics-related machinery (68 percent), but much smaller in the other three of these industries (43-49 percent). In other words, the size of MNE presence clearly differs depending on the measure used in Thailand and in other Asian hosts (Ramstetter 2012). In general, shares of production tend to be larger than shares of labor as shown in Table 1 and shares of exports tend to be even larger. It is thus common to examine how robust estimates of spillovers to the choice of MNE presence measure, which shares of labor and output being among the more common measures used. In this case, it is important that correlations of MNE shares to industry-level estimates of mean energy propensities in local plants appear to be rather strong and negative, whether MNE presence is measured in terms of labor (-0.63) or output (-0.75). In other words, there is a tendency for local plants to use relatively less energy per unit of output in industries where MNE presence is relatively large.

Table 2 shows shares of three different MNE groups, minority-foreign plants with foreign ownership shares of 10-49 percent, majority foreign plants with foreign shares of 50-89 percent and heavily-foreign plants with foreign shares of 90 percent or more. As mentioned in the literature review above, spillover results have often been shown to vary among foreign ownership groups, so we want to see if the results here are also sensitive to the foreign ownership group being considered. For example, heavily-foreign MNEs are often assumed to exercise greater control of their proprietary technologies than other MNEs and this may limit the scope of spillovers from this group. Similarly, local partners tend to have greater power over affiliate decisions in minority-foreign plants, and this may include a larger tendency to share technology with local suppliers or customers, for example. On the other hand, again as described in the literature review, there are several avenues of spillovers and it is not clear how foreign ownership would be related to the scope of spillovers through labor turnover or increased competition, for example. Moreover, all MNEs face conflicting motives, wanting to prevent the leakage of proprietary knowledge that gives them competitive advantages while at the same time wanting to promote profitability in affiliates by helping suppliers and customers to be more efficient.

Correlations of energy intensities to foreign group shares are all lower in absolute value that the correlations to total foreign shares in Table 1, but they do remain negative for all ownership groups regardless of how the foreign group share is measured. Correlations to output shares remain stronger than correlations to labor shares for minority-foreign MNEs (-0.60 vs. -0.26) and heavily foreign MNEs (-0.55 vs. -0.47), but the reverse is true for minority-foreign MNEs (-0.27 vs. -0.44). Heavily-foreign MNEs were the largest of the three ownership groups, accounting just under one-fourth of the output and one-sixth of the labor in the 15 sample industries. Heavily-foreign shares were by far the largest in electronics-related machinery (47 percent of labor, 53 percent of output), followed by motor vehicles (24 and 41 percent, respectively), general machinery (23 and 24 percent, respectively), and metal products (20 and 23 percent), respectively. Majority-foreign shares were the largest in other transport machinery (23 and 56 percent, respectively) but varied greatly depending on whether measure in terms of labor or output. For example, majority-foreign shares of labor were relatively large but corresponding shares of output were substantially smaller in motor vehicles, electronics-related machinery, and rubber, while the reverse pattern was observed in textiles. Minority-foreign shares were more consistently large in other transport machinery, non-electric machinery, metal products, rubber, paper, and beverages.

Thailand had relatively strict foreign ownership limits through 1998 that, in principle, limited foreign shares to 49 percent. However, exceptions were often granted from MNEs undertaking projects approved by the Board of Investment or for American firms that had special exceptions under the Thai-U.S. Amity Treaty. Moreover, after the 1997 economic crisis most foreign ownership restrictions were lifted, and by 2006 very few remained.

4. Estimating Intra-industry Spillovers of Energy Usage Patterns

This section attempts to examine the relationship between ownership and energy intensities after accounting for the effects of other factor use and technical characteristics of plants by estimating a model similar to that in Eskeland and Harrison (2003). The models are derived by differentiating “a translog approximation to a production function” (p. 16) with respect to the energy input in question and interpreted as “inverse input demands” (p. 16). As a result, energy intensities are a function of the logs of other factor inputs (other intermediate consumption [mainly materials and parts], fixed assets, and labor), the log of the quantity of energy electricity (a proxy for the quantity of energy), and factors related to a plant’s technological sophistication. The Thai data contain two estimates of fixed assets, initial and yearend measures; the initial measure is preferable to minimize simultaneity issues but both measures are tried to check the robustness of the results. Unfortunately, the Thai data do not include information on the quantity of energy consumed so this variable must be omitted.[13] In the Thai data, there are two potentially important indicators of technological sophistication, the ratio of research and development (R&D) expenditures to gross output and the number of years in operation or plant vintage.[14] Plant vintage is a complicated indicator, however, and can also reflect the effects of changing economic policies, for example, as well as changes in technology over time. The effect of MNE presence on energy intensities in local plants is then captured by adding the foreign ownership share of labor or of output as independent variables. The resulting model is:

$$EP_{ij}=a0+a1(LK_{ij})+a2(LL_{ij})+a3(LM_{ij})+a4(RD_{ij})+a5(YR_{ij})+a6(FS_j) \quad (1)$$

where

EP_{ij}=energy (fuel and electricity) intensity in local plant i of industry j (percent)

FS_j=the share of MNEs in labor or output of industry j (percent)

LK_{ij}= natural log of the fixed assets less depreciation at yearend in local plant i of industry j (baht)

LL_{ij}=natural log of the number of workers in local plant i of industry j

LM_i=natural log intermediate consumption excluding fuel and electricity in local plant i of industry j (baht)

RD_i=ratio of R&D expenditures to gross output in local plant i of industry j (percent)

YR_i=years of operation for local plant i of industry j (percent)

If the coefficient *a6* is negative, for example, local plants tend to be relatively energy efficient (have relatively low energy intensities) in industries where MNE presence was relatively large, after accounting for the influences of other factor usage and the two indicators of technological sophistication (R&D intensities and plant vintage). In the Thai case, it is also possible to investigate whether the degree of foreign ownership affects MNE-local differentials by estimating the following equation:

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[13] If energy prices were equal for all plants, the value variable could be used instead, but assuming this is unrealistic because prices vary among plants depending on energy mix, quantities consumed, and the timing of consumption (especially important for electricity and piped gas prices).

[14] In addition, Eskeland and Harrison (2003) also include machinery imports as indicators of plant sophistication, but they are not available from this data set.

$$EP_{ij}=b0+b1(LK_{ij})+b2(LL_{ij})+b3(LM_{ij})+b4(RD_{ij})+b5(YR_{ij})+b6(FS1_j)+b7(FS5_j)+b8(FS9_j) \quad (2)$$

where

$FS1_j$=the share of minority-foreign (10-49%) MNEs in labor or output of industry j (percent)

$FS5_j$=the share of majority-foreign (50-89%) MNEs in labor or output of industry j (percent)

$FS9_j$=the share of heavily-foreign (90-100%) MNEs in labor or output of industry j (percent)

Equations (1) and (2) are first estimated in samples of all 15 large energy using industries. Foreign shares are measured at both the 3- and 4-digit levels of the Thai Standard Industrial Classification to check the robustness of the results. If 3-digit MNEs shares are used to estimate equation (1), the coefficient *a6* is always positive and significant at the standard 5 percent level, regardless of the MNEs share measure or the measure of capital used (top block of Table 1). In other words, the results suggest that the negative correlation observed in Table 1 is reversed if the influences of other factor input choice and technical sophistication of local plants is accounted for. Similar results are also obtained when MNE shares are defined at the 4-digit level, though the positive correlation is only weakly significant at the 10 percent level or better if labor shares are used. Control coefficients on labor, capital, and vintage are all positive and highly significant at the 1 percent level or better while the coefficient on materials was negative and highly significant and the coefficient on R&D intensity was insignificant. In other words, results of estimating equation (1) all indicate that labor and capital complemented energy use while materials use was a substitute, while older plants had higher energy intensities and local plants tended to have relatively high energy intensities in industries where MNE presence was large.

However, estimates of equation (2) indicate that the size and statistical significance of these spillovers varied among MNE ownership groups and depended on how the MNE share was measured (Table 1). Moreover, tests of the hypothesis that spillovers were equal among ownership groups were rejected at the 1 percent level or better for 3-digit labor and output share estimates and for 4-digit output share estimates, and at the 10 percent level for 4-digit labor share estimates. 3-digit estimates (second block) also consistently indicated that the coefficient of the heavily-foreign share was smallest, whether it was measured in terms of labor or output. If measured in terms of labor, the coefficient on the majority-foreign share was almost 84-90 percent larger than the coefficient on the minority-foreign share, but if measured in terms of output, it was 7.6-8.0 percent smaller. And the story is different in the 4-digit estimates (fourth block), which indicated that coefficients on the minority-foreign share were always insignificant. In this case, coefficients on the heavily-foreign share were 53-55 percent larger than coefficients on the majority-foreign share if measured in terms of labor but 27-29 percent smaller if measured in terms of labor.

In short, the estimates for all large energy using industries combined suggest that foreign presence did affect energy intensity in local plants, generally encouraging local plants to use less energy efficient technology. This is a plausible result especially if one thinks that local plants need to adopt more energy intensive technologies to compete with MNEs or to participate in their production chains efficiently. Alternatively, these estimates could reflect a tendency for MNEs to be concentrated in industries where energy intensities are relatively high among local plants. It is also difficult to interpret observed differences in the size of spillovers among MNE ownership groups, partially because the results vary greatly depending on the degree of aggregation and how MNE presence is measured.

It is also possible that the nature of these spillovers differ among industry groups. For example, this is suggested by estimates of equations (1) and (2) for a sample of the seven smallest of the 15 large energy using industries listed in (12 billion baht or less, Table 1; beverages, apparel, paper, rubber, plastics, basic metals, and metal products). As indicated above, these also tend to be relatively small industries and contain only 4,492 of the 11,332 local plants in our sample (Table 4a). Results from this sample again suggest that estimates of spillovers are quite sensitive to the level of aggregation and the choice of MNE share measure. For example, estimates of equation (1) indicate local plants had lower energy propensities in industries with large MNE labor shares measured at the three-digit level, but this effect was not statistically significant if MNE shares were measured in terms of output. Moreover, coefficients on MNE shares became positive, though statistically insignificant at standard levels if measured at the 4-digit level. Similar differences were observed in estimates of equation (2), which revealed negative coefficients on MNE shares measured at the 3-digit level but positive ones at the 4-digit level. Correspondingly, it is probably best to conclude that evidence of spillovers is relatively weak in this sample of local plants.

In contrast, the results of estimating these equations in a sample of 6,840 local plants in the eight largest energy using industries (15 billion baht or more, Table 1; food, textiles, chemicals, non-metallic mineral products, non-electric machinery, electronics-related machinery, motor vehicles, and other transport machinery) are more consistent than results for the smaller seven industries or all industries combined (Table 4b). First of all, equation (2) is clearly preferred to equation (1) in all cases. Second, coefficients on majority-foreign shares are always the largest, positive, and statistically significant. In other words, these results consistently suggest that MNE presence was correlated with relatively high energy intensities in this sample of local plants and that the correlation was highest for majority foreign MNEs. The effects of heavily-foreign MNE were also positive and significant in all specifications. However, the effects of minority-foreign MNE presence were not significant if shares are measured at the 4-digit level, though they were significant and larger than the effects of heavily-foreign MNE presence if measured at the 3-digit level. Thus, the correlations suggesting that MNE presence leads to higher energy intensities are relatively strong and consistent in samples of the largest energy using industries. However, the results minority-foreign MNEs vary depending on the level of disaggregation.

Estimates are then performed for industries with relatively low and relatively high energy intensities. There were 5,949 local plants in the nine industries with relatively low energy intensities (4.7 percent or less, Table 1; apparel, paper, chemicals, rubber, metal products, non-electric machinery, electronics-related machinery, motor vehicles, and other transport machinery). Results from this sample were similar to results from the sample of the 5 smaller of the 12 large energy consuming industries in that correlations between foreign shares and local plant energy intensities were relatively weak and inconsistent, depending on the level of aggregation and the measure of the foreign share (Table 5a). When MNE presence was measured as the labor share, heavily-foreign

MNE presence was negatively and significantly correlated with local plant energy intensities, and except when ending capital and a four-digit definition of MNE presence was used (when the correlation was weakly significant at the 10 percent level). One the other hand, majority-foreign MNE presence has a positive and significant effect when a three-digit measure of MNE presence was used, but this correlation was insignificant when a four-digit measure was used. Moreover, when shares of output were used, the negative correlation to heavily-foreign MNE presence at the three-digit level was the only significant one. There is thus some evidence that local plants tended to have relatively low energy intensities in low-energy-intensity industries where heavily foreign MNE presence, but correlations the presence of other MNE groups were weaker.

The final sample examined consisted of 5,373 local plants in six industries with relatively high energy intensities (6.0% or more, Table 1; food, beverages, textiles, plastics, non-metallic mineral products, and basic metals). When MNE presence is measured at the three-digit level, results were similar to those for the sample of the eight largest energy using industries. MNE presence was positively correlated with energy intensities in local plants and correlations were strongest for majority-foreign MNEs (Table 5b). However, the similarity ends here. In this case, correlations to minority-foreign presence were second strongest followed by correlations to heavily-foreign MNE presence, which is the reverse of the ordering in the sample of the largest energy users. Moreover, if MNE presence is measured at the four-digit level, there were other notable differences. Correlations to heavily-foreign presence remain positive and significant, as does the correlation to majority-foreign output shares, but correlations to minority-foreign presence become negative and significant while correlations to majority-foreign output shares become insignificant.

Perhaps the most outstanding result is that in most of the samples examined, estimates correlations of local plant energy intensities to MNE presence are sensitive to the level of aggregation. We tend to believe results from the 3-digit specifications more than the 4-digit ones because many four-digit categories are defined so narrowly as to greatly limit the scope for intra-industry spillovers of energy knowledge and related technologies. However, it is still disquieting that the results are so sensitive to the level of aggregation. Results are also somewhat sensitive to the choice of labor share or output share for measuring MNE presence. This is also disquieting because there are good reasons to use either measure, and both should be relatively reliable, compared to the MNE share of fixed assets or other stock measures, for example.

Finally, we should also emphasize that these estimates of energy intensity spillovers are fundamentally different from previous estimates of productivity spillovers, for example, because they focus on a very small portion of input efficiency. Even in the most energy-intensive industries, mean energy intensities were less than 8 percent in local plants (Table 1). Correspondingly, industry-level shares of energy expenditures are calculated for all plants in the sample, energy shares never exceeded 11 percent (in non-metallic mineral products) and were an average of only 4.3 percent in Thai manufacturing (Ramstetter 2013, Table 5).[15] In contrast, shares of raw materials and parts were an average of 57 percent of output. Thus, when we examine energy intensities, we are examining a very small portion of the production process. There is thus no reason to expect that the nature of general productivity spillovers, which are often hypothesized to be related to linkages and labor mobility, will be related to spillovers of energy technology and usage practices, which probably result more from competitive pressure.

5. Conclusions

This paper began with a review of the substantial literature on productivity spillovers in Asian economies. Compared to studies of other regions, studies of Asia provide relatively abundant evidence of positive productivity spillovers, especially for Indonesia and China. Previous studies of Thailand also suggest positive productivity spillovers in Thailand, though these cross section studies are relatively weak methodologically because they rely on single-year cross sections or relatively small samples of firms or plants.

[15] Note that these shares differ from the simple means in Table 1 because they are calculated at the industry level; i.e., they are weighted means, not simple means.

At the industry level, descriptive statistics suggested that MNE presence was negatively correlated with energy intensities in local plants. However, after accounting for the influences of plant-level factor usage and technical characteristics, correlations between MNE presence and energy intensities in local plants were generally positive. In other words, the econometric evidence presented here suggests that MNE presence generally leads local plants to be less energy intensive. However, this result is not robust. First, the result obtains relatively strongly for the eight largest energy using industries, but not for the seven smaller of the largest energy using industries. It is also relatively weak in the overall sample of 15 industries and in subsamples sorted by energy intensity. Second, the result is often sensitive to the level of disaggregation used when defining foreign MNE shares. Third, it is also somewhat sensitive to whether MNE shares are measured in terms of labor or output. Fourth, and perhaps most importantly, it is possible that MNE presence is coincidentally large in industries where local plants have relatively high energy intensities, primarily for reasons not depicted in the simple model used here.

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Table 1: Energy expenditures (billion baht) and intensities (percent) in local plants, and MNE Shares of Labor and Output (percent)

Industry	Local plants		MNEs shares	
	Energy expen-ditures	Energy inten-sities	Labor	Output
Manufacturing	252.536	5.52	31.44	44.87
Large Energy Users (15 industries)	232.751	5.80	32.87	43.91
Food products	24.753	7.58	13.89	12.46
Beverages	3.325	6.48	27.74	19.63
Textiles	21.990	6.77	13.75	21.92
Apparel	6.000	4.39	16.78	25.35
Paper products	12.104	4.29	21.40	38.30
Chemicals	18.698	4.55	24.37	34.70
Rubber products	7.325	4.50	44.37	42.51
Plastics	8.828	6.05	25.75	33.66
Non-metallic mineral products	20.796	7.86	12.66	9.68
Basic metals	12.251	6.23	28.14	39.64
Metal products	10.212	4.66	37.00	39.71
Non-electric machinery	16.525	4.56	46.39	56.46
Electronics-related machinery	38.187	4.41	68.06	69.54
Motor vehicles	16.618	4.34	49.25	63.25
Other transport machinery	15.138	4.32	43.49	77.92
Correlations to energy intensities in local plants (15 industries)	0.12	1.00	-0.63	-0.75

Note: Data refer to the cost of fuel and electricity used in production processes.

Source: Compilations from data underlying National Statistical Office (2009).

Table 2: MNE Shares of Labor and Output by Owership Group and Correlations to Energy Intensities in Local Plants (percent)

Industry	Labor			Output		
	Minority-foreign	Majority-foreign	Heavily-foreign	Minority-foreign	Majority-foreign	Heavily-foreign
Manufacturing	10.45	6.21	14.78	15.51	7.71	21.65
Large Energy Users (15 industries)	10.44	6.74	15.69	11.33	8.53	24.05
Food products	9.13	2.65	2.11	6.37	2.09	3.99
Beverages	25.47	1.99	0.28	16.12	2.93	0.58
Textiles	6.16	5.61	1.99	5.22	13.57	3.13
Apparel	10.58	2.12	4.08	17.42	1.28	6.65
Paper products	15.56	1.35	4.49	16.03	1.63	20.64
Chemicals	10.85	2.98	10.54	12.10	7.01	15.59
Rubber products	18.99	10.55	14.83	15.42	8.40	18.69
Plastics	7.44	5.75	12.55	11.44	6.30	15.92
Non-metallic mineral products	7.77	2.24	2.65	4.79	1.71	3.18
Basic metals	11.65	4.88	11.61	16.31	10.02	13.31
Metal products	14.11	2.68	20.21	14.21	2.81	22.69
Non-electric machinery	15.64	7.85	22.89	22.26	9.88	24.32
Electronics-related machinery	8.00	13.39	46.67	7.64	8.74	53.15
Motor vehicles	8.57	17.17	23.52	10.40	11.83	41.02
Other transport machinery	18.89	23.28	1.32	21.49	55.78	0.65
Correlations to energy intensities in local plants (15 industries)	-0.26	-0.44	-0.47	-0.60	-0.27	-0.55

Note: Data refer to the cost of fuel and electricity used in production processes.

Source: Compilations from data underlying National Statistical Office (2009).

Table 3: Correlations of MNE Presence to Energy Intensities in Local Plants and Other Slope Coefficients from Equations (1) and (2), 15 Large Energy Using Industries (11,332 observations)

Independent variable, indicator	MNE labor shares				MNE output shares			
	Initial capital		Ending capital		Initial capital		Ending capital	
	Value	P-val	Value	P-val	Value	P-val	Value	P-val
14 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	1.0185	0.00	0.7982	0.00	1.0178	0.00	0.8008	0.00
LL_{ij}	0.4448	0.00	0.5782	0.00	0.4335	0.00	0.5649	0.00
LM_{ij}	-1.3048	0.00	-1.2254	0.00	-1.2924	0.00	-1.2142	0.00
RD_{ij}	-0.0943	0.67	-0.0794	0.72	-0.1529	0.50	-0.1399	0.54
YR_{ij}	0.0417	0.00	0.0436	0.00	0.0402	0.00	0.0421	0.00
FS_j	0.0209	0.02	0.0217	0.02	0.0557	0.00	0.0571	0.00
R^2	0.07	-	0.07	-	0.08	-	0.07	-
14 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	1.0048	0.00	0.7865	0.00	1.0099	0.00	0.7939	0.00
LL_{ij}	0.4312	0.00	0.5626	0.00	0.4369	0.00	0.5677	0.00
LM_{ij}	-1.2952	0.00	-1.2162	0.00	-1.2870	0.00	-1.2090	0.00
RD_{ij}	-0.1012	0.65	-0.0865	0.70	-0.1454	0.52	-0.1322	0.56
YR_{ij}	0.0428	0.00	0.0447	0.00	0.0401	0.00	0.0419	0.00
$FS1_j$	0.0524	0.00	0.0553	0.00	0.0798	0.00	0.0820	0.00
$FS5_j$	0.0995	0.00	0.1018	0.00	0.0737	0.00	0.0755	0.00
$FS9_j$	0.0176	0.11	0.0185	0.09	0.0467	0.00	0.0480	0.00
Test: $FS1_j = FS5_j = FS9_j$	16.17	0.00	16.96	0.00	8.97	0.00	9.30	0.00
R^2	0.08	-	0.07	-	0.08	-	0.07	-
14 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	1.0182	0.00	0.7981	0.00	1.0145	0.00	0.7968	0.00
LL_{ij}	0.4503	0.00	0.5834	0.00	0.4372	0.00	0.5689	0.00
LM_{ij}	-1.3063	0.00	-1.2269	0.00	-1.2889	0.00	-1.2101	0.00
RD_{ij}	-0.0912	0.68	-0.0764	0.73	-0.1378	0.54	-0.1246	0.58
YR_{ij}	0.0418	0.00	0.0437	0.00	0.0423	0.00	0.0442	0.00
FS_j	0.0105	0.08	0.0113	0.06	0.0298	0.00	0.0308	0.00
R^2	0.07	-	0.07	-	0.08	-	0.07	-
14 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	1.0151	0.00	0.7960	0.00	1.0134	0.00	0.7979	0.00
LL_{ij}	0.4425	0.00	0.5749	0.00	0.4285	0.00	0.5588	0.00
LM_{ij}	-1.3043	0.00	-1.2253	0.00	-1.2889	0.00	-1.2112	0.00
RD_{ij}	-0.0934	0.68	-0.0787	0.73	-0.1623	0.48	-0.1497	0.51
YR_{ij}	0.0426	0.00	0.0446	0.00	0.0443	0.00	0.0462	0.00
$FS1_j$	0.0072	0.50	0.0077	0.48	-0.0014	0.85	-0.0009	0.90
$FS5_j$	0.0401	0.00	0.0412	0.00	0.0595	0.00	0.0603	0.00
$FS9_j$	0.0213	0.01	0.0227	0.00	0.0424	0.00	0.0437	0.00
Test: $FS1_j = FS5_j = FS9_j$	2.34	0.10	2.35	0.10	16.87	0.00	16.96	0.00
R^2	0.08	-	0.07	-	0.08	-	0.08	-

Notes: all p-values based on robust standard errors; full details including the constant and industry dummy coefficients available from the authors.

Table 4a: Correlations of MNE Presence to Energy Intensities in Local Plants and Other Slope Coefficients from Equations (1) and (2), 7 Smallest of 15 Large Energy Using Industries (12 billion baht or less; 4,492 observations)

Independent variable, indicator	MNE labor shares				MNE output shares			
	Initial capital		Ending capital		Initial capital		Ending capital	
	Value	P-val	Value	P-val	Value	P-val	Value	P-val
6 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	0.4288	0.00	0.3544	0.00	0.4283	0.00	0.3541	0.00
LL_{ij}	0.6147	0.00	0.6776	0.00	0.6164	0.00	0.6792	0.00
LM_{ij}	-0.7230	0.00	-0.7076	0.00	-0.7233	0.00	-0.7079	0.00
RD_{ij}	-0.0286	0.92	-0.0213	0.94	-0.0278	0.93	-0.0206	0.95
YR_{ij}	0.0083	0.39	0.0090	0.36	0.0083	0.39	0.0090	0.36
FS_j	-0.0457	0.03	-0.0462	0.03	-0.0301	0.15	-0.0308	0.15
R^2	0.03	-	0.03	-	0.03	-	0.03	-
6 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	0.4207	0.00	0.3481	0.00	0.4207	0.00	0.3481	0.00
LL_{ij}	0.6147	0.00	0.6770	0.00	0.6160	0.00	0.6783	0.00
LM_{ij}	-0.7077	0.00	-0.6933	0.00	-0.7089	0.00	-0.6945	0.00
RD_{ij}	-0.0573	0.85	-0.0508	0.86	-0.0587	0.84	-0.0521	0.86
YR_{ij}	0.0067	0.49	0.0074	0.45	0.0067	0.50	0.0073	0.46
$FS1_j$	-0.0409	0.04	-0.0386	0.05	-0.0226	0.42	-0.0211	0.46
$FS5_j$	-1.0607	0.01	-1.0464	0.01	-0.3825	0.00	-0.3818	0.00
$FS9_j$	-0.1680	0.00	-0.1668	0.00	-0.0849	0.00	-0.0858	0.00
Test: $FS1_j = FS5_j = FS9_j$	6.49	0.00	6.75	0.00	5.45	0.00	5.54	0.00
R^2	0.03	-	0.03	-	0.03	-	0.03	-
6 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	0.4334	0.00	0.3583	0.00	0.4301	0.00	0.3550	0.00
LL_{ij}	0.6223	0.00	0.6861	0.00	0.6210	0.00	0.6846	0.00
LM_{ij}	-0.7303	0.00	-0.7148	0.00	-0.7250	0.00	-0.7094	0.00
RD_{ij}	-0.0292	0.92	-0.0219	0.94	-0.0312	0.92	-0.0240	0.94
YR_{ij}	0.0072	0.46	0.0078	0.43	0.0077	0.43	0.0083	0.40
FS_j	0.0259	0.08	0.0260	0.08	0.0138	0.23	0.0137	0.24
R^2	0.03	-	0.03	-	0.03	-	0.03	-
6 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	0.4178	0.00	0.3471	0.00	0.4323	0.00	0.3559	0.00
LL_{ij}	0.6310	0.00	0.6909	0.00	0.6034	0.00	0.6683	0.00
LM_{ij}	-0.7212	0.00	-0.7068	0.00	-0.7165	0.00	-0.7007	0.00
RD_{ij}	-0.0132	0.96	-0.0061	0.98	-0.0382	0.90	-0.0303	0.92
YR_{ij}	0.0062	0.53	0.0068	0.49	0.0073	0.46	0.0080	0.42
$FS1_j$	0.0383	0.04	0.0384	0.04	0.0102	0.44	0.0102	0.44
$FS5_j$	0.0913	0.00	0.0946	0.00	0.0632	0.07	0.0627	0.07
$FS9_j$	0.0123	0.45	0.0119	0.46	0.0319	0.03	0.0312	0.04
Test: $FS1_j = FS5_j = FS9_j$	4.68	0.01	5.07	0.01	1.39	0.25	1.33	0.26
R^2	0.03	-	0.03	-	0.03	-	0.03	-

Notes: all p-values based on robust standard errors; full details including the constant and industry dummy coefficients available from the authors.

Table 4b: Correlations of MNE Presence to Energy Intensities in Local Plants and Other Slope Coefficients from Equations (1) and (2), 8 Largest of 15 Large Energy Using Industries (15 billion baht or more; 6,840 observations)

Independent variable, indicator	MNE labor shares				MNE output shares			
	Initial capital		Ending capital		Initial capital		Ending capital	
	Value	P-val	Value	P-val	Value	P-val	Value	P-val
7 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	1.4081	0.00	1.1178	0.00	1.4019	0.00	1.1185	0.00
LL_{ij}	0.3908	0.00	0.5312	0.00	0.3753	0.00	0.5121	0.00
LM_{ij}	-1.7014	0.00	-1.5780	0.00	-1.6742	0.00	-1.5534	0.00
RD_{ij}	-0.1328	0.64	-0.1184	0.67	-0.2118	0.45	-0.2015	0.48
YR_{ij}	0.0569	0.00	0.0598	0.00	0.0545	0.00	0.0572	0.00
FS_j	0.0307	0.00	0.0329	0.00	0.0630	0.00	0.0659	0.00
R^2	0.10	-	0.09	-	0.10	-	0.09	-
7 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	1.3930	0.00	1.1042	0.00	1.3933	0.00	1.1107	0.00
LL_{ij}	0.3678	0.01	0.5065	0.00	0.3736	0.00	0.5098	0.00
LM_{ij}	-1.6869	0.00	-1.5637	0.00	-1.6640	0.00	-1.5429	0.00
RD_{ij}	-0.1397	0.62	-0.1258	0.65	-0.2003	0.48	-0.1898	0.50
YR_{ij}	0.0584	0.00	0.0613	0.00	0.0544	0.00	0.0571	0.00
$FS1_j$	0.0531	0.04	0.0556	0.03	0.0830	0.00	0.0868	0.00
$FS5_j$	0.1011	0.00	0.1048	0.00	0.0785	0.00	0.0813	0.00
$FS9_j$	0.0282	0.03	0.0313	0.02	0.0551	0.00	0.0582	0.00
Test: $FS1_j=FS5_j=FS9_j$	10.07	0.00	10.26	0.00	5.84	0.00	5.80	0.00
R^2	0.10	-	0.09	-	0.10	-	0.09	-
7 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	1.4093	0.00	1.1183	0.00	1.4041	0.00	1.1180	0.00
LL_{ij}	0.4128	0.00	0.5540	0.00	0.3892	0.00	0.5279	0.00
LM_{ij}	-1.7092	0.00	-1.5858	0.00	-1.6849	0.00	-1.5631	0.00
RD_{ij}	-0.1270	0.65	-0.1126	0.69	-0.1967	0.49	-0.1858	0.51
YR_{ij}	0.0567	0.00	0.0596	0.00	0.0579	0.00	0.0608	0.00
FS_j	0.0097	0.15	0.0112	0.10	0.0323	0.00	0.0340	0.00
R^2	0.10	-	0.09	-	0.10	-	0.09	-
7 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	1.4018	0.00	1.1126	0.00	1.3964	0.00	1.1147	0.00
LL_{ij}	0.4188	0.00	0.5603	0.00	0.3990	0.00	0.5362	0.00
LM_{ij}	-1.7132	0.00	-1.5911	0.00	-1.6896	0.00	-1.5701	0.00
RD_{ij}	-0.1295	0.65	-0.1152	0.68	-0.2171	0.45	-0.2071	0.47
YR_{ij}	0.0585	0.00	0.0614	0.00	0.0610	0.00	0.0639	0.00
$FS1_j$	-0.0128	0.38	-0.0127	0.39	-0.0080	0.39	-0.0074	0.43
$FS5_j$	0.0403	0.00	0.0408	0.00	0.0595	0.00	0.0606	0.00
$FS9_j$	0.0289	0.00	0.0320	0.00	0.0430	0.00	0.0453	0.00
Test: $FS1_j=FS5_j=FS9_j$	3.64	0.03	3.71	0.02	15.41	0.00	15.61	0.00
R^2	0.10	-	0.09	-	0.10	-	0.09	-

Notes: all p-values based on robust standard errors; full details including the constant and industry dummy coefficients available from the authors.

Table 5a: Correlations of MNE Presence to Energy Intensities in Local Plants and Other Slope Coefficients from Equations (1) and (2), 9 Least Energy-Intensive of 15 Large Energy Using Industries (4.7% or less; 5,949 observations)

Independent variable, indicator	MNE labor shares				MNE output shares			
	Initial capital		Ending capital		Initial capital		Ending capital	
	Value	P-val	Value	P-val	Value	P-val	Value	P-val
8 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	0.6426	0.00	0.4302	0.00	0.6378	0.00	0.4258	0.00
LL_{ij}	0.6200	0.00	0.7549	0.00	0.6208	0.00	0.7558	0.00
LM_{ij}	-0.8220	0.00	-0.7456	0.00	-0.8220	0.00	-0.7455	0.00
RD_{ij}	-0.1123	0.60	-0.0840	0.69	-0.1008	0.64	-0.0724	0.73
YR_{ij}	0.0000	1.00	0.0015	0.84	0.0006	0.94	0.0020	0.79
FS_j	-0.0153	0.08	-0.0142	0.10	-0.0140	0.05	-0.0137	0.05
R^2	0.03	-	0.03	-	0.03	-	0.03	-
8 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	0.6268	0.00	0.4164	0.00	0.6286	0.00	0.4180	0.00
LL_{ij}	0.6130	0.00	0.7463	0.00	0.6240	0.00	0.7584	0.00
LM_{ij}	-0.8150	0.00	-0.7393	0.00	-0.8200	0.00	-0.7439	0.00
RD_{ij}	-0.1139	0.59	-0.0855	0.69	-0.0981	0.64	-0.0695	0.74
YR_{ij}	0.0015	0.84	0.0028	0.70	0.0008	0.91	0.0021	0.77
$FS1_j$	-0.0068	0.66	-0.0023	0.88	0.0033	0.80	0.0049	0.70
$FS5_j$	0.0377	0.02	0.0397	0.01	0.0106	0.23	0.0113	0.21
$FS9_j$	-0.0334	0.00	-0.0324	0.00	-0.0222	0.00	-0.0219	0.00
Test: $FS1_j = FS5_j = FS9_j$	12.61	0.00	13.36	0.00	9.40	0.00	9.72	0.00
R^2	0.04	-	0.30	-	0.04	-	0.03	-
8 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	0.6430	0.00	0.4305	0.00	0.6427	0.00	0.4299	0.00
LL_{ij}	0.6133	0.00	0.7483	0.00	0.6145	0.00	0.7498	0.00
LM_{ij}	-0.8218	0.00	-0.7461	0.00	-0.8236	0.00	-0.7470	0.00
RD_{ij}	-0.1201	0.57	-0.0913	0.67	-0.1079	0.61	-0.0805	0.71
YR_{ij}	0.0001	0.99	0.0016	0.83	-0.0003	0.97	0.0012	0.87
FS_j	-0.0052	0.41	-0.0038	0.54	-0.0073	0.14	-0.0064	0.20
R^2	0.03	-	0.03	-	0.03	-	0.03	-
8 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	0.6344	0.00	0.4232	0.00	0.6399	0.00	0.4271	0.00
LL_{ij}	0.6118	0.00	0.7462	0.00	0.6126	0.00	0.7484	0.00
LM_{ij}	-0.8175	0.00	-0.7423	0.00	-0.8211	0.00	-0.7444	0.00
RD_{ij}	-0.1182	0.58	-0.0896	0.67	-0.1089	0.61	-0.0811	0.70
YR_{ij}	0.0002	0.98	0.0017	0.82	0.0001	0.99	0.0015	0.84
$FS1_j$	0.0104	0.40	0.0133	0.29	-0.0019	0.82	-0.0002	0.98
$FS5_j$	0.0149	0.16	0.0165	0.13	0.0035	0.65	0.0041	0.60
$FS9_j$	-0.0144	0.05	-0.0133	0.07	-0.0094	0.10	-0.0085	0.14
Test: $FS1_j = FS5_j = FS9_j$	5.06	0.01	5.37	0.00	1.48	0.23	1.49	0.22
R^2	0.03	-	0.03	-	0.03	-	0.03	-

Notes: all p-values based on robust standard errors; full details including the constant and industry dummy coefficients available from the authors.

Table 5b: Correlations of MNE Presence to Energy Intensities in Local Plants and Other Slope Coefficients from Equations (1) and (2), 6 Most Energy-Intensive of 15 Large Energy Using Industries (6.0% or more, 5,373 observations)

Independent variable, indicator	MNE labor shares				MNE output shares			
	Initial capital		Ending capital		Initial capital		Ending capital	
	Value	P-val	Value	P-val	Value	P-val	Value	P-val
5 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	1.4402	0.00	1.2567	0.00	1.3400	0.00	1.1707	0.00
LL_{ij}	0.0462	0.78	0.1735	0.30	0.1954	0.20	0.3076	0.05
LM_{ij}	-1.6942	0.00	-1.6373	0.00	-1.6160	0.00	-1.5601	0.00
RD_{ij}	-0.0390	0.92	-0.0380	0.92	-0.2695	0.52	-0.2717	0.51
YR_{ij}	0.0860	0.00	0.0878	0.00	0.0731	0.00	0.0748	0.00
FS_j	0.2723	0.00	0.2659	0.00	0.2657	0.00	0.2675	0.00
R^2	0.08	-	0.08	-	0.10	-	0.10	-
5 INDUSTRY DUMMIES; MNE SHARES OF 3-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	1.3749	0.00	1.1988	0.00	1.3247	0.00	1.1576	0.00
LL_{ij}	0.0905	0.57	0.2124	0.20	0.2088	0.17	0.3202	0.04
LM_{ij}	-1.6198	0.00	-1.5645	0.00	-1.5983	0.00	-1.5434	0.00
RD_{ij}	-0.1666	0.69	-0.1669	0.69	-0.2821	0.50	-0.2842	0.49
YR_{ij}	0.0812	0.00	0.0830	0.00	0.0719	0.00	0.0735	0.00
$FS1_j$	0.2442	0.00	0.2378	0.00	0.2100	0.00	0.2113	0.00
$FS5_j$	1.2689	0.00	1.2861	0.00	0.4956	0.00	0.5026	0.00
$FS9_j$	0.3386	0.00	0.3334	0.00	0.2707	0.00	0.2721	0.00
Test: $FS1_j = FS5_j = FS9_j$	25.90	0.00	27.01	0.00	14.92	0.00	15.63	0.00
R^2	0.10	-	0.09	-	0.10	-	0.10	-
5 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (1)								
LK_{ij}	1.4310	0.00	1.2510	0.00	1.4075	0.00	1.2282	0.00
LL_{ij}	0.2148	0.16	0.3393	0.03	0.1506	0.32	0.2706	0.08
LM_{ij}	-1.7792	0.00	-1.7236	0.00	-1.6588	0.00	-1.6011	0.00
RD_{ij}	-0.0174	0.97	-0.0154	0.97	-0.1855	0.64	-0.1846	0.64
YR_{ij}	0.0847	0.00	0.0866	0.00	0.0783	0.00	0.0801	0.00
FS_j	0.0391	0.02	0.0360	0.04	0.1113	0.00	0.1107	0.00
R^2	0.08	-	0.07	-	0.09	-	0.08	-
5 INDUSTRY DUMMIES; MNE SHARES OF 4-DIGIT INDUSTRIES, eq. (2)								
LK_{ij}	1.3536	0.00	1.1842	0.00	1.2708	0.00	1.1157	0.00
LL_{ij}	0.2168	0.16	0.3335	0.03	0.2719	0.07	0.3773	0.01
LM_{ij}	-1.6792	0.00	-1.6265	0.00	-1.5355	0.00	-1.4859	0.00
RD_{ij}	-0.1328	0.74	-0.1330	0.74	-0.3796	0.37	-0.3823	0.37
YR_{ij}	0.0848	0.00	0.0866	0.00	0.0774	0.00	0.0791	0.00
$FS1_j$	-0.0515	0.02	-0.0569	0.01	-0.0695	0.00	-0.0723	0.00
$FS5_j$	0.0460	0.15	0.0446	0.17	0.2045	0.00	0.2046	0.00
$FS9_j$	0.4000	0.00	0.4037	0.00	0.2886	0.00	0.2909	0.00
Test: $FS1_j = FS5_j = FS9_j$	27.32	0.00	0.00	0.00	60.64	0.00	61.60	0.00
R^2	0.09	-	0.00	-	0.13	-	0.12	-

Notes: all p-values based on robust standard errors; full details including the constant and industry dummy coefficients available from the authors.

Appendix Table 1: Gross Output in Sample Plants (billion baht)

Industry	Total	Local	MNCs by foreign share		
			10-49%	50-89%	90%+
Manufacturing	5,854.59	3,227.44	908.28	451.29	1,267.59
Large Energy Users	5,126.00	2,875.04	580.93	437.26	1,232.77
Food products	728.23	637.51	46.40	15.25	29.06
Beverages	161.43	129.74	26.03	4.72	0.93
Textiles	221.87	173.23	11.58	30.12	6.94
Apparel	137.84	102.90	24.02	1.76	9.17
Paper products	150.39	92.78	24.11	2.45	31.04
Chemicals	431.31	281.65	52.20	30.23	67.23
Rubber products	224.79	129.23	34.66	18.89	42.02
Plastics	165.79	109.98	18.96	10.45	26.39
Non-metallic mineral products	183.41	165.65	8.79	3.13	5.84
Basic metals	243.61	147.04	39.74	24.42	32.42
Metal products	249.52	150.44	35.46	7.02	56.61
Non-electric machinery	335.47	146.07	74.68	33.15	81.57
Electronics-related machinery	1,038.37	316.30	79.36	90.76	551.94
Motor vehicles	708.61	260.41	73.70	83.84	290.66
Other transport equipment	145.34	32.09	31.23	81.07	0.94
Small Energy Users	728.60	352.40	327.35	14.04	34.82
Tobacco	44.25	42.65	1.60	0.00	0.00
Leather, footwear	52.08	47.00	2.40	0.92	1.77
Wood products	51.93	47.83	2.87	0.89	0.34
Publishing	61.37	49.54	9.90	0.26	1.67
Petroleum products	362.03	72.07	286.13	3.83	0.00
Miscellaneous & recycling	156.94	93.30	24.46	8.13	31.04

Source: Compilations from data underlying National Statistical Office (2009).

Appendix Table 2: Total Labor in Sample Plants (number)

			MNCs by foreign share		
Industry	Total	Local	10-49%	50-89%	90%+
Manufacturing	2,518,250	1,726,597	263,149	156,283	372,221
Large Energy Users	2,147,192	1,441,407	224,222	144,760	336,803
Food products	372,750	320,982	34,038	9,864	7,866
Beverages	41,961	30,322	10,688	835	116
Textiles	192,536	166,058	11,859	10,794	3,825
Apparel	195,441	162,652	20,677	4,140	7,972
Paper products	60,621	47,650	9,430	819	2,722
Chemicals	111,083	84,017	12,054	3,306	11,706
Rubber products	77,383	43,048	14,692	8,166	11,477
Plastics	132,923	98,699	9,890	7,647	16,687
Non-metallic mineral products	111,963	97,784	8,704	2,511	2,964
Basic metals	49,540	35,601	5,769	2,419	5,751
Metal products	134,082	84,474	18,923	3,591	27,094
Non-electric machinery	121,652	65,223	19,026	9,554	27,849
Electronics-related machinery	393,721	125,763	31,495	52,730	183,733
Motor vehicles	112,807	57,249	9,662	19,367	26,529
Other transport equipment	38,729	21,885	7,315	9,017	512
Small Energy Users	371,058	285,190	38,927	11,523	35,418
Tobacco	8,136	7,312	824	0	0
Leather, footwear	64,805	56,066	4,795	555	3,389
Wood products	52,912	50,567	1,735	352	258
Publishing	53,506	44,228	7,882	206	1,190
Petroleum products	7,654	6,245	1,011	398	0
Miscellaneous & recycling	184,045	120,772	22,680	10,012	30,581

Source: Compilations from data underlying National Statistical Office (2009).

Appendix Table 3: Paid Labor in Sample Plants (number)

			MNCs by foreign share		
Industry	Total	Local	10-49%	50-89%	90%+
Manufacturing	2,509,011	1,718,199	262,864	156,158	371,790
Large Energy Users	2,139,823	1,434,799	223,992	144,648	336,384
Food products	370,735	319,005	34,012	9,853	7,865
Beverages	41,837	30,198	10,688	835	116
Textiles	191,878	165,417	11,842	10,794	3,825
Apparel	194,803	162,048	20,661	4,135	7,959
Paper products	60,317	47,367	9,416	814	2,720
Chemicals	110,715	83,704	12,043	3,269	11,699
Rubber products	77,217	42,906	14,677	8,157	11,477
Plastics	132,519	98,349	9,860	7,625	16,685
Non-metallic mineral products	111,203	97,051	8,685	2,510	2,957
Basic metals	49,394	35,459	5,768	2,416	5,751
Metal products	133,466	83,901	18,898	3,584	27,083
Non-electric machinery	121,378	64,974	19,013	9,554	27,837
Electronics-related machinery	393,014	125,439	31,470	52,724	183,381
Motor vehicles	112,658	57,134	9,644	19,361	26,519
Other transport equipment	38,689	21,847	7,315	9,017	510
Small Energy Users	369,188	283,400	38,872	11,510	35,406
Tobacco	8,100	7,276	824	0	0
Leather, footwear	64,522	55,786	4,792	555	3,389
Wood products	52,402	50,069	1,723	352	258
Publishing	53,230	43,960	7,875	205	1,190
Petroleum products	7,616	6,216	1,002	398	0
Miscellaneous & recycling	183,318	120,093	22,656	10,000	30,569

Source: Compilations from data underlying National Statistical Office (2009).

Appendix Table 4: Unpaid Labor in Sample Plants (number)

Industry	Total	Local	MNCs by foreign share 10-49%	50-89%	90%+
Manufacturing	9,239	8,398	285	125	431
Large Energy Users	7,369	6,608	230	112	419
Food products	2,015	1,977	26	11	1
Beverages	124	124	0	0	0
Textiles	658	641	17	0	0
Apparel	638	604	16	5	13
Paper products	304	283	14	5	2
Chemicals	368	313	11	37	7
Rubber products	166	142	15	9	0
Plastics	404	350	30	22	2
Non-metallic mineral products	760	733	19	1	7
Basic metals	146	142	1	3	0
Metal products	616	573	25	7	11
Non-electric machinery	274	249	13	0	12
Electronics-related machinery	707	324	25	6	352
Motor vehicles	149	115	18	6	10
Other transport equipment	40	38	0	0	2
Small Energy Users	1,870	1,790	55	13	12
Tobacco	36	36	0	0	0
Leather, footwear	283	280	3	0	0
Wood products	510	498	12	0	0
Publishing	276	268	7	1	0
Petroleum products	38	29	9	0	0
Miscellaneous & recycling	727	679	24	12	12

Source: Compilations from data underlying National Statistical Office (2009).