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# Foreign Ownership and Energy Efficiency in Thai Manufacturing Plants

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## Abstract

This paper examines two aspects of the effects of foreign multinational enterprises (MNEs) on energy efficiency in Thai manufacturing using data on medium-large plants from the industrial census for 2006. First, descriptive statistics and results of econometric estimation indicate that MNEs had a moderate tendency to use energy relatively efficiently, especially in food products, plastics, basic metals, and non-metallic mineral products. However, after accounting for the influences of plant-level factor usage and technical characteristics, differences in energy intensities between MNEs and local plants were not common, suggesting that both groups of plants generally used energy with similar efficiency. Second, industry-level, descriptive statistics suggest 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 more energy intensive. However, this result is sensitive to the choice of sample industries, the measure of MNE presence used, and particularly to the level of aggregation used when measuring defining MNE presence.

**Keywords:** multinational enterprise, energy efficiency, spillover, Thailand, manufacturing
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# 1. Introduction

This paper asks how foreign multinational enterprises (MNEs) affected two aspects of energy efficiency in Thailand's medium-large, manufacturing plants in 2006, defining energy efficiency as the ratio of purchased energy (electricity and fuel) to gross output.[2] It first asks whether plants controlled by MNEs used energy more efficiently than medium-large, local plants. It then examines whether MNE presence in an industry affected local plant energy efficiency in that industry (i.e., if intra-industry, energy efficiency spillovers from MNEs existed).

Answering these questions is important because energy consumption is usually the largest ultimate source of air pollution generated by manufacturing plants. Greater energy conservation generally implies increased energy efficiency and is an important way to limit or reduce this pollution, especially in developing economies like Thailand where incentives for pollution abatement have been relatively weak. Much of the more advanced energy saving technology in the world is controlled by MNEs. It is thus possible that MNEs will use energy more efficiently than non-MNEs and that the presence of foreign MNEs might create spillovers that lead local plants or to use energy with greater efficiency.

The paper first reviews the relatively sparse, previous literature analyzing energy efficiency differentials between foreign MNEs and local firms or plants in developing economies, as well as related literature on MNE-local productivity differentials productivity spillovers from MNEs to local firms or plants (Section 2). Second, it describes the database used, compares energy expenditures and energy intensities in MNEs and local plants, and foreign MNE shares of labor and output local plants (Section 3). It then analyzes whether MNE-local differentials in energy intensities or if 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.

# 2. Energy Efficiency in MNEs and Energy Spillovers to Local Firms

Most theoretical analysts agree that MNEs tend to possess relatively large amounts of technological knowledge and networks, marketing expertise and networks, especially international ones, and sophisticated and capable management.[3]

[2] Energy produced by plants or abatement efforts are not considered.

[3] Correspondingly, MNEs have 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). Most

Correspondingly, Dunning (1988) asserted that a firm must first have "ownership advantages" related to possession of intangible assets, as well as "location advantages" and "internalization advantages" before investing.[4] If MNEs have relatively large amounts of knowledge-based, intangible assets, MNEs will tend to be relatively efficient producers compared to non-MNEs. Thus, MNEs are likely to use at least one of their main inputs such as energy, other materials, labor, or capital more efficiently than non-MNEs. MNEs may also create spillovers affecting the efficiency local firms, which are predominantly non-MNEs.

*2a. MNEs, Productivity, and Energy Efficiency in Developing Economies*

Energy conservation and pollution control often require relatively sophisticated technologies that MNEs possess in relatively large amounts. MNE consumers in richer economies also tend to favor products and services of firms with strong environmental protection. Correspondingly, evidence from Cole et al. (2006) suggests that Japanese firms with foreign direct investment (FDI) tend to have better environmental performance (pollute less and manage emissions better) than firms without FDI.

Although the existing literature on energy efficiency is limited, most of it indicates that MNEs tend to be relatively energy efficient, and thus tend to pollute less, than local counterparts. For example, Eskeland and Harrison (2003, 16-18) derive an energy demand model from a translog production function, and interpret the dependent variable as the share of energy's factor income in output, or energy intensity. Independent variables are other factor inputs (other intermediate consumption, fixed assets, and labor), the quantity of energy used, and factors related to a plant's technological sophistication such as plant vintage and the ratio of R&D expenditures to output or sales. One of their main findings (p. 21) was "foreign plants are significantly more energy efficient and use cleaner types of energy" than their local peers in Coˆte d'Ivoire, Mexico, and Venezuela. Ramstetter et al. (2013) and Ramstetter and Narjoko (2014) used similar methodologies finding that MNE plants generally used energy relatively efficiently in the manufacturing industries of Indonesia, Malaysia, and Thailand, but that MNE-local differentials were often insignificant after plant- and industry-level characteristics were accounted for. Using a different methodology and sample, Hartono et al. (2011) find that local, private

theoretical analyses seek to explain why the MNE chooses to invest abroad when it (at least) initially has several cost disadvantages compared to local firms, and why it diversifies production across countries rather than concentrates in one location (Caves 2007; Dunning and Lundan 2008; Markusen 2002).

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

plants tended to have significantly higher energy intensities than state-owned enterprises (SOEs), but that MNE-SOE differentials in energy intensities were not significant statistically. In a related study of provincial data, He (2006) provides evidence that FDI enterprises produce "with higher [SO2] pollution efficiency", but that stronger environmental regulation has simultaneously, though moderately, deterred FDI among Chinese provinces.

Because energy demand functions are essentially inverse production functions, it is not surprising that the more voluminous literature on productivity differentials yields similar findings. For example, studies of productivity differentials between foreign MNEs and local plants in the manufacturing industries of Malaysia (Oguchi et al 2002, Haji Ahmad 2010 chapter 6) and Thailand (Ramstetter 2004, 2006) suggest that productivity differentials were relatively small and often statistically insignificant. Evidence for China (Jefferson and Su 2006), Indonesia (Takii 2004, 2006) and Vietnam (Ramstetter and Phan 2013) suggests that significant productivity differentials between MNEs and local plants were somewhat more common when estimates were performed in large heterogeneous samples of manufacturing firms or plants. However, differentials often become statistically insignificant when samples are disaggregated by industry in Indonesia and Vietnam.

*2b. Energy Spillovers*

In this context, spillovers refer to the effects that foreign MNE presence has on local plants and operate through at least three major channels. The first channel is direct linkages between MNEs and local plants. Backward linkages are usually though to be more important than forward linkages in this context. Labor mobility is a second channel that can be especially important when managers or technical staff leave MNEs to join local firms or set up their own firms. The entry or expansion of foreign MNEs can create a third competition effect that results when local plants are motivated to increase efficiency in order to compete with MNEs.

Several literature 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).[5] 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,

[5] 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.

estimates of spillovers are larger when cross sectional methodologies are used, but fixed effects estimates using panel data are currently thought to be more reliable.[6]

The most comprehensive studies of spillovers in Thailand are cross section studies using 1996 census data. Industry-level results from Kohpaiboon (2006a, 2006b) and plant-level results from Ramstetter (2006) suggested positive productivity spillovers from MNEs. Kohpaiboon's results suggested that spillovers were relatively strong in industries with relatively low protection. 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. In a sample of MNEs in Greater Bangkok, Sajarattanochote and Poon (2009) found evidence of limited regional spillovers to first- and second-order neighbors and large variation in technology transfers depending on the MNE's nationality, sector, size, and age.

For Indonesia, cross section evidence in 1980 and 1991 from Blomström and Sjöholm (1999) and Sjöholm (1997, 1999a, 1999b) indicated that productivity spillovers tended to be positive, and relatively strong in industries with intense competition among local plants and in regions with diversified industrial structures. There was inconsistent evidence of large spillovers in industries with large technological gaps between MNEs and local plants, while foreign ownership shares and geographical proximity did not affect spillovers. Panel analysis for 1990-1995 (Takii 2005, 2006) found positive intra-industry spillovers that were stronger in industries with small technical gaps and from minority-foreign MNEs. 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.

For China, analysis of a firm-level panel for 1998-2005 by Lin et al (2009) indicates that HMT (Hong Kong, Macao, Taiwan) firms generated negative horizontal spillovers, while non-HMT firms created positive horizontal spillovers. They also found that both state-owned and non-state firms benefitted from strong vertical spillovers. Liu's (2008) evidence for 1995-1999 suggests that intra-industry spillovers were negative in the short term, but positive in the long term, and that backward linkages were the most important spillover channel. Xu and Sheng's (2012) results for 2000-2003 indicate that positive spillovers occur through forward linkages when domestic firms purchase high-quality intermediate goods or equipment from foreign firms, but that the extent of spillovers varies greatly among domestic firms. Du et al (2012) found that non-HMT MNE presence had positive effects on all individual firm level productivity in 1998-2007, while HMT presence

[6] 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.

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 as well as forward linkages to their local buyers. 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) used Cobb-Douglas estimates and found positive productivity spillovers for 2000-2004 when MNE presence was measured as value added or fixed assets' shares, but insignificant or negative spillovers when MNE presence was measured as employment shares. Haji Ahmad (2010, Ch. 7) used the same data set and a more general translog production function, but found little evidence of significant spillovers. In more homogeneous samples, she also found that the results varied greatly among industry sub-groups.

For Vietnam, Pham's (2008) cross section, Cobb-Douglas estimates found positive spillovers that were largest in Hanoi and Ho Chi Minh City, and from MNEs that were not wholly-foreign. Nguyen et al. (2008) found that backward, vertical spillovers were positive in manufacturing, while horizontal spillovers were positive in services. Le and Pomfret (2011) analyzed 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. In contrast, Ramstetter and Phan (2013) found no consistently significant spillovers in 2001-2006. In sum, cross section results generally suggest some degree of positive spillovers, but results vary depending on specification, sample, and productivity measure, and evidence from panel analysis is relatively weak.

## 3. The Data, Energy Expenditures and Intensities, and Foreign Shares

This analysis relies on plant-level data for 2006 collected for the Thai industrial census in 2007. The data set included 73,391 plants, but 50,771 small plants with 19 or fewer workers were excluded (Table 1).[7] Almost all of the excluded small plants (99.7 percent) were local plants with foreign ownership shares under 10 percent.[8] Local plants also accounted for the vast majority of the workers (99.4 precent) and expenditures on fuel and electricity (97.7 percent) in the excluded small

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

[8] These 50,771 small plants were a small portion of the total number of small plants in published estimates (i.e., they were a sample of the population of small plants). Consistent with international standards, MNEs are defined as plants with foreign ownership shares of 10 percent or more.

plants. These predominately local, small plants were excluded because it is not economically meaningful to compare their energy intensities or other technologies with those of MNEs, which are usually much larger. On the other hand, some of the excluded small plants probably had the potential to be affected by spillovers from MNEs, though most were probably not affected by MNE presence. Exclusion of small plants also has the benefit of removing most extreme outliers from the sample. 4,169 of the medium-large plants with 20 or more workers reported unusually low values for output per worker (50,000 baht or less), value added per worker (10,000 baht or less), and fixed assets per worker (10,000 baht or less).[9] These plants were excluded because low values of these indicators suggest their data are unreliable in important respects and to further reduce the influence of outliers. Medium-large plants reporting extremely low values of these key variables were also predominantly local (98 percent; calculated from data underlying Table 1). However, local plants accounted for somewhat smaller shares of the workers (87 percent) and fuel and electricity expenditures (56 percent) in plants with extremely low values of these variables.

Among the remaining 18,765 medium-large plants, there were 4,828 duplicate records reporting the same values for 11 key variables as another record.[10] The vast majority (87 percent) had different location information but identical performance information. This suggests that a large number of plants belonging to multi-plant firms and operating in different locations reported the identical firm-level information, as in the 1996 census (Ramstetter 2004, 2006). Duplicates were primarily local plants (93 percent), but local plant shares of workers (82 percent) and fuel and electricity expenditures (76 percent) were lower (calculated from data underlying Table 1). Duplicates also accounted for 21 percent of heavily-foreign plants (90 percent or more foreign ownership), 9 percent of majority-foreign plants (50-89 percent foreign ownership), and 11 percent of minority foreign plants (10-49 percent foreign ownership). In order to avoid double counting, maximize sample size, and coverage of large, multi-plant firms, 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 dissatisfactory because it results in a database that mixes up firm- and plant-level information. Perhaps the most obvious, resulting

[9] These cutoffs are all less than 3.3 percent 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).

[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.

difficulty is distortion of location information. In economies like Thailand where there are many multi-plant firms, this also complicates economic interpretation because the meaning of firm- and plant-level analyses 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 (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 higher average labor productivity and capital intensity than local plants in this sample. On the other hand, the share of MNEs in energy (electricity and fuel) expenditures (43 percent) was similar to shares of value added and output. In other words, energy intensities, measured as the ratio of energy expenditures to gross output or value added, were on average rather similar in MNEs and local plants.

15 large energy using industries accounted for an average of 92 percent of energy expenditures by Thailand's medium-large manufacturing plants in 2006 (Table 2).[11] Energy intensities tended to be larger in the 15 large energy using industries than in the overall manufacturing sample for all ownership groups except heavily-foreign MNEs (Table 3). The primary reason that these industries have relatively high energy intensities is their use of relatively energy-intensive production processes compared to other industries. This paper focuses on the analysis of the 15 large energy using industries because they are likely to be the largest source of energy-related degradation or pollution in Thai manufacturing.

The eight largest energy using industries are of particular concern. The largest was electronics-related machinery (38 billion baht or 15 percent of the manufacturing total, including excluded industries), followed by food, textiles, and non-metallic mineral products (19-22 billion baht or 8.2-9.8 percent each), and then chemicals, motor vehicles, non-electric machinery, and other transport equipment (15-19 billion baht or 6.0-7.4 percent each; Table 2). As might be expected, the combined share of these eight industries in energy expenditures (68 percent) was larger than corresponding shares of manufacturing output (65 percent) or employment (58 percent). Among other industries, output or employment shares were larger than the 6 percent threshold in only two case, petroleum products' output share (6.2 percent) and apparel's employment share (7.8 percent). On the other hand,

[11] In this paper, most of these industries (10 of the 15) are defined at the 2-digit level of the International Standard Industrial Classification (ISIC), three (beverages, rubber, and plastics) are 3-digit categories, one (food) is a combination of 3-digit categories, and the final one (electronics-related machinery) is a combination of four closely related 2-digit categories.

several of the eight large energy using industries accounted for less than 5 percent of output (textiles=3.8 percent, non-metallic mineral products=3.1 percent, other transport equipment=2.5 percent) or employment (non-electric machinery=4.8 percent, motor vehicles, chemicals, and non-metallic mineral products=4.4-4.5 percent each, other transport machinery=1.5 percent). In contrast, electronics-related machinery and food products accounted for large shares of output (18 and 12 percent, respectively) and employment (16 and 15 percent, respectively), in addition to energy.

The MNE share of electricity and fuel expenditures in the 15 large energy using industries was slightly higher than the average for all manufacturing (45 vs. 43 percent, Table 2). MNE shares were largest (61-88 percent) in the four machinery industries (non-electric machinery, electronics-related machinery, motor vehicles, and other transport equipment). However, MNE ownership patterns differed markedly among industries. Heavily-foreign MNEs were relatively large in electronics-related machinery and motor vehicles, majority-foreign MNEs relatively large in other transport equipment, and minority-foreign MNEs relatively large in non-electric machinery.

The first question of this paper is whether MNEs use energy more efficiently than local plants in Thailand. If one compares industry-level energy intensities among ownership groups, there is little evidence of a strong relationship between ownership shares and energy intensities (Table 3). If one averages mean intensities across all 15 large energy consuming industries, heavily-foreign and majority-foreign MNEs do have lower intensities than local plants, but the differential is small, only 0.23-0.27 percentage points. And mean intensities were almost identical for minority-foreign MNEs local plants. Industry-level differentials between wholly-foreign MNEs and local plants were usually negative (11 of 15 industries) but relatively large, negative differentials of less than -1 percentage point were observed in only five of the 15 industries. Similarly, large positive differentials of greater than 1 percent were observed in three industries. For minority- and majority-foreign plants, relatively large positive differentials were equally as common as relatively large negative differentials (4 industries each for minority-foreign plants and 6 each for majority-foreign plants).

The paper’s second concern is how foreign ownership shares correlate to energy intensities of local plants. In this respect, industry-level correlations of mean energy intensities for local plants to foreign MNE shares of both labor and output were negative for all MNE groups (Table 4). Correlations to output shares were 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 was true for minority-foreign MNEs (-0.27 vs. -0.44). Industry-level correlations of local plant energy intensities to total MNE shares were also negative and even stronger, both when MNE presence was measured in terms of labor (-0.63) or output (-0.75). In other words, at the industry level, there was a tendency for local plants to use relatively less energy per unit of output in industries where MNE presence was relatively large. This result was qualitatively consistent despite large variation of MNE shares depending on the measure used.

Similar to shares of energy expenditures, heavily-foreign MNEs were the largest of the three MNE groups, accounting just under one-fourth of the output and one-sixth of the labor in the 15 sample industries (Table 4). 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 largest in other transport machinery (23 and 56 percent, respectively), but varied greatly depending on whether measure in terms of labor or output. In contrast, 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.

## 4. Estimating Energy Intensities

The simple industry-level comparisons in Tables 3 and 4 suggest that MNE-local differentials in energy intensities were generally rather small and their direction was not very consistent among these 15 industries, but that there may have been stronger negative correlation between local plant energy intensities and MNE ownership shares. However, these comparisons may mask important plant-level differences and fail to adequately reflect the influences of variation in other factor inputs and technological characteristics on energy use in sample plants. Correspondingly, this section examines the relationships among MNE ownership, MNE ownership shares, and energy intensities after accounting for the effects of other factor use and technical characteristics of plants. To this end, a model similar to that in Eskeland and Harrison (2003) is estimated. The models are derived by differentiating “a translog approximation to a production function” with respect to the energy input in question and interpreted as “inverse input demands” (p. 16).

*4a. Conditional MNE-Local Differentials in Energy Intensities*

In Eskeland and Harrison (2003), 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. Unfortunately, the Thai data do not include information on the quantity of energy consumed so this variable must be omitted.[12] 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.[13] 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.

MNE-local differentials in energy intensities can be measured by adding dummy variables that identify MNE ownership groups and using local plants as the reference group in a sample of all plants. The resulting model is:

$$EP_{ij} = a0 + a1\left(LE_{ij}\right) + a2\left(LK_{ij}\right) + a3\left(LM_{ij}\right) + a4\left(RD_{ij}\right) + a5\left(YR_{ij}\right) + a6(DF_{ij}) \quad (1)$$

where

$DF_{ij}$ = a dummy equal to 1 if plant i of industry j is an MNE, 0 otherwise

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

$LE_{ij}$ = natural log of the number of workers in plant i of industry j

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

$LM_{ij}$ = natural log intermediate consumption excluding fuel and electricity in plant i of industry j (baht)

$RD_{ij}$ = ratio of R&D expenditures to gross output in plant i of industry j (percent)

$YR_{ij}$ = years of operation for plant i of industry j (percent)

[12] If energy prices were equal for all plants, the value variable could be used instead, but prices vary among plants depending on energy mix, quantities consumed, and the timing of consumption.
[13] In addition, Eskeland and Harrison (2003) also include machinery imports as indicators of plant sophistication, but they are not available from this data set.

If the coefficient *a6* is negative and statistically significant, for example, it would mean that MNEs had significantly lower energy intensities 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:

$$EP_{ij} = b0 + b1\left(LE_{ij}\right) + b2\left(LK_{ij}\right) + b3\left(LM_{ij}\right) + b4\left(RD_{ij}\right) + b5\left(YR_{ij}\right) + b6(DF1_{ij}) + b7\left(DF5_{ij}\right) + b8(DF9_{ij}) \quad (2)$$

where
$DF1_{ij}$ = a dummy equal to 1 if plant i of industry j is a minority-foreign (10-49%) MNE, 0 otherwise
$DF5_{ij}$ = a dummy equal to 1 if plant i of industry j is a majority-foreign (50-89%) MNE, 0 otherwise
$DF9_{ij}$ = a dummy equal to 1 if plant i of industry j is a majority-foreign (90-100%) MNE, 0 otherwise

Because all slope coefficients are likely to differ across the 15 industries (reflecting the heterogeneity of energy requirements among them), the emphasis is on analysis of regressions performed at the industry level. These results are then compared to regressions for all major polluting industries combined. However, these 15 industries are rather aggregate, generally being defined at the 2-digit level. Thus, industry effects are further accounted for by comparing estimates including 3-digit industry dummies as feasible for each sample.[14]

There are at least three potentially important problems with these estimates. First, as explained above, removal of duplicates has the unfortunate consequence of making the use of location dummies meaningless. Thus, we cannot control for the effect of plant location accurately when using these data. Second, the lack of data on energy quantities creates a potentially important omitted variable problem. Third, there are obvious concerns over potential simultaneity, particularly among plants' choice of

[14] As noted above, three of the 15 industries (beverages, rubber, and plastics) are 3-digit categories making the use of 3-digit dummies meaningless. In industries where further disaggregation is meaningful, robustness check were also performed using 4-digit dummies with qualitatively similar results (Ramstetter and Kohpaiboon 2012, Tables 4-5). Further robustness checks were also performed using an alternative, yearend estimate of fixed asset stocks, again with qualitatively similar results. The initial capital stock is preferable because it reduces the chances of simultaneity issues becoming problematic.

energy, labor, and material inputs. However, we were unable to find adequate instruments for capital, labor, and other intermediate consumption. Correspondingly, simultaneity remains a potential problem in these cross section estimates. On the other hand, all estimates use robust standard errors to account for potential heteroscedasticity and provide a more detailed examination of MNE-local differentials in energy intensities than previously available.

When equations (1) and (2) were estimated in large samples of the 11,322 plants in all 15 large energy consuming industries combined, coefficients on labor, capital, and vintage were positive and highly significant at the 1 percent level and the coefficient on intermediate consumption other than energy was negative and highly significant (Ramstetter and Kohpaiboon 2012, p. 24, 38). In other words, labor and capital complemented the use of labor, while other intermediates were a substitute. Older plants had significantly higher energy intensities, consistent with the notion that newer plants are generally more energy efficient. However, R&D had no significant effect on energy efficiency. When equations (1) and (2) were estimated for the 15 industries separately, coefficients on capital were positive and significant at the standard 5 percent level in 23 of 30 estimates, while coefficients on other intermediates was negative and significant in 26 estimates (Ramstetter and Kohpaiboon 2012, pp. 39-46). Coefficients on labor were also positive when significant, but were insignificant in 18 estimates. Coefficients were also insignificant in most estimates for vintage (26) and R&D (27). In other words, although the controls in models (1) and (2) performed relatively well in the large, combined sample, many control coefficients became insignificant at the industry level.

The fit of both equations (1) and (2) was also rather poor; $R^2$ was only 0.10 in the large, combined sample and between 0.02 and 0.11 in 14 of the 15 industry samples (Table 5). It was a bit higher (0.18) in the food products industry, and low $R^2$ values are common in cross sections. However, these models did not explain variation in energy intensities particularly well. One reason for low explanatory power is that coefficients on the foreign ownership were rarely significant, both in the large, combined sample, and in 10 of the 15 industry-level samples. In food products, plastics, and basic metals, MNE-local differentials were negative and significant and tests of the null hypothesis that MNE-local differentials were the same for minority-, majority- and heavily-foreign MNEs could not be rejected. In non-metallic mineral products, the null of identical differentials for all MNE groups was rejected and there were significantly differentials involving majority- and heavily-foreign MNEs. This null was also rejected in beverages, but the only significant differential (involving heavily-foreign MNEs) was positive. Coefficients were also negative and significant for heavily-foreign MNEs in paper or weakly significant for heavily-foreign MNEs non-electric machinery, but the null of identical coefficients for all MNE group could not be rejected and results from equation (1) suggested the coefficient for all MNEs was insignificant.

In short, these estimates provide weak evidence that all MNEs tended to have lower energy intensities and thus be more energy efficient than local plants in Thai manufacturing in food products, plastics, and basic metals, while heavily-foreign MNEs were relatively energy efficient in non-metallic mineral products. On the other hand, heavily-foreign MNEs had relatively high energy intensities in beverages and the most prominent result was that MNEs and local plants tended to have similar energy intensities in most industries, and when all sample plants were combined.

*4b. Intra-industry Spillovers*

To examine the extent of intra-industry spillovers, the sample is first limited to local plants, which makes foreign ownership dummies irrelevant. The effect of MNE presence on local plant energy intensities is then captured by adding MNE ownership shares of labor or output in the relevant industry as independent variables. The resulting model is:

$$EP_{ij} = c0 + c1\left(LE_{ij}\right) + c2\left(LK_{ij}\right) + c3\left(LM_{ij}\right) + c4\left(RD_{ij}\right) + c5\left(YR_{ij}\right) + c6(FS_j \quad (3)$$

where

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

If the coefficient $c6$ is significantly 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 these spillover estimates differ depending on the MNE ownership share:

$$\begin{aligned} EP_{ij} &= d0 + d1\left(LE_{ij}\right) + d2\left(LK_{ij}\right) + d3\left(LM_{ij}\right) + d4\left(RD_{ij}\right) + d5\left(YR_{ij}\right) \\ &\quad + d6(FS1_j) + d7\left(FS5_j\right) + d8(FS9_j) \end{aligned} \quad (4)$$

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 (3) and (4) are first estimated in large samples of all 15 large energy using industries. Foreign shares of output are measured at both the 3- and 4-digit levels to check the robustness of the results.[15] In estimates of equation (3), the coefficient on the foreign share variable is always positive and significant at the standard 5 percent level and usually highly significant at the 1 percent level (Table 6). However, when equation (4) is estimated, tests of the null hypothesis that coefficient MNE share coefficients were identical for all MNE ownership groups is always rejected at the 1 percent level so these estimates are probably more accurate. When MNE shares are measured at the 3-digit level, their coefficients are positive and significant for all ownership groups, and largest for majority-foreign MNEs, followed by minority foreign MNEs, and lastly by wholly-foreign MNEs. In other words, the results suggest that local plant energy intensities were higher in industries where MNE presence was relatively large and that the effects of majority-foreign MNE presence was strongest, while the effects of heavily-foreign MNE presence was weakest. When MNE shares are measured at the 4-digit level, the effects of minority-foreign MNE presence become insignificant but results for majority-foreign MNEs (strongest) and heavily-foreign MNEs (weakest) are significant and qualitatively similar to the 3-digit results. In short, if plant-level factor usage, R&D intensity, and vintage are accounted for, there were strong, positive correlations of most MNE shares to local plant energy intensities. These results contrast starkly with the negative, industry-level correlations reported in Table 4.

To investigate this possibility that these correlations differ among industry groups, we divide the sample into two groups, first by energy purchase levels and second by energy intensity. Results for the 5,692 local plants in the eight largest energy using industries (expenditures of 15 billion baht or more: food, textiles, chemicals, non-metallic mineral products, non-electric machinery, electronics-related machinery, motor vehicles, and other transport machinery) and results for the 4,808 local plants in the six most energy intensive industries (mean intensities of 6.0 percent or more: food, beverages, textiles, plastics, non-metallic mineral products, and basic metals), were similar to the results for all 15 industries combined in three important respects (Table 6). First, when equation (3) was estimated, the coefficient on the MNE share was always positive and usually highly significant, the 4-digit labor share for the eight largest energy using industries being the sole exception. Second, when equation (4) was estimated, the null hypothesis that coefficients all MNE groups were equal was always rejected at the 5 percent level or better; hence equation (4) is preferred. Third, when equation (4) was estimated, coefficients on all 3-digit MNE shares were positive and significant and the

[15] As in estimates of equations (1) and (2), robustness checks were also made using an alternative, yearend estimate of fixed asset stocks, again with qualitatively similar results. In addition, we tried added terms interacting the foreign share variables with a dummy identifying plants with R&D, but coefficients on these interaction terms were insignificant in all but a very few estimates.

coefficients for majority-owned MNE shares were always the largest. However, when 4-digit shares were used, the coefficients on minority-foreign MNEs were negative and significant both groups, and the coefficients on majority-foreign MNEs were smaller than the coefficient on heavily-foreign MNEs in the six most energy-intensive industries, but not the in the eight largest energy users. Thus, although results for these groups are similar to each other and to results for the overall sample in important respects, they are sensitive to the level of MNE share disaggregation.

Results for the 3,844 local plants seven smallest users of the 15 large energy using industries listed in (12 billion baht or less: beverages, apparel, paper, rubber, plastics, basic metals, and metal products) and for the 4,728 local plants in the nine industries with relatively low energy intensities (4.7 percent or less: apparel, paper, chemicals, rubber, metal products, non-electric machinery, electronics-related machinery, motor vehicles, and other transport machinery) varied more from results for the other samples considered and from each other (Table 6). In the seven relatively small energy users, equation (4) was again preferred to equation (3) when 3-digit shares were used. In these estimates, spillover coefficients were all negative, usually significant (the output share for minority-foreign MNEs being the sole exception), and largest in absolute value for majority foreign MNEs followed by heavily-foreign MNEs. However, when 4-digit output shares were used, equation (3) was preferred and the coefficient on the MNE share was positive and significant. When 4-digit labor shares were used, all MNE share coefficients were positive and at least weakly significant.

In the nine least energy intensive industries, results were a bit more consistent. Equation (4) was preferred in all cases and coefficients on minority-foreign shares were always insignificant (Table 6). When 4-digit shares were used, coefficients on majority- and heavily-foreign MNE shares were also insignificant if the standard 5 percent level is used. However, if 3-digit shares were used, coefficients on majority-foreign shares were positive and significant while coefficients on heavily-foreign MNE shares were negative and significant. It is also important to point out the explanatory power of both equations (3) and (4) was much weaker in the samples of relatively small energy users and low energy-intensity industries ($R^2$<=0.04) than in the other samples examined ($R^2$>=0.08).

It is notable that correlations of local plant energy intensities to MNE presence are often sensitive to the level of aggregation. I 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, but 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 emphasize that these estimates of energy intensity spillovers differ from previous estimates of productivity spillovers, for example, because they focus on a small portion of input efficiency. Even in the most energy-intensive industries, mean energy intensities were 10 percent or less (local plants in non-metallic mineral products, (Table 3). In contrast, expenditures on raw materials and parts were an average of 57 percent of output (Ramstetter 2013, Table 5). Thus, when examining energy intensities, the focus is on a small portion of the production process.

*4c.What are the Policy Implications?*

The results presented above suggest that MNEs and local plants generally use energy with similar efficiency and provided weak indications that local plants tend to have relatively high energy intensities in industries with relatively large MNE presence. If one believes the first result, and simultaneously believes that the Thai government should encourage greater energy efficiency among manufacturing plants, the clearest policy implication of this study is that policies encouraging energy efficiency should not discriminate on the basis of MNE ownership. Rather policy should seek to promote energy efficiency among all plants, by increasing the cost of energy and encouraging conservation, for example. However, this is a common sense approach to energy and manufacturing policy that is probably valid regardless of the results obtained in this econometric exercise.

The second, weaker result is more difficult to reconcile with the common sense approach to policy because one might interpret the results to mean that restricting foreign presence could lead to greater energy efficiency in local plants. However, even if one ignores the weakness of this result, it is important to reemphasize the important fact that mean energy intensities were 10 percent or less (for local plants in non-metallic mineral products) in all industry-ownership groups examined. Correspondingly, even if MNE presence adversely affects energy efficiency in local plants, effects on inputs other than energy and on other aspects of local plant activity (e.g, wages, exports, imports) are probably more important. Any policy affecting MNE presence should consider all of these effects. The need for caution is amplified by the result's weakness, particularly its sensitivity to aggregation and alternative measures of MNE presence.

It is also important to reemphasize that all results refer to 2006 when energy technologies, particularly renewable energy technologies, and Thai energy policy, both differed greatly from more recent years. Correspondingly, these statistical results are probably of more historical interest than of current policy relevance. It is thus important to update the analysis and to check the robustness of the results, using panel data if possible.

Careful consideration of two changes since 2006 is particularly important. First, the adoption of the *20-Year Energy Efficiency Development Plan* in 2011 represents the Thai government's first serious attempt to reduce energy intensities, and prioritizes reductions in the transportation and industrial (including manufacturing) sectors (Ministry of Energy 2011, p. 1). Nonetheless, general reviews of Thailand's energy policies in 2006-2015 suggest that the top priorities remain to secure "a sufficient and stable energy supply" and "to supervise and maintain energy prices at appropriate, stable and affordable levels" (APERC various years a, quotes from 2015 issue, pp. 225-226). Moreover, the 20-year efficiency plan and other summaries of the plan's salient aspects (APERC, various years b; Intarajinda and Bhasaputra 2012, pp. 68-70) indicates that the plan relies heavily on regulatory measures, many of which do not appear to be transparently formulated. Frequently, Thai regulatory agencies also lack sufficient human resources to administer regulations efficiently.[16] Correspondingly, it is not surprising that ratios of Thailand's aggregate final energy consumption or CO2 emissions to real GDP (standardized as 2002=1) have continued to increase in recent years.[17]

On the other hand, the 20-year plan does break important new ground by suggesting several new taxes designed to promote energy conservation and use of low-carbon alternatives to coal and oil, for example. Although the details are vague and it is difficult to ascertain the extent to which such taxes have been implemented in recent years, a couple of trends suggest that Thailand may be beginning an important transition to a more energy efficient, lower emission society. The most important of the trends is a decline in the use of coal, which accounted for 9-12 percent of final energy consumption in 1997-2010 but only 6 percent of the total in 2011-2014 (EGEDA 2017). In 2014 the quantity of coal consumed was also 44 percent lower than the peak reached in 2010. On the other hand, the share of gas, a much cleaner fuel, rose substantially from 3 percent in 2006 to 8 percent in 2011 and 10 percent in 2014. In addition, although commercial electricity prices in Bangkok were among the lowest among 14 major Asian cities in November 2006, in January 2016 they were among the highest.[18] Nonetheless, gasoline remains relatively cheap in

[16] This is a chronic problem affecting many parts of the Thai bureaucracy, not just energy policy.

[17] Ratios of final energy consumption (EGEDA 2017) to real GDP (NESDB various years) are alternative measures of energy intensities often used in the literature and if normalized for 2002=1, they increased from 0.97-1.01 in 1997-2003 to 1.14-1.24 in 2004-2011, and 1.29-1.33 in 2012-2013, before falling to 1.18 in 2014. Ratios of CO2 emissions (EGEDA 2017) to real GDP (again defined as 2002=1) also increased from 0.94-1.06 in 1997-2003 to 1.10-1.24 in 2004-2011, and 1.25-1.28 in 2012-2013, before falling to 1.21 in 2014.

[18] Commercial electricity prices are the highest marginal price reported in Beijing, Hong Kong, Seoul, Taipei, Yokohama, and 9 of the 10 ASEAN capitals (all except Bandar Seri Begawan) by JETRO

Bangkok, and my impression is that energy taxes designed to promote energy conservation remain relatively low in Thailand. Moreover, until the political will to increase energy taxes becomes stronger, increases in energy efficiency are likely to remain slow.

## 5. Conclusions

This paper began with a review of the substantial literature on how differences between MNEs and non-MNEs might create differences in productivity or energy efficiency between foreign MNEs and local plants in Thai manufacturing, and how local plant productivity and energy efficiency might be affected by MNE presence. Compared to studies of other regions, studies of Asia provide relatively abundant evidence of positive productivity differentials and spillovers, especially for Indonesia and China. Previous studies also suggested positive productivity spillovers in Thailand, but little evidence of significant productivity differentials. Evidence for Malaysia also suggests productivity differentials tended to be insignificant, as were productivity spillovers.

At the industry level, descriptive statistics suggested that MNEs generally used energy somewhat more efficiently than local plants and the 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, most MNE-local energy intensity differentials were insignificant and most correlations between MNE presence and energy intensities in local plants became positive. However, the relatively strong evidence that MNE presence is positively correlated with local plant energy intensities is sensitive to the sample, the measure of MNE presence, and particularly to the level of aggregation at which MNE presence is measured. This sensitivity suggests that MNE presence may be 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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(various years). In 2006 Bangkok and Kuala Lumpur had the lowest prices of these 14 cities, 71 percent cheaper than the cost in the most expensive city, Phnom Penh. In 2006 Bangkok had the fourth highest prices at 70 percent of the most expensive levels in Hong Kong. Gasoline has always been relatively cheap in Bangkok (ranked 9 of 14 and 40 percent of the maximum price (Hong Kong) in 2006 and 12 of 14 or 32 percent of the maximum (in Seoul) in 2016.

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Table 1: Key Indicators for Thai Manufacturing

| Sample | Number of plants | Thousands | | Values in billion baht | | | |
|---|---|---|---|---|---|---|---|
| | | Workers | Paid workers | Fixed assets (avg.) | Elec-tricity, fuel | Output | Value added |
| Published industrial census estimates (NSO 2009) | | | | | | | |
| All plants | 457,968 | 4,460.3 | 3,819.0 | 3,183.2 | 317.7 | 7,304.5 | 1,758.8 |
| 1-15 workers | 431,675 | 983.4 | 396.1 | 300.6 | 10.7 | 262.4 | 91.1 |
| 16+ workers | 26,293 | 3,476.9 | 3,422.9 | 2,882.6 | 307.0 | 7,042.2 | 1,667.7 |
| All plants in database underlying NSO (2009) | | | | | | | |
| All plants | 73,931 | 3,726.4 | 3,591.5 | 2,972.9 | 311.6 | 7,146.6 | 1,716.6 |
| 1-15 workers | 47,638 | 249.5 | 168.7 | 90.3 | 4.6 | 104.4 | 44.2 |
| 16+ workers | 26,293 | 3,476.9 | 3,422.9 | 2,882.6 | 307.0 | 7,042.2 | 1,672.5 |
| 20+ workers | 22,934 | 3,418.6 | 3,371.0 | 2,859.4 | 305.0 | 7,001.2 | 1,661.7 |
| Sample plants | 13,937 | 2,518.3 | 2,509.0 | 2,403.0 | 252.5 | 5,854.6 | 1,378.5 |
| Local plants in database (foreign shares 0-9%) | | | | | | | |
| All plants | 71,274 | 2,782.5 | 2,648.9 | 1,764.9 | 188.7 | 4,093.3 | 1,007.1 |
| 1-15 workers | 47,497 | 248.0 | 167.2 | 88.8 | 4.5 | 99.4 | 43.3 |
| 16+ workers | 23,777 | 2,534.5 | 2,481.7 | 1,676.1 | 184.2 | 3,993.9 | 963.8 |
| 20+ workers | 20,503 | 2,477.7 | 2,431.3 | 1,654.5 | 182.4 | 3,956.4 | 953.6 |
| Sample plants | 11,950 | 1,726.6 | 1,718.2 | 1,355.4 | 144.1 | 3,227.4 | 794.2 |
| Minority-foreign plants in database (foreign shares 10-49%) | | | | | | | |
| All plants | 1,220 | 304.9 | 304.6 | 381.2 | 42.0 | 992.4 | 166.3 |
| 1-15 workers | 97 | 1.0 | 1.0 | 0.6 | 0.1 | 2.0 | 0.5 |
| 16+ workers | 1,123 | 303.9 | 303.6 | 380.5 | 41.9 | 990.4 | 165.8 |
| 20+ workers | 1,063 | 302.9 | 302.6 | 379.6 | 41.8 | 988.6 | 165.6 |
| Sample plants | 909 | 263.1 | 262.9 | 353.0 | 37.3 | 908.3 | 149.4 |
| Majority-foreign plants in database (foreign shares 50-89%) | | | | | | | |
| All plants | 440 | 178.1 | 178.0 | 270.4 | 27.9 | 495.7 | 95.7 |
| 1-15 workers | 20 | 0.2 | 0.2 | 0.2 | 0.0 | 0.7 | 0.1 |
| 16+ workers | 420 | 177.9 | 177.8 | 270.2 | 27.9 | 495.0 | 95.6 |
| 20+ workers | 409 | 177.7 | 177.6 | 269.9 | 27.8 | 494.0 | 95.5 |
| Sample plants | 355 | 156.3 | 156.2 | 225.6 | 25.4 | 451.3 | 87.6 |
| Heavily-foreign plants in database (foreign shares 90-100%) | | | | | | | |
| All plants | 997 | 460.8 | 460.1 | 556.5 | 53.0 | 1,565.2 | 447.6 |
| 1-15 workers | 24 | 0.3 | 0.3 | 0.7 | 0.0 | 2.2 | 0.3 |
| 16+ workers | 973 | 460.6 | 459.8 | 555.8 | 53.0 | 1,563.0 | 447.2 |
| 20+ workers | 959 | 460.3 | 459.6 | 555.3 | 52.9 | 1,562.2 | 447.1 |
| Sample plants | 723 | 372.2 | 371.8 | 469.0 | 45.7 | 1,267.6 | 347.2 |
| Alternative estimates for Thai manufacturing | | | | | | | |
| See notes | - | 5,504.1 | - | 6,114.2 | - | 8,313.2 | 2,812.5 |

Notes: For industrial census data (NSO 2009), fixed assets are averages of initial and ending stocks; for alternative estimates (see Ramstetter and Kohpaiboon 2012 for sources): employment is the average of labor force survey estimates for quarters 1-4; value added and gross output (total income) are from national accounts data; fixed assets (gross capital stock at replacement value) from capital stock estimates; database includes one plant from each set of duplicates and excludes plants with unreasonably low output, value added, or fixed assets per worker (see text for details).

Source: Compilations from data underlying NSO (2009)

Table 2: Fuel and Electricity Expenditures (total in billion baht, MNE shares in percent)

| Industry | MNE shares by ownership group | | | | |
|---|---|---|---|---|---|
| | Total | 10%+ | 10-49% | 50-89% | 90%+ |
| Manufacturing | 252.536 | 43 | 15 | 10 | 18 |
| Large Energy Users | 232.751 | 45 | 15 | 11 | 19 |
| Food products | 24.753 | 13 | 7 | 4 | 2 |
| Beverages | 3.325 | 38 | 31 | 4 | 3 |
| Textiles | 21.990 | 21 | 5 | 13 | 3 |
| Apparel | 6.000 | 25 | 13 | 4 | 8 |
| Paper products | 12.104 | 45 | 17 | 1 | 26 |
| Chemicals | 18.698 | 28 | 14 | 8 | 6 |
| Rubber products | 7.325 | 47 | 24 | 5 | 18 |
| Plastics | 8.828 | 31 | 10 | 6 | 15 |
| Non-metallic mineral products | 20.796 | 8 | 6 | 1 | 1 |
| Basic metals | 12.251 | 41 | 29 | 4 | 9 |
| Metal products | 10.212 | 38 | 12 | 3 | 23 |
| Non-electric machinery | 16.525 | 62 | 43 | 4 | 15 |
| Electronics-related machinery | 38.187 | 84 | 12 | 8 | 64 |
| Motor vehicles | 16.618 | 61 | 13 | 16 | 32 |
| Other transport equipment | 15.138 | 88 | 13 | 74 | 1 |
| Small Energy Users | 19.785 | 23 | 17 | 2 | 4 |
| Tobacco | 1.514 | 2 | 2 | 0 | 0 |
| Leather, footwear | 2.222 | 7 | 4 | 1 | 2 |
| Wood products | 2.790 | 8 | 3 | 4 | 1 |
| Publishing | 2.670 | 14 | 10 | 2 | 3 |
| Petroleum products | 4.218 | 44 | 44 | 0 | 0 |
| Miscellaneous & recycling | 6.371 | 31 | 18 | 5 | 9 |

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

Source: Compilations from data underlying NSO (2009).

Table 3: Fuel and Electricity Intensities in MNEs by Foreign Share (percent of gross output) and MNE-local differentials (percentage points)

| Industry | Energy intensities | | | | MNE-local differentials | | |
|---|---|---|---|---|---|---|---|
| | 0-9% | 10-49% | 50-89% | 90%+ | 10-49% | 50-89% | 90%+ |
| Manufacturing | 5.24 | 4.80 | 4.98 | 5.23 | -0.438 | -0.258 | -0.008 |
| Large Energy Users | 5.40 | 5.39 | 5.16 | 5.13 | -0.013 | -0.236 | -0.274 |
| Food products | 7.58 | 4.79 | 5.96 | 4.54 | -2.790 | -1.622 | -3.035 |
| Beverages | 6.48 | 4.55 | 3.17 | 9.59 | -1.931 | -3.314 | 3.107 |
| Textiles | 6.77 | 7.86 | 8.27 | 6.20 | 1.090 | 1.500 | -0.575 |
| Apparel | 4.39 | 4.13 | 7.25 | 4.22 | -0.260 | 2.858 | -0.173 |
| Paper products | 4.29 | 5.76 | 6.32 | 3.27 | 1.467 | 2.030 | -1.014 |
| Chemicals | 4.55 | 4.05 | 5.49 | 4.38 | -0.499 | 0.940 | -0.174 |
| Rubber products | 4.50 | 5.35 | 3.15 | 3.95 | 0.842 | -1.352 | -0.550 |
| Plastics | 6.05 | 4.28 | 4.24 | 5.16 | -1.773 | -1.813 | -0.893 |
| Non-metallic mineral products | 7.86 | 10.43 | 3.35 | 4.99 | 2.566 | -4.512 | -2.877 |
| Basic metals | 6.23 | 4.48 | 3.45 | 4.77 | -1.746 | -2.777 | -1.458 |
| Metal products | 4.66 | 4.88 | 5.78 | 5.87 | 0.213 | 1.118 | 1.209 |
| Non-electric machinery | 4.56 | 4.69 | 5.76 | 3.41 | 0.137 | 1.207 | -1.151 |
| Electronics-related machinery | 4.41 | 5.63 | 4.08 | 4.54 | 1.224 | -0.326 | 0.129 |
| Motor vehicles | 4.34 | 4.79 | 4.11 | 4.15 | 0.450 | -0.225 | -0.191 |
| Other transport equipment | 4.32 | 5.15 | 7.07 | 7.86 | 0.822 | 2.749 | 3.538 |
| Small Energy Users | 4.83 | 3.33 | 4.42 | 5.61 | -1.500 | -0.404 | 0.784 |

Note: Energy intensities are the ratio of expenditures on fuel and electricity used in production processes to output; figures for manufacturing (21 industries), large energy users (15 industries), and small energy users (6 industries) are means of the industries included in each group.

Source: Compilations from data underlying NSO (2009).

Table 4: MNE Shares of Labor and Output by Ownership Group and Correlations to Energy Intensities in Local Plants (percent)

| Industry | Labor | | | Output | | |
|---|---|---|---|---|---|---|
| | 10-49% | 50-89% | 90%+ | 10-49% | 50-89% | 90%+ |
| 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 local plant energy intensities (15 industries) | (0.26) | (0.44) | (0.47) | (0.60) | (0.27) | (0.55) |

Note: Energy intensities are the ratio of expenditures on fuel and electricity used in production processes to output; correlations of total MNE shares (the sum of minority-, majority-, and heavily-foreign MNE shares) to local plant energy intensities were -0.63 for labor shares and -0.75 for output shares.

Source: Compilations from data underlying NSO (2009).

Table 5: Conditional MNE-Local Differentials in Energy Intentisty in 15 Large Energy Using Industries, Estimates from Equations (1) and (2)

| | Equation (1) | | Equation (2) | | | | | Obser- |
|---|---|---|---|---|---|---|---|---|
| Industry | $DF_i$ | $R^2$ | $DF1_i$ | $DF5_i$ | $DF9_i$ | *TestDF* | $R^2$ | vations |
| 15 industries | -0.1184 | 0.10 | -0.0451 | -0.1249 | -0.3999 | 0.55 | 0.10 | 11,322 |
| Food products | -1.4398 a | 0.18 | -1.6102 a | -0.3804 | -2.2476 | 0.85 | 0.18 | 1,986 |
| Beverages | 0.8745 | 0.08 | 0.4128 | -0.1544 | 6.6527 a | 7.44 a | 0.09 | 165 |
| Textiles | 0.4227 | 0.09 | 0.7537 | -0.1932 | -0.7258 | 0.60 | 0.09 | 955 |
| Apparel | 0.0812 | 0.02 | -0.3349 | 2.6852 | -0.7744 | 0.55 | 0.03 | 895 |
| Paper | 0.3004 | 0.10 | 0.4486 | 1.9320 | -2.5586 b | 2.10 | 0.10 | 485 |
| Chemicals | 0.0309 | 0.07 | -0.4698 | 0.8156 | -0.0946 | 0.73 | 0.07 | 869 |
| Rubber | -0.2387 | 0.11 | 0.2527 | -1.1319 | -0.6618 | 0.70 | 0.11 | 332 |
| Plastics | -1.2293 a | 0.02 | -1.5300 a | -1.6988 | -0.5985 | 0.64 | 0.02 | 1,004 |
| Non-metallic mineral products | -0.4826 | 0.07 | 1.6611 | -4.6616 a | -4.2353 a | 7.02 a | 0.08 | 891 |
| Basic metals | -1.5818 b | 0.05 | -1.6794 c | -2.4218 c | -1.1011 | 0.37 | 0.05 | 372 |
| Metal products | 0.4597 | 0.03 | -0.0507 | 0.7464 | 0.5146 | 0.17 | 0.03 | 1,239 |
| Non-electric machinery | -0.2983 | 0.06 | 0.1999 | 0.6646 | -1.5138 c | 2.09 | 0.07 | 784 |
| Electronics-related machinery | 0.7142 | 0.05 | 1.2761 | -0.0203 | 0.6396 | 0.66 | 0.06 | 817 |
| Motor vehicles | -0.2301 | 0.04 | 0.1608 | -0.6712 | -0.4642 | 0.23 | 0.04 | 449 |
| Other transport machinery | 0.9792 | 0.10 | -0.1272 | 1.7636 | 3.9577 | 0.58 | 0.11 | 159 |

Notes: a=signficant at the 1% level, b=significant at the 5% level, c=significant at the 10% level (all p-values based on robust standard errors); estimated equations also include 3-digit industry dummies as relevant (see explanation in the text); the *TestDF* column shows results of a Wald test of the null hypothesis that *DF1i=DF5i=DF9i*; for robustness checks using alternative defintions of capital and industry dummies, estimates of other slope coefficients, and precise p-values, see Ramstetter and Kohpaiboon (2012, Appendix Tables 4, 5).

Table 6: Correlations of MNE Presence to Energy Intensities in Local Plants in 15 Large Energy Using Industries, Estimates from Equations (3) and (4)

| Industries, | Equation (3) | | Equation (4) | | | | |
|---|---|---|---|---|---|---|---|
| specification | $FS_j$ | $R^2$ | $FS1_j$ | $FS5_j$ | $FS9_j$ | *TestFS* | $R^2$ |
| 15 large energy consuming industries, 9,536 observations | | | | | | | |
| 3-digit labor shares | 0.0392 a | 0.08 | 0.0628 a | 0.1280 a | 0.0373 a | 11.74 a | 0.08 |
| 3-digit output shares | 0.0729 a | 0.08 | 0.0880 a | 0.0899 a | 0.0619 a | 5.75 a | 0.08 |
| 4-digit labor shares | 0.0159 b | 0.08 | -0.0006 | 0.0506 a | 0.0348 a | 4.81 a | 0.08 |
| 4-digit output shares | 0.0374 a | 0.08 | -0.0064 | 0.0743 a | 0.0534 a | 27.15 a | 0.08 |
| 8 largest energy consuming industries, 5,692 observations | | | | | | | |
| 3-digit labor shares | 0.0483 a | 0.09 | 0.0552 b | 0.1276 a | 0.0489 a | 6.45 a | 0.10 |
| 3-digit output shares | 0.0788 a | 0.10 | 0.0875 a | 0.0932 a | 0.0692 a | 3.07 b | 0.10 |
| 4-digit labor shares | 0.0125 c | 0.09 | -0.0393 b | 0.0496 a | 0.0479 a | 3.64 b | 0.10 |
| 4-digit output shares | 0.0377 a | 0.08 | -0.0223 b | 0.0717 a | 0.0529 a | 28.05 a | 0.10 |
| 7 smaller energy users of the large energy consuming industries, 3,844 observations | | | | | | | |
| 3-digit labor shares | -0.0271 | 0.04 | -0.0409 b | -1.0607 a | -0.1680 a | 6.49 a | 0.03 |
| 3-digit output shares | -0.0120 | 0.04 | -0.0290 | -1.1777 b | -0.1652 a | 5.68 a | 0.04 |
| 4-digit labor shares | 0.0418 a | 0.04 | 0.0573 a | 0.1099 a | 0.0291 c | 4.07 a | 0.04 |
| 4-digit output shares | 0.0288 b | 0.04 | 0.0252 c | 0.0839 b | 0.0462 a | 1.30 | 0.04 |
| 6 most energy-intensive, large energy consuming industries, 4,808 observations | | | | | | | |
| 3-digit labor shares | 0.3151 a | 0.08 | 0.2582 a | 1.4077 a | 0.3996 a | 28.00 a | 0.10 |
| 3-digit output shares | 0.3051 a | 0.10 | 0.2406 a | 0.5327 a | 0.3089 a | 12.80 a | 0.11 |
| 4-digit labor shares | 0.0492 a | 0.08 | -0.0594 b | 0.0639 c | 0.4704 a | 30.36 a | 0.10 |
| 4-digit output shares | 0.1298 a | 0.09 | -0.0728 a | 0.2313 a | 0.3240 a | 63.75 a | 0.13 |
| 9 least energy-intensive, large energy consuming industries, 4,728 observations | | | | | | | |
| 3-digit labor shares | -0.0022 | 0.03 | -0.0028 | 0.0527 a | -0.0233 b | 9.14 a | 0.03 |
| 3-digit output shares | -0.0087 | 0.03 | -0.0098 | 0.0233 b | -0.0239 a | 9.75 a | 0.04 |
| 4-digit labor shares | -0.0007 | 0.03 | 0.0038 | 0.0226 c | -0.0095 | 3.28 b | 0.03 |
| 4-digit output shares | -0.0057 | 0.03 | -0.0086 | 0.0139 c | -0.0108 c | 2.93 b | 0.03 |

Note: see text for a detailed definition of industry groups by use and by intensity; a=significant at the 1% level, b=significant at the 5% level, c=significant at the 10% level (all p-values based on robust standard); estimated equations also include 3-digit industry dummies as relevant (see explanation in the text); the *TestFS* column shoes results of a Wald test of the null hypothesis that *FS1j=FS5j=FS9j*; detailed results including robustness checks using alternative definitions of capital and interaction of foreign shares with a dummy identifying plants with R&D, estimates of other slope coefficients, and precise p-values are available from the authors.

Source: Author's estimate