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# Energy Savings through Foreign Acquisitions? Evidence from Indonesian Manufacturing Plants

Arlan Brucal* Beata Javorcik† Inessa Love‡

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**Abstract**

The link between foreign ownership and environmental performance remains a controversial issue. This paper contributes to our understanding of this subject by analyzing the impact of foreign acquisitions on plant-level energy intensity. The analysis applies a difference-in-differences approach combined with propensity score matching to the data from the Indonesian Manufacturing Census for the period 1983-2001. It covers 210 acquisition cases where an acquired plant is observed two years before and at least three years after an ownership change and for which a carefully selected control plant exists. The results suggest that while foreign ownership increases the overall energy usage due to expansion of output, it decreases the plant's energy intensity. Specifically, compared to plants that remained domestic, acquired plants reduce energy intensity by about 30% two years after acquisition. In contrast, foreign divestments tend to increase energy intensity. At the aggregate level, we find that entry of foreign-owned plants is associated with industry-wide reduction in energy intensity.

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# 1 Introduction

Foreign direct investment (FDI) has been a powerful force of convergence across countries. In addition to bringing capital and creating jobs, FDI stimulates economic growth by enhancing firm-level efficiency. It does so directly by transferring cutting-edge technologies and management practices to its affiliates (Arnold and Javorcik, 2009; Chen, 2011; Javorcik and Poelhekke, 2017) and by encouraging product and process innovation (Guadalupe et al., 2012) as well as indirectly through knowledge spillovers (Javorcik, 2004; Blalock and Gertler, 2008).

The spectacular growth in FDI flows, along with the increasing importance of developing countries as host countries, has raised concerns about the potential effect of FDI on the natural environment (Zarsky, 1999). On the one hand, environmentalists argue that highly polluting multinationals relocate to countries with weaker environmental standards in order to circumvent costly regulations in their home country. In this way, they increase pollution levels not only in host countries but also globally.[1] On the other hand, supporters of globalization point out that FDI has a positive effect on natural environment because multinationals tend to use more efficient and cleaner technologies than their domestic counterparts.[2] Since the existing literature (reviewed below) has produced mixed results, the issue remains controversial.

This study contributes to our understanding of the link between FDI and environmental protection by taking a novel approach. Rather than examining whether FDI flows are influenced by environmental standards in the destination countries or whether polluting industries are more likely to engage in FDI, we examine the impact of foreign acquisitions on energy consumption and carbon dioxide ($CO_2$) emissions of acquired plants.[3] We use plant-level panel data from the Indonesian Manufacturing Census covering the period 1983-2001. To establish a causal effect of foreign acquisitions on plant performance, we combine a difference-in-differences approach with propensity score matching. This allows us to account for confounding factors that affect both domestic and foreign-owned establishments (e.g., sector-specific policies and other shocks), selection on observables and unobservable time-invariant plant heterogeneity. To the best of our knowledge, this study is the first to employ such an approach in determining the effect of foreign ownership on plant-level environmental performance.

[1] Anecdotal evidence abound. For instance, in 2013, the smoke haze from Indonesia's palm oil production, which was dominated by foreign investors, elevated to dangerous levels and caused significant health hazards not only in Indonesia, but also in Malaysia and Singapore (Chachavalpongpun, 2013).

[2] Rondinelli and Berry (2000) list a number of examples showcasing how multinationals and their affiliates help improve the environmental condition of their host country. Meanwhile, Blackman and Wu (1999) using survey results, find that FDI plants perform superior to their Chinese counterparts in energy efficiency, largely due the use of advanced efficiency-enhancing generation technologies.

[3] A foreign acquisition takes place when a firm headquartered abroad buys a significant stake (of at least 10%) in a domestic firm in order to assume partial or full control over it. This case is distinct from 'greenfield investment'– a foreign direct investment where a parent company establishes an entirely new facility.

The ideal measure of a plant's environmental performance is the total amount of pollution it emits at a particular time period, principally because it accounts for (potentially) different pollution abatement technologies applied by different firms. However, getting data on plant-level emissions across periods remains extremely difficult, particularly in developing countries. This is the reason why a number of studies resort to approximations of environmental performance using plant-level expenditures on pollution-emitting inputs such as energy (see, for example, Eskeland and Harrison, 2003; Cole et al., 2008a). Building upon this literature, we try to approximate plant-level environmental performance by estimating energy usage in physical units and $CO_2$ emissions from fuel combustion.

We can observe fuel switching because the dataset includes plant-level expenditures (in Rps) and physical usage (e.g., in metric tons or liters) of each energy input. The energy inputs consist of fuels and lubricants and electricity use. Fuels and lubricants are divided into more detailed inputs, which include gasoline, diesel, diesel oil, kerosene, lubricant, bunker oil, coal, coke, public gas, liquefied petroleum gas (LPG), firewood, and charcoal. We have information on the amount of fuels and lubricants that are used for electricity generation, as some of the plants produce electricity for their own consumption and for sale to other end users. With this information, any reallocation to lower-carbon inputs is captured in our emission measure.[4]

Our analysis is based on 210 foreign acquisition cases where an acquired plant is observed two year before and at least three years after an ownership change and for which a carefully selected control plant exists. The results suggest that while foreign ownership increases total energy use and carbon dioxide ($CO_2$) emissions in acquired plants due to expansion of the production scale, it lowers the energy and emission intensity of output. The reduction in energy use relative to output is nontrivial, ranging from 26% in the acquisition year to 30% two years later. These results are robust to different matching and estimation procedures, a longer time horizon and accounting for the potential effect of markup and competition pressures from foreign affiliates within the same local market.

We also find that the reduction in fuel intensity takes place immediately after the ownership change, while the reduction in electricity intensity happens more slowly and is somewhat less pronounced. Robust increases in capital-labor ratio and investment in machinery strengthen the

[4] A global pollutant, such as $CO_2$, may be of lesser interest compared to local pollutants (e.g. particulate matter and sulfur dioxide). Nonetheless, $CO_2$ is extremely difficult to abate. This was particularly true in Indonesia during our sample period, which would make our energy- and emission-measure a close approximation of total $CO_2$ emissions. To date, there are three kinds of fossil-fuel-based carbon abatement technologies (CATs): (1) higher efficiency conversion processes; (2) fuel switching to lower carbon alternatives; and (3) carbon capture and storage (CCS). Differences in combustion efficiency are already captured by differences in plant-level total energy usage, on which we have information. It is also unlikely that the CCS technology was available in Indonesia during our sample period, as the first wave of feasibility studies for CCS in the country were conducted in early 2003 to 2005 (Best et al., 2011).

argument that the within-plant decline in energy- and emission intensity cannot be fully accounted for by economies-of-scale from expanding production. Our results also indicate that plants with different initial energy intensity benefit from acquisition differently. In particular, plants with higher energy intensity (possibly smaller and less efficient plants) tend to reduce their energy and emission intensities more than those that are already less energy intensive. This finding might explain why previous literature on the relationship between foreign ownership and plant-level energy intensity produced mixed results (see, for example, Eskeland and Harrison, 2003; Cole et al., 2008a).

In an additional exercise, we consider foreign divestments, i.e., sales of foreign affiliates to domestic owners. We find that such divestments are associated with an increase in energy and emission intensities as well as a decline in output. This observation is consistent with the findings of Javorcik and Poelhekke (2017). The increase in energy use relative to output is quite substantial at 29% two years after the ownership change.

At the aggregate level, we find that energy and emission intensities in Indonesian manufacturing as a whole improved by 31% from 1983 to 2001. We show that at the industry level the decline in the aggregate weighted energy intensity is positively associated with the increased presence of foreign affiliates. The improvement seems to be driven by both within-plant reduction in energy intensity as well as reallocation of market shares towards more energy-efficient producers.

Our paper contributes to the literature examining how foreign ownership influences plant-level environmental performance. Within this broad literature, there are very few studies that studied firm's actual energy use or pollution emissions and the evidence is still mixed. Pargal and Wheeler (1996) use plant-level data from Indonesia and find that foreign ownership does not have significant effect on water pollution intensity. Using plant-level data from Ghana, Cole et al. (2008a) find no strong evidence of foreign ownership influencing total energy use. Eskeland and Harrison (2003) use plant-level data from Cote d'Ivoire, Mexico and Venezuela and find that the energy share, i.e., the cost of energy use divided by the total value of the plant's output, is negatively related to foreign ownership. Due to data limitations, none of these studies is able to take into account selection into foreign ownership (i.e., the possibility that foreign investors choose to acquire local plants with better environmental performance) or unobservable plant heterogeneity. In this paper, we not only address selection into foreign ownership and unobservable plant heterogeneity but we also measure energy use in physical units and provide a more detailed analysis on the types of fuel used.[5],[6]

[5]In a related study, Cole et al. (2011) consider per-capita emissions of pollutants in 112 major Chinese cities during the 2001-4 period. They find that the share of output of foreign-owned firms increases emissions while output of firms from Hong Kong, Macao, and Taiwan either reduces pollution or has no effect. The aggregated nature of the data (city level) makes it difficult to draw conclusions about the effect of foreign ownership on firm-level environmental performance.

[6]Another strand of literature looks into the tendency of foreign firms to adopt environmental management systems (EMS) relative to their domestic counterparts. The results are generally mixed (see, for example, Hettige et al., 1996;

Finally, our work makes a contribution to the relatively new literature examining the effects of foreign acquisitions on the acquired plants (Arnold and Javorcik, 2009; Chen, 2011; Guadalupe et al., 2012; Wang and Wang, 2015). Previous studies on foreign acquisitions centered on plant-level productivity, profitability and innovation. We enhance our understanding of this issue by pointing out the positive impact of foreign acquisitions on plant-level environmental performance, an outcome that has not been considered by the existing studies.

The rest of the paper is organized as follows. Section 2 provides background information on Indonesia and on why multinational owners are more likely to invest in energy efficiency. Section 3 describes the data and discusses why Indonesia is an appropriate setting to study the impact of foreign acquisition on plant-level environmental performance. Section 4 discusses our approach to understanding the link between FDI and plant-level energy consumption and $CO_2$ emission patterns. In section 5, we estimate the impact of acquisition on plant-level energy consumption and $CO_2$ emissions. Section 6 further analyzes the effect of foreign acquisition by looking at changes in the relative use of each energy input, energy-related structural changes, and nonlinear effect arising from different pre-acquisition energy intensity. Section 7 presents the result from analyzing the effect of divestments, while section 8 examines how FDI can influence industry-wide energy- and emission-intensities. We conclude by considering potential policy implications of our findings.

## 2 Background Information

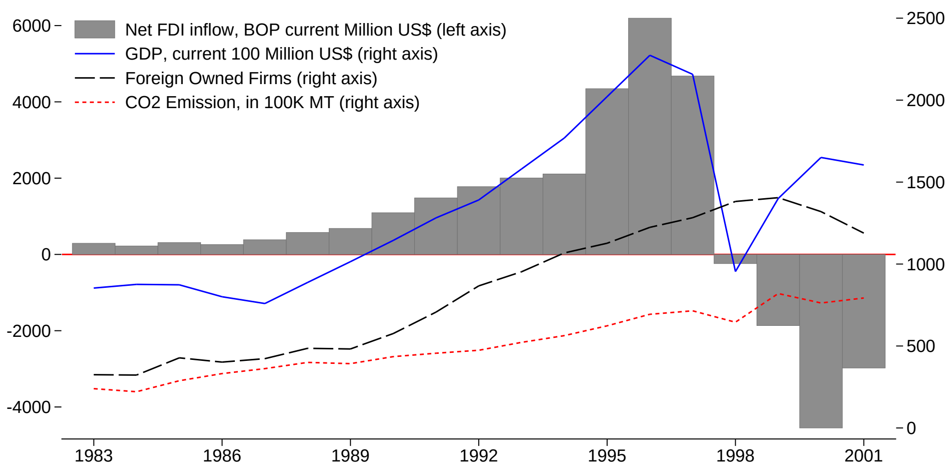
### 2.1 Overview of Indonesia

Indonesia is a suitable setting for studying the effects of foreign acquisitions on plant-level energy efficiency. This is for two reasons. First, the country received significant inflows of FDI, ranking as the $5^{th}$ largest recipient of FDI among developing countries in the mid 1990s (see Arnold and Javorcik, 2009). The influx of FDI was in part driven by significant reductions in trade barriers and industrial deregulation in the early 1980s and 1990-1996. The period of high capital inflows also coincided with economic recessions in the United States, Japan and some European countries. During this period, competing FDI destinations, such as Thailand, experienced a rise in labor cost and had limited infrastructure, which may have prompted investors to reallocate their portfolios to other emerging economies, including Indonesia. Second, as pointed out by Garcia et al. (2007), environmental protection in Indonesia was generally weak and ineffective during the country's impressive industrial growth in the 1980s and 1990s. Thus, the results of our analysis will not be influenced by pollution-related policies in the host country and will give us a cleaner picture of the impact of FDI on plant performance in terms of energy efficiency.

Dasgupta et al., 2000; Albornoz et al., 2009).

Figure 1 illustrates Indonesia's net FDI inflows, Gross Domestic Product (GDP), $CO_2$ emissions and the number of foreign-owned plants from 1983 to 2001. The vertical bars represent the net FDI inflows from balance-of-payment statistics measured in million US$, the solid line indicates the country's GDP in 100 million US$, the dashed line is the number of foreign-owned plants (calculated based on the Census of Manufacturing) and the dotted line is the $CO_2$ emissions in 100,000 metric tons (MT based on Oak Ridge National Laboratory data). The graph shows an upward trend in all the variables, with the number of foreign plants picking up in 1984, followed by the GDP and net FDI flows increasing around 1987. Interestingly, the GDP increased at a much faster pace than did emissions, suggesting that emissions per dollar unit of output may have declined during the period. Both the GDP and FDI inflows experienced a significant decline following the 1997-1998 Asian financial crisis.

**Figure 1: Indonesia's Net FDI inflows, Gross Domestic Product, $CO_2$ Emissions and Foreign-Owned Firms, 1983-2001**




Sources of Data: The World Bank, Oak Ridge National Laboratory, Indonesian Census of Manufacturing

## 2.2 FDI and Energy Intensity

Improvements in energy use amongst plants can be achieved through different methods, ranging from those that call for little or no investment to obtain immediate paybacks and those that would require a sizable commitment of capital funds. The low- or no-cost opportunities include installing energy-saving lighting options, influencing employee behavior by keeping employees informed about the plants' energy-efficiency goals and progress and recognizing them for their role in supporting these initiatives, and partnering with utility providers to identify appropriate procurement or demand-side management plans. Other channels that might entail some capital costs include introducing new technology (e.g. reducing process-heating costs by introducing waste-heat recovery technology) and improving mechanical performance by altering operation procedures of machineries or replacing them with more energy efficient ones. Plants may also implement environmental/energy management standards (e.g., ISO 14001). Other channels, which may require significant capital costs include improving facility design, continuous research and development or hiring energy managers.

There are two main reasons why foreign affiliates are more likely than domestically owned establishments to invest in energy efficiency. First, investments in energy efficiency amongst multinationals may be driven by factors inherent to companies involved in a global supply chain. For example, multinationals based in OECD countries may employ more energy-efficient and cleaner technologies in compliance with more stringent regulations or standards implemented in the region, compared with other companies in developing countries (Cole et al., 2008b). The use of these energy-efficient technologies and management practices may be passed on to their affiliates in developing countries to maintain their production standards and meet the requirements of their environmentally conscious export markets. These technologies and management systems can be also indirectly passed on to the affiliates' suppliers to maintain their global standard and reputation (Blalock and Gertler, 2008).

Second, investment in energy efficiency fundamentally involves decisions on higher initial capital costs and uncertain lower future energy operating costs at present values (Gillingham et al., 2009). Consequently, firm-level characteristics can be crucial in determining a firm's propensity to invest in improving energy efficiency (DeCanio and Watkins, 1998). Some domestic firms may under-invest in energy efficient technologies due to capital constraints or financial issues (Anderson and Newell, 2004). Information problems, such as shortsightedness and bounded rationality of management, may also force locally owned firms to resort to sub-optimal alternatives (DeCanio, 1993, 1998). In contrast, these issues are less serious for foreign affiliates as they generally dominate locally-owned firms in terms of capital (Arnold and Javorcik, 2009) and in international training and experience of decision makers within the firm (Cole et al., 2008a).

Anecdotal evidence supports the view that foreign affiliates tend to be more energy efficient than local plants. For instance, Byrne et al. (2014) report that multinational cement companies in Sub-Saharan Africa are more energy efficient than locally owned companies producing mainly for their local markets. The authors also find that locally owned firms have poorer access to knowledge on low-carbon technologies and have weaker incentives to innovate.

# 3 Data

## 3.1 Data sources

We use data from *Survei Manufaktur*, the Indonesian Census of Manufacturing conducted by the National Statistical Office (BPS). The data encompass all manufacturing plants with 20 or more employees on an annual basis since 1975. The census has detailed information on fuel and electricity use, both in terms of values and physical quantities.[7] The sample available to us spans the period from 1983 to 2001 covering about 40,000 plants with 300,893 plant-year observations, of which 27,182 observations belong to plants that have had a foreign acquisition case during the period.

Following Arnold and Javorcik (2009), we define a foreign acquisition case as a change in the foreign ownership share to at least 20%. The exact value of the threshold does not affect our results because more than 99% of the future acquisition targets have foreign capital share equal to zero in the pre-acquisition period. And in 95% of the cases, the post-acquisition foreign ownership shares is at least 25%. In more than 75% of cases, it is at least 50% (Figure 2).

Acquired plants are distributed across a wide range of industries, but mostly concentrated in energy-intensive sectors. The main one is manufacturing of fabricated metal products, machinery and equipment which comprises 25.6% of the acquired plants observations in the sample data. 21.8% are involved in textile and wearing apparel industries, and 19.1% are in manufacture of chemicals and chemical, petroleum, coal, rubber and plastic products.[8]

Table 1 provides summary statistics for plants that have gone through a foreign acquisition and for plants that have always remained domestic. For the former, only the post-acquisition summary statistics are shown. Acquired plants outperform domestic plants in terms of almost all the economic variables. For example, they are on average much bigger, employ a higher share of skilled labor, rely more on international markets, invest more in machinery and have a higher capital-labor ratio. In terms of environmental attributes, they spend more on energy in absolute terms and emit more $CO_2$. Their production process is, however, less energy intensive and produces lower $CO_2$ emissions per unit of output.

[7] The survey questionnaires and other relevant information about the dataset can be accessed online at http://www.rand.org/labor/bps/statistik_industri.html.

[8] For more description on the distribution of acquired plants by industry and acquisition cases by year, see Figures A.I and A.II in the Appendix, respectively.

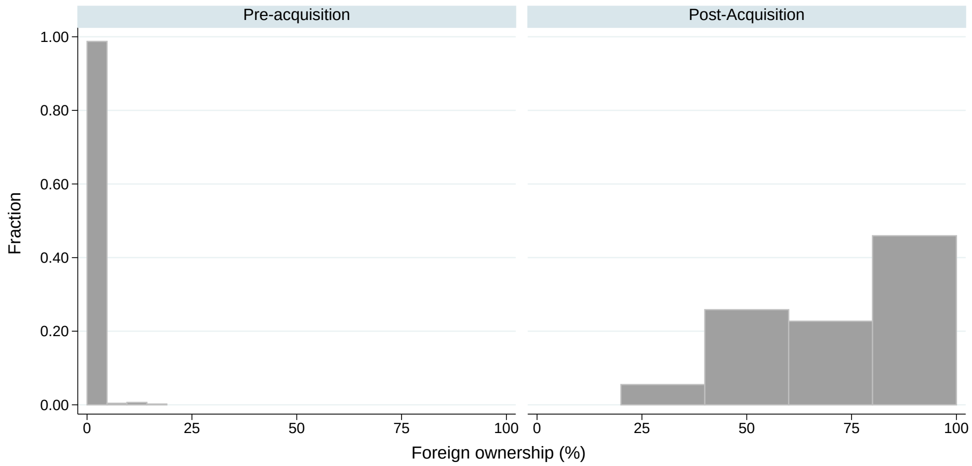
### Table 1: Summary Statistics

| Variables | Domestic Firms | | | Acquired Firms | | |
|---|---|---|---|---|---|---|
| | Obs | Mean | Std. Dev. | Obs | Mean | Std. Dev. |
| *Economic* | | | | | | |
| Output (in Million Rps) | 288988 | 25.36 | 280.39 | 27142 | 172.49 | 550.81 |
| Employment (no. of workers) | 288973 | 150.49 | 572.32 | 27136 | 471.73 | 835.26 |
| Unskilled workers | 238225 | 119.93 | 472.84 | 20639 | 374.13 | 689.48 |
| Skilled workers | 237822 | 25.32 | 134.59 | 20580 | 78.11 | 159.29 |
| Capital (in Million Rps) | 189156 | 25.62 | 1773.01 | 17896 | 132.54 | 1530.97 |
| Materials (in Million Rps) | 288990 | 13.26 | 135.39 | 27142 | 87.38 | 319.04 |
| Per worker wage (in '000 Rps) | 288990 | 2.59 | 36.98 | 27142 | 8.54 | 41.58 |
| Investment in machinery (in Million Rps) | 233694 | 9.21 | 268.48 | 23705 | 57.05 | 780.72 |
| Exporter dummy | 289266 | 0.08 | 0.27 | 27182 | 0.27 | 0.45 |
| Share of exports | 289266 | 6.31 | 22.41 | 27182 | 21.45 | 37.61 |
| Share of imported materials | 289266 | 11.70 | 28.64 | 27182 | 38.23 | 40.52 |
| Capital-labor ratio | 189146 | 117.45 | 7439.63 | 17894 | 326.25 | 3630.25 |
| Share of skilled workers | 237822 | 13.59 | 14.55 | 20580 | 21.81 | 18.57 |
| Public ownership dummy | 289266 | 0.03 | 0.18 | 27182 | 0.04 | 0.19 |
| Age | 273844 | 13.41 | 14.20 | 25098 | 11.94 | 14.93 |
| *Environmental* | | | | | | |
| Energy expenditure (in Million Rps) | 288848 | 0.79 | 11.48 | 27127 | 4.35 | 23.17 |
| Energy use ('000 MBTUs) | 288776 | 18.87 | 347.63 | 27114 | 108.30 | 859.45 |
| $CO_2$ emissions (in Million kg) | 288775 | 1.48 | 26.74 | 27114 | 8.99 | 77.70 |
| Energy expenditure intensity | 288848 | 0.05 | 0.07 | 27127 | 0.04 | 0.06 |
| Energy use intensity (MBTUs/Rps) | 288776 | 0.99 | 3.50 | 27114 | 0.79 | 1.86 |
| Emission intensity (kg $CO_2$/Rps) | 288775 | 79.13 | 320.09 | 27114 | 63.14 | 143.73 |
| No. of Plants | | 39,652 | | | 2,970 | |

Note: Following Arnold and Javorcik (2009), nominal figures are deflated using a set of 192 wholesale price indices for manufactured commodities, published by the Indonesian Statistical Office. Figures on investment and capital are deflated as follows. For buildings, we use a wholesale price index for residential and commercial buildings (WPI) published in the Statistical Yearbook of Indonesia, and for machinery and vehicles the average of the WPIs for 5-digit sectors producing machinery and vehicles, respectively. For other assets, we employ the economy-wide WPI. We use a CPI specific to energy instead because the Indonesian Statistical Office does not publish a wholesale price index for energy.

Source: Indonesian Census of Manufacturing

**Figure 2: Distribution of foreign ownership in acquired firms, 1983-2001.**




Source: Indonesian Census of Manufacturing

## 3.2 Measuring energy usage and emissions

The main advantage of our data is the availability of detailed information on plant-level expenditures and physical usage (e.g., in metric tons, kWh or liters) of each energy input. The energy inputs consist of fuels and lubricants and electricity. Fuels and lubricants are divided into more detailed inputs, which include: gasoline, diesel, diesel oil, kerosene, lubricant, bunker oil, coal, coke, public gas, liquefied petroleum gas (LPG), firewood, and charcoal. We also have information on the amount of fuel and lubricants used for electricity generation, as some of the plants produce electricity for their own consumption and for sale to other end users. The detailed information on the kind of energy inputs used will allow us to capture any reallocation to lower-carbon inputs that may be associated with ownership changes.

Our data set also includes information on the amount of electricity sold and the amount bought from the state-owned power company *Perusahaan Listrik Negara* (PLN) and from other independent power producers (non-PLN). When calculating the total energy usage, we use total electricity purchased less electricity sold. Recognizing that some of the plants were generating their own electricity, we also account for the total amount of fuel used to generate their own electricity.

The original data set includes 300,893 plant-year observations. 61,561 of these contain positive energy expenditure on a particular energy input but do not include the information on energy use in physical units. We impute the plant-level physical energy consumption using the following equation:

$$lny_{it} = \beta lnCost_{it} + ISIC_k + PROV_l + YEAR_m + u_{it} \tag{1}$$

where $y_{it}$ is the physical measure of energy inputs (e.g., gasoline in liters) and $Cost_{it}$ is total cost of energy inputs (e.g., gasoline in '000 Rps). $ISIC$, $PROV$ and $YEAR$ are industry (ISIC 4-digit level), province and year fixed effects, respectively. We estimate this specification separately for each energy input.[9] In this way, we impute the usage of each energy input in physical units. Except for kerosene, the model explains more than 90% of the variation of energy use in physical units.[10]

The energy content of each energy input (in British Thermal Units or BTUs) is calculated using conversion factors from reliable US agencies and institutions found in Table A.II.[11] [12]

The key variables of interest are energy intensity (defined in two ways) and emission intensity. Following Eskeland and Harrison (2003), we first define energy intensity as total expenditure on energy per 1000 Rps of real output. It is plausible that acquired firms, possibly due to greater reliance on international markets, use technologies that utilize more expensive but cleaner energy inputs. Thus, energy expenditure per unit of output may remain constant (or even increase) but actual energy use (in BTUs) per unit of output may decline. In order to address this issue, we also express energy intensity as the total physical energy use (in MBTUs) per currency unit of output. We repeat the same process to calculate a plant's emissions intensity, which is defined as total carbon dioxide emissions (in kg $CO_2$) per currency unit of output.

## 4 Empirical Strategy

The empirical strategy used to identify the effect of foreign ownership on plant-level environmental performance is anchored on three foundations. First, the study focuses on the changes from domestic to foreign ownership taking place within the same plant. In particular, we consider plants that are observed for at least four consecutive years and which have initially less than 20% foreign equity and at least 20% of equity belonging to foreign owners thereafter. By focusing on ownership change we are able to take into account the selection bias that would plague a comparison of domestic plants to

[9] Table A.I reports the list of energy inputs as well as the goodness-of-fit from estimating equation 1.

[10] There are also observations where there are physical units but total cost is missing. We regard these observations as missing in the data.

[11] British Thermal Unit (BTU) is a traditional unit of energy. The US Energy Information Administation interprets BTU as the amount of energy needed to heat one pound of water from 39 to 40 degrees Fahrenheit (EIA, 2011).

[12] A sample calculation of the energy usage of a plant using 100 barrels of diesel fuel at a certain time period is illustrated below:

$$\text{100 barrels diesel x } \frac{\text{5.825 million BTUs (MBTUs)}}{\text{1 barrel}} = \text{582.50 MBTUs}$$

We follow the same procedure for calculating $CO_2$ emission (in kg $CO_2$). Using the same example above, we calculate the $CO_2$ emission as below:

$$\text{582.50 MBTUs x } \frac{71.80 \text{ kg } CO_2}{\text{1 MBTU}} = 41,845.04 \text{ kg } CO_2$$

all foreign plants, due to the possibility that foreign affiliates may choose the most energy-efficient domestic plants. This approach, however, dramatically reduces the number of observations that can be considered. Fortunately, thanks to large FDI inflows into Indonesia during the sample period, we are able to observe 210 acquisition cases reporting information sufficient for our analysis. In our view, this number is large enough to allow us to generalize the results with confidence.

Second, we use a difference-in-differences approach to compare the performance of foreign-acquired plants with the performance of plants remaining in domestic hands. This approach eliminates the influence of all unobservable elements of the acquisition decision that are constant or strongly persistent over time.

The main challenge is how to develop a reasonable estimate of the counterfactual, that is, the change in the variables of interest that would have been observed had the acquisition not occurred. It is well recognized that the estimates obtained by comparing a treatment group with the remainder of the population could be biased if the two groups have significant differences in pre-treatment observable characteristics (Dehejia and Wahba, 2002). As shown in the left panel of Table 2, the domestic plants are different from acquired plants even before they were acquired in almost all the aspects, including their output and energy consumption, suggesting that running a simple difference-in-differences may not yield an unbiased estimate of the impact of foreign acquisition on plant-level environmental performance.

Third, in order to develop a reasonable counterfactual, we employ a one-to-one propensity score matching (PSM) (Rosenbaum and Rubin, 1983, 1985). That is, for each treated plant that will be acquired by foreign investors next period we identify a control plant of a similar size (measured in terms of ouput) and with a similar energy intensity (measured as energy expenditure over output) using the procedure developed by Leuven and Sianesi (2012). We ensure that each acquired plant is paired with a domestic plant that is operating in the same sector and year and has very similar output and energy consumption in the two years preceding the ownership change.[13] Matching within the industry-year cell ensures that we control for sector- and time-specific confounding factors that affect both domestic and acquired firms. We use a matching procedure with replacement.

The underlying assumption for the validity of the procedure is that conditional on the observable characteristics that are relevant for the acquisition decision, potential outcomes for the treated and control plants are orthogonal to treatment status. Thus, we need to argue that both the treated and the control plants most likely faced the same business and regulatory environments, energy prices, sector-specific and macroeconomic shocks, and trends before the acquisition taking place. This is partly established by matching within the same industry-year cell. When we compare the sample means of the variables used in matching procedure between the treatment group and the

[13]See Table 2 for a list of variables.

control group, we find that there is no statistically significant difference in the pre-acquisition period (see the top panel of Table 2). It is even more comforting that, except for the share of imported materials, there is no significant difference between the means of variables not used in matching (see the bottom panel of Table 2). These observations suggest that our matching procedure has performed quite well in obtaining control units that are comparable to acquired plants on nearly all observed covariates.

**Table 2: Balancing test for matched domestic and acquired plants.**

| Variables | Unmatched sample (pre-acquisition, N=258,827) | | | Matched sample (pre-acquisition, N=420) | | |
|---|---|---|---|---|---|---|
| | Acquired | Domestic | p-value | Treated | Control | p-value |
| ***Used in matching*** | | | | | | |
| Log (Real output)$_{t-1}$ | 10.62 | 7.71 | 0.000 | 9.89 | 9.88 | 0.951 |
| Log (Energy expenditure/output)$_{t-1}$ | -4.10 | -3.81 | 0.000 | -3.87 | -3.83 | 0.752 |
| Log (Real output)$_{t-2}$ | 10.58 | 7.76 | 0.000 | 9.74 | 9.74 | 0.997 |
| Log (Energy expenditure/output)$_{t-2}$ | -4.10 | -3.81 | 0.000 | -3.93 | -3.86 | 0.574 |
| ***Unused in matching*** | | | | | | |
| Log (Energy expenditure)$_{t-1}$ | 6.52 | 3.98 | 0.000 | 6.02 | 6.04 | 0.868 |
| Log(Energy use)$_{t-1}$ | 9.48 | 6.93 | 0.000 | 8.95 | 9.00 | 0.779 |
| Log ($CO_2$ emission)$_{t-1}$ | 13.88 | 11.32 | 0.000 | 13.33 | 13.38 | 0.760 |
| Log (Employment)$_{t-1}$ | 5.52 | 4.10 | 0.000 | 5.18 | 5.29 | 0.338 |
| Exporter dummy$_{t-1}$ | 0.30 | 0.08 | 0.000 | 0.19 | 0.18 | 0.706 |
| Share of imported materials$_{t-1}$ | 0.37 | 0.08 | 0.000 | 0.26 | 0.19 | 0.050 |
| Share of skilled workers$_{t-1}$ | 0.22 | 0.14 | 0.000 | 0.24 | 0.22 | 0.291 |
| Log(Investment in machinery)$_{t-1}$ | 8.62 | 5.43 | 0.000 | 8.19 | 7.80 | 0.105 |
| Log (Energy expenditure/output)$_{t-1}$ | -4.10 | -3.81 | 0.000 | -3.87 | -3.83 | 0.752 |
| Log(Energy use/output)$_{t-1}$ | -1.15 | -0.86 | 0.000 | -0.94 | -0.87 | 0.645 |
| Log($CO_2$ emission/output)$_{t-1}$ | 3.26 | 3.53 | 0.000 | 3.44 | 3.50 | 0.612 |
| Log(Energy exp./materials exp.)$_{t-1}$ | -3.23 | -2.98 | 0.000 | -2.87 | -3.07 | 0.201 |
| $\Delta$ Log (Real output)$_{t-1}$ | 0.22 | 0.05 | 0.000 | 0.15 | 0.14 | 0.893 |
| $\Delta$ Log (Energy expenditure)$_{t-1}$ | 0.20 | 0.06 | 0.000 | 0.21 | 0.17 | 0.644 |
| $\Delta$ Log (Energy use)$_{t-1}$ | 0.21 | 0.07 | 0.000 | 0.22 | 0.20 | 0.887 |
| $\Delta$ Log ($CO_2$ emission)$_{t-1}$ | 0.22 | 0.08 | 0.000 | 0.21 | 0.20 | 0.857 |
| $\Delta$ Log (Energy expenditure/output)$_{t-1}$ | -0.02 | 0.01 | 0.014 | 0.06 | 0.03 | 0.684 |
| $\Delta$ Log(Energy use/output)$_{t-1}$ | -0.00 | 0.03 | 0.038 | 0.06 | 0.06 | 0.975 |
| $\Delta$ Log($CO_2$ emission/output)$_{t-1}$ | 0.00 | 0.03 | 0.063 | 0.06 | 0.05 | 0.938 |
| $\Delta$ Log(Energy exp./materials exp.)$_{t-1}$ | -0.02 | 0.01 | 0.068 | 0.02 | 0.04 | 0.842 |

Note: Acquired and treated plants are those that were previously domestic and remained acquired for at least two years after the acquisition case. Domestic plants are those plants that had no acquisition case, while control plants are those year-plant observations that had foreign equity below the threshold for four consecutive years.
Source: Indonesian Census of Manufacturing

After obtaining the matched pairs, we examine the effect of foreign acquisitions on outcomes of interest using a difference-in-differences approach. More specifically, we estimate the following equation on the matched sample which is observed in the pre-acquisition period and in one of the post-acquisition periods:

$$y_{it} = \alpha_i + \gamma Post_t + \beta(Post_t * Acquired_i) + \varepsilon_{it} \tag{2}$$

where $i$ denotes plant and $t$ is the year. We compare two periods, i.e., $t = T-1, T+s$ where $T$ is the acquisition year and $s$ =0,1,2. A separate model is estimated for each $s$.

# 5 Results

## 5.1 OLS results

Before we go into the matching results, we perform a difference-in-differences estimation on the unmatched sample ignoring the selection bias and controlling only for 4-digit ISIC-industry-year fixed effects. The results, presented in Panel A of Table 3, show that acquired firms experience a large, persistent and statistically significant increase in output, accompanied by an increase in energy use (both in terms of expenditure and physical units) and $CO_2$ emissions. Meanwhile, there is also substantial, persistent and statistically significant decline in energy cost of output and in $CO_2$ emissions per unit of output.

In Panel B, we additionally control for unobserved time-invariant plant-level heterogeneity. Doing so effectively controls for pre-acquisition characteristics of acquired affiliates (and lagged characteristics of plants remaining in domestic hands throughout their presence in the sample). The effect on the variables of interests remains the same, except that the magnitude of effect becomes smaller. This patterns suggest that there may be some unobserved non-random plant-level characteristics associated with acquisition decisions that are influencing the outcome variables. The results indicate that it is important to address selection bias in the analysis.

In Panel (C), we repeat the exercise from Panel (B) dropping the acquisition cases that are not included in our matched sample as described in Section 4. Doing so makes the estimated effects slightly smaller and somewhat less significant. This improves our confidence in the estimates because it indicates that there is little evidence of sample selection when it comes to which acquisition cases are included in the final matching exercise. If anything, focusing on the smaller sample will lead us to underestimate the effects of foreign acquisition on the variables of interest.

## Table 3: Difference-in-differences on the unmatched sample.

| | Panel (A) | | | Panel (B) | | | Panel (C) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Always domestic + acquired plants | | | Always domestic + acquired plants | | | Always domestic + matched acquired plants | | |
| | t | t+1 | t+2 | t | t+1 | t+2 | t | t+1 | t+2 |
| Log(Output) | 2.156*** | 2.339*** | 2.423*** | 1.034*** | 1.197*** | 1.245*** | 0.839*** | 0.974*** | 0.949*** |
| Log(Energy Expenditure) | 1.770*** | 1.938*** | 1.985*** | 0.766*** | 0.906*** | 0.916*** | 0.647*** | 0.763*** | 0.703*** |
| Log(Energy Use, in MBTUs) | 1.724*** | 1.913*** | 1.967*** | 0.712*** | 0.868*** | 0.891*** | 0.584*** | 0.721*** | 0.703*** |
| Log ($CO_2$ Emissions) | 1.743*** | 1.927*** | 1.971*** | 0.727*** | 0.878*** | 0.890*** | 0.621*** | 0.746*** | 0.721*** |
| Log(Energy Expenditure/Output) | -0.347*** | -0.373*** | -0.414*** | -0.249*** | -0.269*** | -0.323*** | -0.194** | -0.214** | -0.266*** |
| Log(Energy Use/Output) | -0.393*** | -0.398*** | -0.431*** | -0.302*** | -0.307*** | -0.348*** | -0.257*** | -0.256*** | -0.267** |
| Log ($CO_2$ Emissions/Output) | -0.374*** | -0.384*** | -0.428*** | -0.287*** | -0.297*** | -0.349*** | -0.220** | -0.230*** | -0.248** |
| Log(Energy Expenditure/Materials) | -0.331*** | -0.333*** | -0.412*** | -0.295*** | -0.288*** | -0.395*** | -0.252** | -0.217** | -0.384*** |
| Log(Energy Use/Materials) | -0.369*** | -0.357*** | -0.433*** | -0.342*** | -0.327*** | -0.418*** | -0.308*** | -0.264*** | -0.378*** |
| Log ($CO_2$ Emissions/Materials) | -0.350*** | -0.342*** | -0.427*** | -0.330*** | -0.321*** | -0.423*** | -0.280*** | -0.245** | -0.370*** |
| Industry-year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm fixed effects | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample Size | | 169,141 - 180,901 | | | 165,905 - 177,840 | | | 165,307 - 177,155 | |

Note: The table shows the results of a difference-in-differences analysis on the unmatched sample. The dependent variables are as listed in each panel. Each entry corresponds to a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. All panels include plants that have always been domestic. Panels A and B also include all domestic plants that have undergone foreign acquisitions. In Panel C only those acquired plants that are used in matching regressions are included. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

## 5.2 Results from the Difference-in-Differences on the Matched Sample

Perhaps the most transparent and intuitive way of presenting the impact of acquisition on plant-level environmental performance is through a graph where the outcomes for the matched domestic and acquired firms are placed side-by-side before and after the acquisition (see Figure 3). There is a number of features of the graph that are worth discussing. First, it appears that the matching procedure created a set of domestic and acquired plants that are very comparable to each other prior to the time of acquisition. Both groups display very similar paths two years prior to the ownership change. This comparability holds true across all variables of interest. Second, the paths start to diverge already in the acquisition year and the gap between the groups increases over the two subsequent years. Third, the figure suggests an increase in the use of energy, both in terms of value and physical units, and in $CO_2$ emission levels of the acquired plants. The increase in energy use and emissions is intuitive because these outcome variables are positively associated with the expansion of output. However, acquired plants experience a substantial decrease in their energy consumption and emissions per unit of output relative to the plants that remain in domestic hands. The difference between energy and emission intensities of acquired plants and those of the control group gets larger over time.

The effect of foreign acquisitions is formally tested by estimating equation 2, and the results are presented in Table 4. Results suggest that the acquired plants experience a statistically significant increase in output relative to the control group already during the acquisition period.[14] The effect is sizeable as the acquired plants outperform the controls by 83.8 log points or about 131%.[15] The difference between the two groups increases to 101.3 log points or about 175% in the subsequent two years. The finding is consistent with previous studies that looked at the effect on foreign acquisitions on the scale of production (see, for example, Aitken and Harrison, 1999; Arnold and Javorcik, 2009).

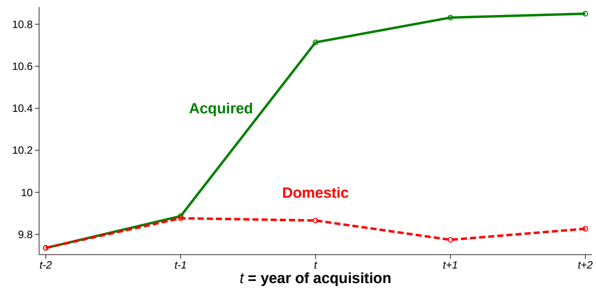
The expansion in output coincides with significant increases in energy consumption, both in terms of expenditure and physical units (measured in monetary terms or in MBTUs, respectively), although the latter effect is of a lesser magnitude. For example, energy expenditure increases by about 76% during the year of acquisition while the physical energy use goes up by 71%. $CO_2$ emissions follow the same trend although at a relatively smaller magnitude when compared to energy expenditure. It should also be noted that the increases in energy and emission levels are substantially smaller when compared to increases in output.

[14]One of the reasons for this immediate effect is that foreign firms transplant their management practices to host countries (Bloom et al., 2012), and that just within months improvements in management practices translate into better performance (Bloom et al., 2013).

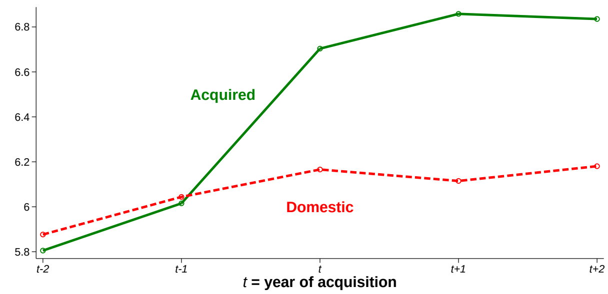
[15]The change in the variable of interest associated with the foreign acquisition dummy is calculated as $e^{(\beta)} - 1$. In this case, the change is $e^{(0.838)} - 1 = 1.311$.

## Figure 3: Trajectories of output, energy expenditure and energy intensities: Acquired vs. domestic plants

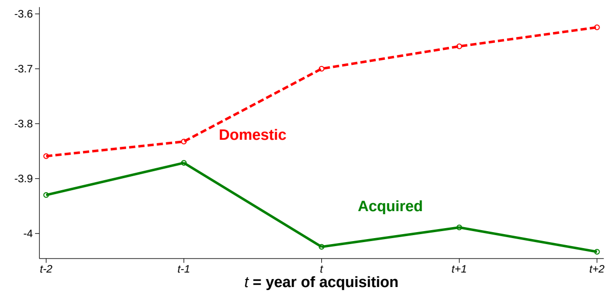
(a) Log(output)



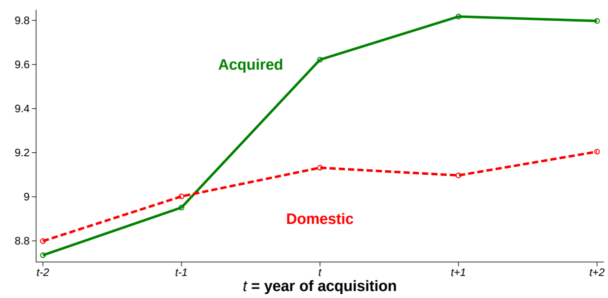

(b) Log(energy expenditure in Rps)



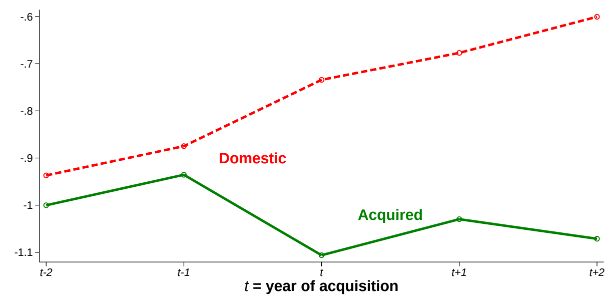

(c) Log(energy expenditure/output)



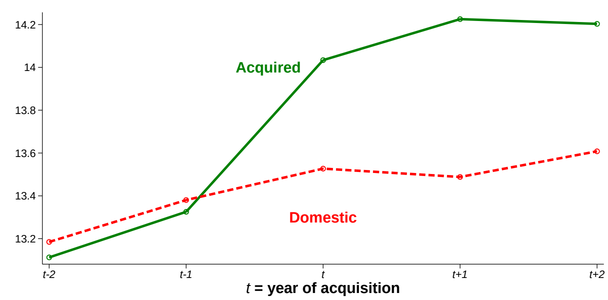

(d) Log(energy use in MBTUs)



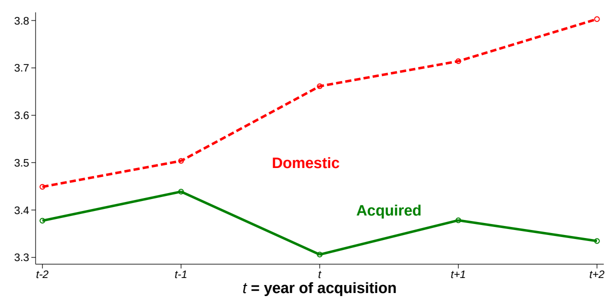

(e) Log(energy use/output)




(f) Log($CO_2$ emission in kg $CO_2$)




(g) Log($CO_2$ emissions/output)




The figure illustrates the average value of each variable of interest in a given time period for the treated (acquired) and control (domestic) group. The horizontal axes indicate the year relative to the period $t$ where treated plants are acquired.

Table 4: **Regression Results: Difference-in-differences analysis on the matched sample.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | Log(Output) | | |
| Post*Acquired | **0.838*** ** | **1.047*** ** | **1.013*** ** |
| | **(0.113)** | **(0.117)** | **(0.122)** |
| R-sq. (within) | 0.203 | 0.240 | 0.229 |
| No. of Obs. | 840 | 840 | 840 |
| | Log (Energy Expenditure in Rps) | | |
| Post*Acquired | **0.567*** ** | **0.773*** ** | **0.705*** ** |
| | **(0.118)** | **(0.126)** | **(0.132)** |
| R-sq. (within) | 0.145 | 0.178 | 0.163 |
| No. of Obs. | 838 | 838 | 835 |
| | Log(Energy Use in MBTUs) | | |
| Post*Acquired | **0.539*** ** | **0.770*** ** | **0.664*** ** |
| | **(0.118)** | **(0.130)** | **(0.136)** |
| R-sq. (within) | 0.138 | 0.178 | 0.168 |
| No. of Obs. | 838 | 838 | 835 |
| | Log ($CO_2$ Emissions) | | |
| Post*Acquired | **0.562*** ** | **0.792*** ** | **0.673*** ** |
| | **(0.120)** | **(0.130)** | **(0.137)** |
| R-sq. (within) | 0.150 | 0.188 | 0.176 |
| No. of Obs. | 838 | 838 | 835 |
| | Log (Energy Expenditure/Output) | | |
| Post*Acquired | **-0.276** ** | **-0.282** ** | **-0.326** ** |
| | **(0.119)** | **(0.118)** | **(0.127)** |
| R-sq. (within) | 0.013 | 0.014 | 0.016 |
| No. of Obs. | 838 | 838 | 835 |
| | Log (Energy Use/Output) | | |
| Post*Acquired | **-0.304** ** | **-0.285** ** | **-0.367*** ** |
| | **(0.120)** | **(0.125)** | **(0.137)** |
| R-sq. (within) | 0.015 | 0.014 | 0.019 |
| No. of Obs. | 838 | 838 | 835 |
| | Log ($CO_2$ Emissions/Output) | | |
| Post*Acquired | **-0.282** ** | **-0.262** ** | **-0.357*** ** |
| | **(0.119)** | **(0.124)** | **(0.136)** |
| R-sq. (within) | 0.014 | 0.015 | 0.021 |
| No. of Obs. | 838 | 838 | 835 |

Note: The table shows the result of estimating equation 2 on the matched sample described in Section 4. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign affiliates were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

Next we focus on energy and emission intensities, which are obtained by dividing energy consumption (measured in monetary terms and in MTBUs) and emissions by the total value of output. The estimated magnitudes are economically meaningful. They suggest that the share of energy cost in the total value of output falls in the acquired plants (relative to the control group) by 24% in the year after the acquisition with a further decline to 28% after two years. In terms of physical energy use, the acquired plants reduce their energy intensity by 26% during the acquisition year and by about 30% two years after. We find a similar pattern for emission intensity. Overall, the results suggest that acquired plants tend to use less energy intensive and perhaps cleaner production techniques. Below we subject this finding to a series of robustness checks.

### 5.3 Are our findings a result of increased local competition from foreign affiliates?

One may be concerned that increased competition resulting from entry of foreign affiliates may be influencing our results. For instance, acquired plants may increase competitive pressures on the control group by seizing some of their market share. This can lead to less energy efficient production processes in the control plants due to a smaller scale. Failure to account for this effect might lead us to overestimate the effects of foreign acquisitions on energy and $CO_2$ intensity.

To address this concern, we follow Javorcik and Poelhekke (2017) and adjust the matching procedure so that the matched acquired and domestic plants are located in different counties ("*kabupaten*"). In this way, we avoid the potential effects of competition in the local market which may confound our results. The estimates are presented in Table 5. They are very similar to our baseline findings. The reduction in energy and emission intensities remain negative and statistically significant.

### 5.4 Are our findings driven by increases in markups?

It is possible that Indonesian producers acquired by foreign investors increase their markups and that higher markups are responsible for our finding of a lower energy intensity.[16] Although it would not invalidate our results, as after all energy usage per unit value of output is a meaningful outcome, it is still interesting to shed some light on this issue. We, therefore, normalize energy expenditure, physical energy use and emission level by the value of expenditures on material inputs. If our result is an artifact of changes in markups, then we would not expect to see foreign acquisitions affecting these redefined energy-intensity measures.

The results, presented in the top panel of Table 6, show that our initial findings are robust to the alternative definition of energy and emission intensities. They show that acquired plants experience a reduction in energy costs per unit cost of materials relative to domestic plants. The estimated

[16] Javorcik and Poelhekke (2017) show that changes in ownership are associated with changes in markups.

**Table 5: Difference-in-differences analysis on the matched sample, accounting for potential spillovers of foreign affiliates to the local competition.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | | Log(Output) | |
| Post*Acquired | **0.829*** ** | **1.037*** ** | **1.008*** ** |
| | **(0.114)** | **(0.116)** | **(0.123)** |
| R-sq. (within) | 0.199 | 0.238 | 0.225 |
| No. of Obs. | 836 | 836 | 836 |
| | | Log (Energy Expenditure in Rps) | |
| Post*Acquired | **0.573*** ** | **0.758*** ** | **0.701*** ** |
| | **(0.118)** | **(0.126)** | **(0.134)** |
| R-sq. (within) | 0.145 | 0.173 | 0.161 |
| No. of Obs. | 834 | 834 | 831 |
| | | Log (Energy Use in MBTUs) | |
| Post*Acquired | **0.546*** ** | **0.769*** ** | **0.651*** ** |
| | **(0.119)** | **(0.131)** | **(0.138)** |
| R-sq. (within) | 0.137 | 0.176 | 0.165 |
| No. of Obs. | 834 | 834 | 831 |
| | | Log ($CO_2$ Emissions in kg $CO_2$) | |
| Post*Acquired | **0.560*** ** | **0.785*** ** | **0.653*** ** |
| | **(0.120)** | **(0.132)** | **(0.140)** |
| R-sq. (within) | 0.150 | 0.186 | 0.174 |
| No. of Obs. | 834 | 834 | 831 |
| | | Log (Energy Expenditure/Output) | |
| Post*Acquired | **-0.262** ** | **-0.286** ** | **-0.324** ** |
| | **(0.119)** | **(0.119)** | **(0.128)** |
| R-sq. (within) | 0.012 | 0.015 | 0.016 |
| No. of Obs. | 834 | 834 | 831 |
| | | Log (Energy Use/Output) | |
| Post*Acquired | **-0.288** ** | **-0.276** ** | **-0.374*** ** |
| | **(0.120)** | **(0.126)** | **(0.139)** |
| R-sq. (within) | 0.014 | 0.014 | 0.021 |
| No. of Obs. | 834 | 834 | 831 |
| | | Log ($CO_2$ Emissions/Output) | |
| Post*Acquired | **-0.275** ** | **-0.259** ** | **-0.372*** ** |
| | **(0.119)** | **(0.124)** | **(0.138)** |
| R-sq. (within) | 0.013 | 0.016 | 0.024 |
| No. of Obs. | 834 | 834 | 831 |

Note: The table shows the result of estimating equation 2 on the matched sample described in Section 4. Matched plants do not come from the same county or *kabupaten*. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign affiliates were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

decline is actually consistently larger. We also see similar declines in physical energy use and $CO_2$ emissions per unit cost of materials.

Another way to take into account the potential effect of markup is to control for changes in share of exported output before and after the acquisition. To test the robustness of our results, we add export share as an explanatory variable to equation 2. The results are summarized in the fourth panel of Table 6. As before, we find that the acquired plants decrease their energy expenditure per unit of output and the difference between the two groups widens over time. In particular, the acquired plants reduce their energy expenditure intensity by about 22% a year after the acquisition and two years after. We also estimate a specification that includes the share of exported output and its interaction with the Acquired dummy variable (see bottom panel of Table 6). We find that the estimated effects are robust to this additional control.

## 5.5 Robustness Checks

In this section, we subject our results to other sensitivity and robustness checks. In particular, we test whether our results hold if we exclude the period of the Asian financial crisis, include a longer time horizon, or employ a different matching procedures.

### 5.5.1 Excluding the Asian financial crisis

Another possible concern is that the effect of the 1997-1998 Asian financial crisis may be influencing our results. Some studies find that, thanks to access to financing from parent companies, foreign affiliates performed significantly better than domestic firms during the crisis (see, among others, Blalock et al., 2008; Alfaro and Chen, 2012). If that's the case, then the smaller scale of production in domestic establishments resulting in lower energy efficiency could be driving our findings. Failure to account for this effect might lead to biased estimates of the effect of foreign acquisition on output and consequently on energy consumption and $CO_2$ emissions.

To address this concern, we dropped years beyond 1997 to avoid the effects of the Asian financial crisis which may confound our results. A graph showing the unconditional mean of the variables of interest after dropping the Asian crisis period and beyond for the matched treated and control plants are presented in Figure A.III. Pre-acquisition parallel trends in all outcome variables are still observed, as well as the divergence in the acquisition year and two subsequent years. Meanwhile, the estimates are presented in Table A.III. We still observe significant reduction in energy intensity during the acquisition year and two years after. The effects for the year following the acquisition, though still negative, are imprecisely estimated.

**Table 6: Robustness check: Accounting for potential markup effect of acquisition.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | Log(Energy Expenditure/Materials Expenditure) | | |
| Post*Acquired | **-0.310**** | **-0.266**** | **-0.382**** |
| | **(0.123)** | **(0.128)** | **(0.147)** |
| R-sq. (within) | 0.021 | 0.011 | 0.018 |
| No. of Obs. | 808 | 810 | 807 |
| | Log(Energy Use/Materials Expenditure) | | |
| Post*Acquired | **-0.339***** | **-0.279**** | **-0.426***** |
| | **(0.124)** | **(0.134)** | **(0.153)** |
| R-sq. (within) | 0.024 | 0.011 | 0.019 |
| No. of Obs. | 808 | 810 | 807 |
| | Log($CO_2$ Emissions/Materials Expenditure) | | |
| Post*Acquired | **-0.328***** | **-0.266**** | **-0.428***** |
| | **(0.124)** | **(0.134)** | **(0.153)** |
| R-sq. (within) | 0.020 | 0.010 | 0.020 |
| No. of Obs. | 808 | 810 | 807 |
| | Log(Energy Expenditure/Output) | | |
| Post*Acquired | -0.266** | **-0.290**** | **-0.331***** |
| | (0.117) | **(0.117)** | **(0.126)** |
| Export share | -0.002 | 0.001 | 0.001 |
| | (0.002) | (0.002) | (0.002) |
| R-sq. (within) | 0.016 | 0.015 | 0.016 |
| No. of Obs. | 838 | 838 | 835 |
| | Log(Energy Expenditure/Output) | | |
| Post*Acquired | -0.317** | **-0.382***** | **-0.406***** |
| | (0.134) | **(0.136)** | **(0.146)** |
| Export share | -0.003 | -0.001 | -0.001 |
| | (0.002) | (0.002) | (0.002) |
| Post*Acquired*Export share | 0.003 | 0.004 | 0.004 |
| | (0.003) | (0.003) | (0.003) |
| R-sq. (within) | 0.018 | 0.023 | 0.021 |
| No. of Obs. | 838 | 838 | 835 |

Note: The table reflects the result of estimating equation 2 on the matched sample described in Section 4. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

### 5.5.2 Longer time horizon

Our analysis so far has focused on a relatively short period and, due to missing values, the number of observations fluctuated between time periods. To further check the robustness of our findings, we extend the time horizon to six years under foreign ownership. This exacerbates the problem of missing values to a large extent because we now have fewer post-treatment observations for acquisitions taking place towards the end of the sample period. To maintain comparability across periods, we keep the sample constant; that is, we focus only on plants that have non-missing observations in all periods considered for all the outcome variables.

Table A.IV present the summary of the results. While the number of observations inevitably decreases, our result remain robust and consistent with our baseline estimation. Even if we control for the potential effect of increased local competition from foreign affiliates; that is, we restrict the control group to those plants that are situated in different countries or *kabupatens*, our results remain consistent with our baseline findings (see Table A.V).

### 5.5.3 Are our results dependent on a particular matching procedure?

We also test the robustness of our results to different matching procedures. In order to show this, we employ a one-to-one coarsened exact matching (CEM) procedure following Iacus et al. (2009) and Iacus et al. (2011).[17] A detailed procedure is presented in Appendix AI and the results summarized in Table A.VII. The results are qualitatively the same, with output, energy use and emissions increasing up to two years after the acquisition, while energy and emission intensities being significantly reduced. The treatment effects are notably larger in magnitude and more precisely estimated.

Another potential concern is a one-to-one matching procedure requires us to drop many observations. To address this concern, we use the propensity score from the previous matching procedures to reweight observations in our difference-in-differences estimation (as, for instance, done by Guadalupe et al. (2012)). A detailed procedure is presented in Appendix AII and the results summarized in Table A.VIII. Our results remain consistent with baseline estimates, suggesting that are findings are robust to changing the empirical approach.

[17] The application of CEM is not without precedence. For example, Wang et al. (2010) use CEM to estimate the magnitude of spillovers generated by academic "superstars" to their collaborators' publication rates. Singh and Agrawal (2011) use the same matching technique to determine how firms are making use of their recruits' prior stock of ideas. Beatty and Tuttle (2015) employ CEM in studying the effect of the unprecedented increase in Supplemental Nutrition Assistance Program on participants' expenditure on food.

# 6 Structural Change and Heterogeneous Effects

In this section, we deepen our analysis by looking at whether acquired plants undergo structural changes in their production processes and whether there exist heterogeneous effects among target plants with different pre-acquisition energy intensities.

## 6.1 Do acquired plants reallocate across energy inputs?

Do acquired plants change their mix of energy inputs? We investigate this question in Table A.IX which considers as outcome variables the plants' expenditures on major energy sources: fuel and lubricants, electricity (net of own generation), and their respective intensities. The left panel corresponds to results using expenditure-based measures. We also consider energy consumption measured in physical units (right panel of Table A.IX) to check the robustness of our results.

The results indicate that foreign ownership affects the plant's mix of energy sources. During the acquisition year, expenditures on fuel and lubricants in acquired plants increase by 48% relative to the control group with the gap increasing to almost 72% two years after. Meanwhile, consumption of electricity in acquired plants increases at a much higher rate, beginning at 114% during the acquisition period, then increases to 117% a year later before declining at 100% in the subsequent year. All of these changes are statistically significant. The results using energy use in physical units are almost identical and consistently significant.

As for energy intensity, we observe a significant reduction in the cost of fuel and lubricants per unit of output during the acquisition period. The acquired plants' fuel intensity declines by 34% during the acquisition period and by about 35% two years after. We also observe evidence suggesting a reduction in the electricity cost per unit of output due to foreign acquisition, although the estimates are less precise. The magnitude of reduction is also consistently lower than that of fuel and lubricants, which might suggest that the expansion in production associated with foreign acquisition is largely driven by increased consumption of electricity.

We conjecture that expansion of acquired firms is fueled mostly by electricity because of the relatively lower electricity rates prevailing in Indonesia compared to its neighboring countries. This conjecture is consistent with the findings of other studies suggesting that the kind of technology a firm will use to reduce emissions (either through pollution abatement or increasing energy efficiency) may be effectively influenced by policies that directly affect factor prices (see, for example, Khanna and Zilberman, 2001; Harrison et al., 2015). Indonesia's lower industrial electricity tariffs might also explain why a lot of FDI that flowed into the country during the sample period are generally electricity-intensive industries (e.g., manufacture of machinery). The low electricity tariffs are due to the country's generous subsidies (Mourougane, 2010).

We also test whether the acquired plants' reallocation are due to possible energy subsidies provided by the government to foreign investors or multinationals. In other words, we check if acquired plants faced lower fuel and electricity prices after the acquisition and in subsequent years. We find no evidence in favor of this view (see Table A.X).

### 6.2 Are our estimates purely attributed to economies of scale?

As we have shown, acquired plants tend to expand their production significantly after the acquisition. However, larger output can be associated with less energy per unit of output if there are economies of scale in energy use. Therefore, it is possible that the improvement in energy efficiency in the acquired plants stem purely from expansion of output, and thus are not necessarily specific to foreign acquisition.[18]

In order to address this concern, we examine the relationship between energy expenditure and output allowing for a different intercept and a different slope for the acquired plants.[19] More specifically, we estimate the following equation:

$$exp_{it} = \alpha + \beta_1(Post_t * Acquired_i) + \beta_2 y_{i,t-1} + \beta_3(Post_t * Acquired_i) * y_{i,t-1} + \gamma_i + \delta_t + \varepsilon_{it} \quad (3)$$

where $exp_{it}$ is firm $i$'s energy expenditure (in logarithm) at year $t$, $Acquired$ is foreign acquisition dummy as previously defined, $Post$ is the post-acquisition period, $y$ is real output (in logarithm) and $\gamma_i$ and $\delta_t$ are plant and year fixed effects, respectively. We cluster standard error at the plant level.

We estimate equation 3 using the full as well as the matched sample. We then plot the estimated relationship for varying lagged output levels to get the combined marginal effect of the regressors at different lagged output levels, while eliminating common-to-firms and year-specific factors that may confound the results. We do so separately for acquired plants and for plants that remained in domestic hands. The idea is that if energy intensity is all attributed to the scale effect, then we can expect the trajectory of energy use as output grows to be parallel between the two groups. In other words, we want to test whether foreign acquisition affects energy use, controlling for the effect of economies of scale.

Panels (a) and (b) of Figure A.IV illustrate the results from estimating equation 3 on the unmatched

[18]Note, however, that even if the improvement in energy intensity were due to expansion of output, these economies-of-scale effect of foreign acquisitions would still lead to higher energy efficiency at the aggregate level. We will come back to this issue in the subsequent subsection.

[19]We also estimate a regression using contemporaneous output a regressor, taking note that this regression is subject to serious reverse causality issues. Notwithstanding, our results remain consistent with the baseline regression.

and the matched sample, respectively.[20] In both panels, the lines are clearly not parallel between the two groups. In particular, the acquired plants have flatter relationship compared to that of domestic plants suggesting a smaller increase in energy use as the output expands. Even if we choose comparatively similar domestic plants, energy expenditure for acquired plants rises at a significantly slower rate (see Panel b).

We also find evidence to support the view that domestic plants undergo structural changes once they are acquired by foreign firms. In particular, we find that while acquired plants tend to increase both their capital stock and employment, they also tend to become more capital-intensive (see Table A.XII). We do not observe strong evidence suggesting that acquired plants tend to invest more, although we see very strong and economically significant increase in purchases of machinery. The above observations, coupled with the fact that we see an indication of relatively higher reliance on electricity, suggests that our results cannot be just driven completely by the scale effect.

### 6.3 Pre-acquisition energy intensity

The evidence presented thus far suggests that foreign acquisitions lower energy consumption and emission levels per unit of output. Nonetheless, it is not obvious whether these effects are similar across all plants. It could be that the effect of a change in ownership on plant-level environmental performance is stronger for plants that were initially smaller and less energy efficient. In other words, the improvement in the production technique may be larger for plants that were initially further from the technological frontier.

To test this hypothesis, we estimate equation 2 augmented with an interaction term between the foreign acquisition dummy and the plant's energy intensity level in the pre-acquisition year. We focus on the period one year after the acquisition where we expect the treatment to have the most significant effect. The results are presented in Table A.XIII and are also plotted in Figure A.V. In the figure, the solid line corresponds to point estimates, while dashed lines denote 95% confidence intervals. We observe that the magnitude of the decline in the cost of energy per unit of output is larger at higher levels of pre-acquisition energy intensity. This is also true of energy use and emissions per unit of output. These results indicate that relatively more energy intensive (and perhaps less efficient and smaller) plants tend to benefit more in terms of reducing energy use and emission intensities from foreign acquisitions. This finding might explain why previous literature had mixed results on the effect of foreign acquisitions on plant-level environmental performance (see, for example, Eskeland and Harrison, 2003; Cole et al., 2008a).

[20] For the detailed regression result, see Table A.XI.

# 7 Do Foreign Divestments Lead to Lower Energy Efficiency?

If foreign acquisitions lead to improvements in energy efficiency, it is not unreasonable to expect that foreign divestments would have the opposite effect. This would be consistent with the existing literature that finds that foreign divestments wipe out some of the benefits brought by foreign ownership. For instance, Javorcik and Poelhekke (2017) find that foreign divestments in Indonesia are associated with a drop in the total factor productivity and a decline in output, markups, as well as export and import intensities.

Therefore, we consider the impact of losing a foreign parent on energy-related performance. We follow the same approach as before (see Section 4), but rather than focusing on foreign acquisitions we consider the cases of divestment. More specifically, we consider plants that had at least 20% of foreign equity and where foreign ownership dropped to less than 20% and remained below this threshold for at least three years. We compare the performance of these divested plants to the performance of the plants that remained in foreign hands. This is different from the previous analysis where our control plants are those that remain domestic. We perform this exercise first using the OLS and then focusing on the matched sample.

## 7.1 OLS results

The results of our difference-in-differences estimation on the unmatched sample, which ignores the selection bias and controls only for 4-digit-ISIC-industry-year fixed effects, are presented in Panel (A) of Table 7. The sample includes all divested affiliates and all affiliates remaining under foreign ownership throughout. We find that divested affiliates experience a large, persistent, and statistically significant drop in output. The output shrinkage is accompanied by a decline in energy consumption and $CO_2$ emissions. More importantly from the perspective of our study, we observe a persistent and statistically significant increase in energy cost per output and emission intensity.

## Table 7: Difference-in-differences on the unmatched sample, divestments.

| | Panel (A) | | | Panel (B) | | | Panel (C) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Always foreign and divested plants | | | Always foreign and divested plants | | | Always foreign and matched divested plants | | |
| | t | t+1 | t+2 | t | t+1 | t+2 | t | t+1 | t+2 |
| Log(Output) | -1.248*** | -1.254*** | -1.248*** | -0.490*** | -0.501*** | -0.497*** | -0.540*** | -0.544*** | -0.536*** |
| Log(Energy Expenditure in Rps) | -1.001*** | -0.999*** | -0.995*** | -0.392*** | -0.385*** | -0.388*** | -0.427*** | -0.421*** | -0.426*** |
| Log(Energy Use in MBTUs) | -0.990*** | -0.989*** | -0.984*** | -0.367*** | -0.362*** | -0.365*** | -0.402*** | -0.396*** | -0.403*** |
| Log ($CO_2$ Emission) | -0.990*** | -0.989*** | -0.984*** | -0.370*** | -0.366*** | -0.369*** | -0.405*** | -0.399*** | -0.407*** |
| Log(Energy Expenditure/Output) | 0.227*** | 0.234*** | 0.234*** | 0.093*** | 0.108*** | 0.105*** | 0.104*** | 0.114*** | 0.104*** |
| Log(Energy Use/Output) | 0.238*** | 0.244*** | 0.245*** | 0.118*** | 0.131*** | 0.127*** | 0.130*** | 0.139*** | 0.127*** |
| Log ($CO_2$ Emissions/Output) | 0.238*** | 0.244*** | 0.244*** | 0.115*** | 0.127*** | 0.123*** | 0.127*** | 0.136*** | 0.123*** |
| Log(Energy Expenditure/Materials) | 0.243*** | 0.251*** | 0.254*** | 0.098*** | 0.113*** | 0.117*** | 0.119*** | 0.131*** | 0.126*** |
| Log(Energy Use/Materials) | 0.253*** | 0.260*** | 0.264*** | 0.124*** | 0.137*** | 0.141*** | 0.146*** | 0.157*** | 0.150*** |
| Log ($CO_2$ Emissions/Materials) | 0.253*** | 0.260*** | 0.264*** | 0.123*** | 0.135*** | 0.139*** | 0.145*** | 0.156*** | 0.149*** |
| Industry-year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Plant fixed effects | No | No | No | Yes | Yes | Yes | Yes | Yes | Yes |
| Sample Size | 22566-23926 | | | 22400 - 23807 | | | 21722-23039 | | |

Note: The table shows the results of difference-in-differences analysis on the unmatched sample. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

In Panel (B), we additionally control for firm unobserved heterogeneity which controls for pre-divestment characteristics of both divested affiliates and lagged characteristics for those remaining in foreign hands. The effects of divestment on output, energy and emission levels and intensities are all consistent with the previous estimation procedure. However, the magnitude of effect are uniformly smaller in magnitude, which indicates that it is important to address selection bias in the analysis.

in Panel (C), we repeat the exercise in Panel (B) but drop cases that are not included in our matched sample. Doing so makes the estimates larger, while maintaining the statistical significance. Nonetheless, our difference-in-differences estimation still generates the smallest effect in terms of output and energy consumption shrinkage, suggesting that our matching procedure, if anything, will lead us to underestimate the effects of divestment.

### 7.2 Results from difference-in-differences on matched sample

We now turn to our difference-in-differences analysis on the matched sample. Here, we are able to analyze 256 divested plants (out of 609 divestment cases) for the period 1983-2001 that had carefully selected control plants within the 4-digit-ISIC-industry-year cell. We follow the matching procedure in Section 4, resulting in a well-balanced matched sample even in variables that were not used in the matching (see Table A.VI).

The results are summarized in Table 8. We find that divested plants experience a drop in output relative to the control group. Output declines by 27% in the year of ownership change and the decline persists in the two subsequent years. In other words, the affiliates would have seen a much faster increase in output had they remained foreign owned.

The decline in output is accompanied by an increase in energy cost per unit of output, starting with a 26% rise in the year of divestment and persisting in the two subsequent years. We observe the same pattern for physical energy use (in MBTUs) and $CO_2$ emissions per unit of output. We also note that the effect of divestment, while pointing in the opposite direction, is quite similar in magnitude to the effect of acquisition on energy and emission intensities.

We also normalize the energy use and emission levels using material expenditure to test for the possible effect of reduced markups. The idea is that divested plants may rely less on exports, which consequently would reduce their markups (Javorcik and Poelhekke, 2017). If this is the case, then we should expect to see a larger effect when we normalize energy and emission levels with a variable that is less likely to be influenced by markups. This conjecture finds no support in the data. We find that divestment causes a plant's energy use per unit of material expenditure to increase by 32%. This effect persists in two years after the year of divestment. The pattern also holds for physical

Table 8: **Difference-in-differences analysis on matched sample.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | | Log(Output) | |
| Post*Acquired | **-0.318*** ** | **-0.397*** ** | **-0.313*** ** |
| | **(0.081)** | **(0.092)** | **(0.091)** |
| R-sq. (within) | 0.030 | 0.038 | 0.035 |
| No. of Obs. | 1024 | 1024 | 1024 |
| | | Log (Energy Expenditure/Output) | |
| Post*Acquired | **0.296*** ** | **0.406*** ** | **0.290** ** |
| | **(0.099)** | **(0.108)** | **(0.121)** |
| R-sq. (within) | 0.021 | 0.035 | 0.016 |
| No. of Obs. | 1022 | 1022 | 1022 |
| | | Log (Energy Use/Output) | |
| Post*Acquired | **0.296*** ** | **0.454*** ** | **0.258** ** |
| | **(0.106)** | **(0.119)** | **(0.126)** |
| R-sq. (within) | 0.019 | 0.036 | 0.017 |
| No. of Obs. | 1022 | 1022 | 1022 |
| | | Log ($CO_2$ Emissions/Output) | |
| Post*Acquired | **0.289*** ** | **0.453*** ** | **0.249** ** |
| | **(0.106)** | **(0.120)** | **(0.126)** |
| R-sq. (within) | 0.019 | 0.036 | 0.018 |
| No. of Obs. | 1022 | 1022 | 1022 |
| | | Log(Energy Expenditure/Materials) | |
| Post*Acquired | **0.382*** ** | **0.429*** ** | **0.369*** ** |
| | **(0.111)** | **(0.122)** | **(0.136)** |
| R-sq. (within) | 0.030 | 0.040 | 0.029 |
| No. of Obs. | 1007 | 1003 | 1002 |
| | | Log (Energy Use/Materials) | |
| Post*Acquired | **0.381*** ** | **0.478*** ** | **0.338** ** |
| | **(0.118)** | **(0.133)** | **(0.143)** |
| R-sq. (within) | 0.027 | 0.040 | 0.030 |
| No. of Obs. | 1007 | 1003 | 1002 |
| | | Log ($CO_2$ Emissions/Materials) | |
| Post*Acquired | **0.375*** ** | **0.476*** ** | **0.327** ** |
| | **(0.118)** | **(0.133)** | **(0.143)** |
| R-sq. (within) | 0.027 | 0.041 | 0.033 |
| No. of Obs. | 1007 | 1003 | 1002 |

Note: The table reflects the result of estimating equation 2 on the matched sample described in Section 4, but focusing on divestments. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to divestment (as listed in each column) and a year before initally foreign-owned plants become domestic. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

energy use and $CO_2$ emission levels when normalized by expenditures on materials. Overall, our findings suggest that the benefit of foreign ownership, which manifests themselves into less energy- and $CO_2$ emission-intensive production processes, are due to continuous injection of knowledge and technological know-how from the parent company.

# 8 FDI and Industry-wide Energy and Emission Intensities

Our analysis so far suggests that foreign ownership improves a plant's environmental performance by leading to less energy- and emission-intensive production mode. Therefore, it is useful to explore the implications of FDI inflows at the aggregate level. To shed light on this issue, we describe the developments in aggregate (weighted average) energy intensity (measured as energy expenditure/output) for the entire Indonesian manufacturing sector during our sample period. We decompose these developments into changes in the unweighted average energy intensity and reallocation effects. Then we examine how aggregate energy and the two components are affected by the number of foreign affiliates participating in the local industry.

Following Olley and Pakes (1996) and Pavcnik (2002), we compile the aggregate energy intensity measure $W_t$, which is the average of the plants' individual energy intensities weighted by the plant's share in total manufacturing output $s_{it}$. We calculate $W_t$ for the entire Indonesian manufacturing sector for each year $t$. Then we decompose the aggregate energy intensity into the unweighted aggregate energy intensity (i.e., the average energy intensity taken over all plants) and the covariance between plant's share of the entire sector's output and its energy intensity:

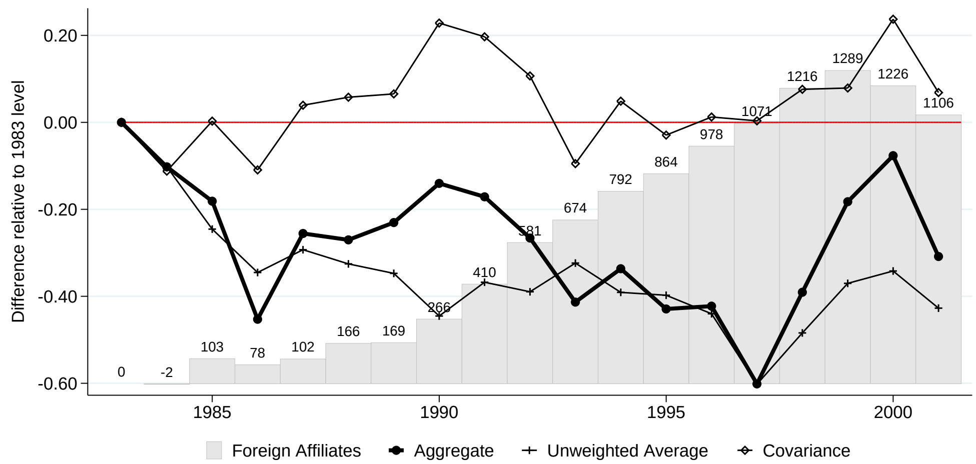
$$\underbrace{W_t = \sum_i s_{it}\, lnEIP_{it}}_{\substack{\text{Aggregate weighted}\\ \text{energy intensity}}} \quad = \quad \underbrace{\overline{lnEIP}_t}_{\substack{\text{Unweighted average}\\ \text{energy intensity}}} \quad + \quad \underbrace{\sum_i (s_{it} - \overline{s}_t)(lnEIP_{it} - \overline{lnEIP}_t)}_{Covariance} \tag{4}$$

where $s_{it}$ is the share of plant $i$'s output in the total manufacturing output at time $t$, $\overline{s}_t$ is the average output share, $lnEIP_{it}$ is firm $i$'s log(energy expenditure/output), $\overline{lnEIP}_t$ is the average log(energy expenditure/output) over all plants in the sector.

A change in the first term (unweighted average energy intensity) captures within-plant improvements in energy intensity. The second term (covariance), if positive, indicates that more output is produced by more energy intensive producers. A change in the covariance captures the effects of reallocation of market shares and resources across firms with different energy intensity levels.

The results of this exercise are summarized in Table A.XIV. Following Pavcnik (2002), we report the changes relative to 1983 levels, which is the first year of the sample. Our calculations show that aggregate energy intensity for the entire Indonesian manufacturing sector has declined by 39% in 1998 relative to the 1983 levels. We also find that the aggregate energy intensity is negatively associated with increases in foreign affiliates, particularly before the 1997 financial crisis (see Figure 4).

**Figure 4: Aggregate energy intensity, its components and the number of foreign affiliates in the Indonesian manufacturing industry, 1983-2001.**




Note: Figures are relative to 1983 levels.
Source: Indonesian Census of Manufacturing; Authors' calculation.

Given the strong downward trend of aggregate energy intensity as more foreign affiliates enter the market, it is natural to ask how changes in the number of participating foreign affiliates are associated with industry-wide aggregate energy intensity. To answer this question, we regress aggregate energy intensity and each of its components on the number of foreign affiliates in a particular industry. More specifically, we calculate the aggregate weighted energy intensity, unweighted average energy intensity and covariance at the 4-digit ISIC level. Then following Harrison et al. (2012) and Javorcik and Li (2013), we estimate the following equation:

$$Y_{jst} = \beta Foreign_{jt} + \gamma_j + \lambda_{st} + \varepsilon_{jst} \tag{5}$$

where $Y_{jst}$ is the aggregate energy intensity and its components relevant to industry $j$ operating in sector $s$ (i.e., 2-digit ISIC) at year $t$ and $Foreign$ is the log-transformed number of foreign affiliates in the industry.[21] $\gamma_j$ and $\lambda_{st}$ are 4-digit ISIC industry and 2-digit ISIC sector-year fixed effects, respectively. We weight all observations using the maximum number of plants observed in each

[21] As some industry-year cells have no foreign affiliates, we add 1 to the number of foreign affiliates before transforming it into logarithm.

industry during the entire sample period to ensure that industries with large plant populations receive higher weight, which makes our result representative of the national level. We cluster standard errors at the industry level.

To test the robustness of our result, we repeat the above regression using the share of foreign affiliates in the industry output as our indicator of foreign affiliates' participation in the market. We also look at the different aggregate measures of environmental performance, including energy energy use and $CO_2$ emission intensities as well as those normalized by expenditure on marterials to check for potential markup effects. Table 9 summarizes our results.

Our estimation results imply that increased participation of foreign affiliates is negatively associated with industry-level aggregate energy and emission intensities. This suggests that foreign affiliates' participation may be facilitating improvements in aggregate measure of environmental performance. We also find that both within-plant improvement and reallocation towards bigger and less energy-intensive plants drive the improvement in aggregate energy intensity.

## 9 Conclusions

This study contributes to literature by examining the causal effect of FDI on plant-level environmental performance. More specifically, it asks how foreign acquisitions influence plant-level energy and $CO_2$ emission intensities using data from the Census of Indonesian Manufacturing covering the period 1983-2001. Our analysis improves on the previous literature in three important respects. First, we focus on physical consumption of energy and carbon dioxide emissions, instead of relying on energy expenditure which is a less suitable proxy. Second, we examine the changes in ownership taking place within the same plant. This allows us to focus on changes in plant-level environmental performance introduced by foreign ownership. Third, rather than focusing on the narrow question of energy expenditure, we consider a wider range of outcomes which can potentially explain the changes in energy consumption and emission patterns of acquired plants.

Our measure of pollution impact is far from perfect. The analysis is limited to global pollution (i.e., $CO_2$ emissions) and completely ignores the impact of FDI on local pollutants, which may be of greater interest when analyzing the impact of cross-country differences in local environmental regulations. Devising a close approximation of plant-level emissions of local pollutants is extremely challenging as it requires information on plant-level pollution abatement which is not available in our data set. Moreover, our analysis does not address the potential technological and management spillover effects of FDI on domestic plants or the possible outsourcing of the "dirty" part of the multinational to other sectors or other countries.

Despite these methodological imperfections, the data show remarkable plant-level operational changes

## Table 9: Regression results: Decomposition of weighted aggregate energy intensity

| | Measure based on number of FAs | | | Measure based on output share of FAs | | |
|---|---|---|---|---|---|---|
| | $W_t$ | $\overline{lnEIP}$ | Covariance | $W_t$ | $\overline{lnEIP}$ | Covariance |
| **Log (Energy Expenditure/Output)** | | | | | | |
| Foreign Affiliates | **-0.226*** ** | **-0.086** ** | **-0.140*** ** | **-0.772* ** | **-0.552** ** | -0.219 |
| | **(0.041)** | **(0.034)** | **(0.044)** | **(0.410)** | **(0.276)** | (0.318) |
| Adj. R-sq. | 0.853 | 0.829 | 0.774 | 0.842 | 0.827 | 0.764 |
| Observations | 1408 | 1408 | 1408 | 1408 | 1408 | 1408 |
| **Log (Energy Use/Output)** | | | | | | |
| Foreign Affiliates | **-0.215*** ** | **-0.070** ** | **-0.146*** ** | **-0.740* ** | **-0.490* ** | -0.250 |
| | **(0.039)** | **(0.034)** | **(0.040)** | **(0.401)** | **(0.271)** | (0.336) |
| Adj. R-sq. | 0.859 | 0.852 | 0.784 | 0.850 | 0.851 | 0.775 |
| Observations | 1408 | 1408 | 1408 | 1408 | 1408 | 1408 |
| **Log (CO2 Emission/Output)** | | | | | | |
| Foreign Affiliates | **-0.217*** ** | **-0.077** ** | **-0.140*** ** | **-0.761* ** | **-0.521* ** | -0.239 |
| | **(0.039)** | **(0.035)** | **(0.040)** | **(0.405)** | **(0.277)** | (0.328) |
| Adj. R-sq. | 0.853 | 0.834 | 0.783 | 0.844 | 0.833 | 0.775 |
| Observations | 1408 | 1408 | 1408 | 1408 | 1408 | 1408 |
| **Log (Energy Expenditure/Materials)** | | | | | | |
| Foreign Affiliates | **-0.254*** ** | **-0.093** ** | **-0.161** ** | **-0.822* ** | **-0.698** ** | -0.125 |
| | **(0.061)** | **(0.043)** | **(0.065)** | **(0.454)** | **(0.307)** | (0.381) |
| Adj. R-sq. | 0.873 | 0.874 | 0.789 | 0.863 | 0.874 | 0.779 |
| Observations | 1407 | 1407 | 1407 | 1407 | 1407 | 1407 |
| **Log (Energy Use/Materials)** | | | | | | |
| Foreign Affiliates | **-0.243*** ** | **-0.076* ** | **-0.167*** ** | **-0.788* ** | **-0.628** ** | -0.160 |
| | **(0.058)** | **(0.041)** | **(0.060)** | **(0.444)** | **(0.299)** | (0.392) |
| Adj. R-sq. | 0.881 | 0.882 | 0.804 | 0.872 | 0.883 | 0.794 |
| Observations | 1407 | 1407 | 1407 | 1407 | 1407 | 1407 |
| **Log (CO2 Emission/Materials)** | | | | | | |
| Foreign Affiliates | **-0.244*** ** | **-0.082** ** | **-0.162*** ** | **-0.804* ** | **-0.657** ** | -0.147 |
| | **(0.057)** | **(0.041)** | **(0.060)** | **(0.450)** | **(0.301)** | (0.386) |
| Adj. R-sq. | 0.877 | 0.872 | 0.805 | 0.868 | 0.873 | 0.796 |
| Observations | 1407 | 1407 | 1407 | 1407 | 1407 | 1407 |
| No. of industries (4-digit ISIC) | 79 | 79 | 79 | 79 | 79 | 79 |
| No. of sectors (2-digit ISIC) | 9 | 9 | 9 | 9 | 9 | 9 |
| No. of years | 19 | 19 | 19 | 19 | 19 | 19 |

Note: Period coverage is 1983-2001. Each regression includes 4-digit ISIC industry and 2-digit ISIC-year fixed effects. FA stands for foreign affiliates. Robust standard errors clustered at the 4-digit ISIC industry level are in parentheses. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

associated with ownership changes. First, we see a positive and significant effect of a foreign acquisition on real output of the plant, and consequently, its levels of energy use and $CO_2$ emissions. More interestingly from the perspective of the study is the second effect, namely, the improvement in the efficiency of using energy inputs due to FDI-induced innovations and investments. We see indications of falling energy use and emission intensities, which implies that each additional unit of output is produced with lower energy and $CO_2$ content. There is also an indication that foreign acquisitions are actually facilitating structural changes in production processes relating to energy use and emissions, suggesting that the improvement in energy use is not solely due to economies of scale. We also observe the exact opposite effect when we analyze the effect of divestments on plant-level energy and $CO_2$ emission intensities.

At the aggregate level, we find that the entry of foreign affiliates is negatively related to industry-wide average energy intensity. It is possible that, besides the direct effects, increased foreign participation in the domestic market may also have an indirect effect on other plants' energy consumption and emission patterns. More future research is, however, needed to examine the developments in energy and emission efficiency spillovers in the aftermath of foreign acquisitions and divestments.

Our findings also provide a way to reconcile the conflicting results within the broad literature of foreign ownership and plant-level environmental performance. Our results indicate that the discrepancy between the findings of previous studies may be a consequence of failing to account for the initial energy intensity (or efficiency) levels of acquired plants. The impact of acquisition on more energy intensive domestic plants is found to be more significant and larger than on those that are already less energy intensive (and presumably more efficient) domestic plants. Moving forward, it would interesting to empirically investigate other dimensions influencing the heterogeneity of acquisition-induced effects on plant-level emissions.

The results of our study have broader implications, particularly in terms of promoting "green growth" in response to the threats of climate change and environmental degradation. More specifically, we show that FDI can serve as a channel for international transfer of environmentally-friendly technologies and practices, thus directly contributing to environmental progress. The study also provides direction on how to maximize the positive environmental benefits of FDI, which not only includes attracting foreign investors but also formulating policies that directly affect factor prices.

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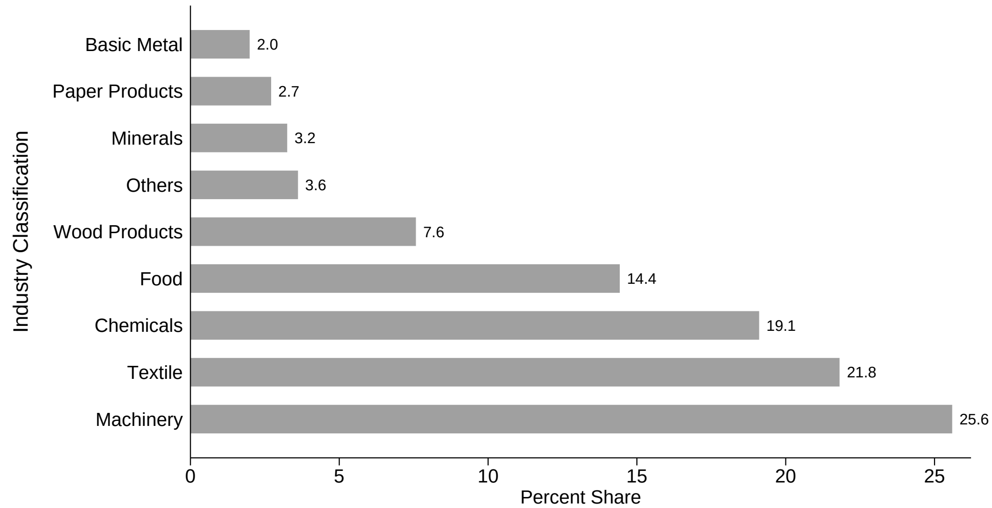
# Appendices

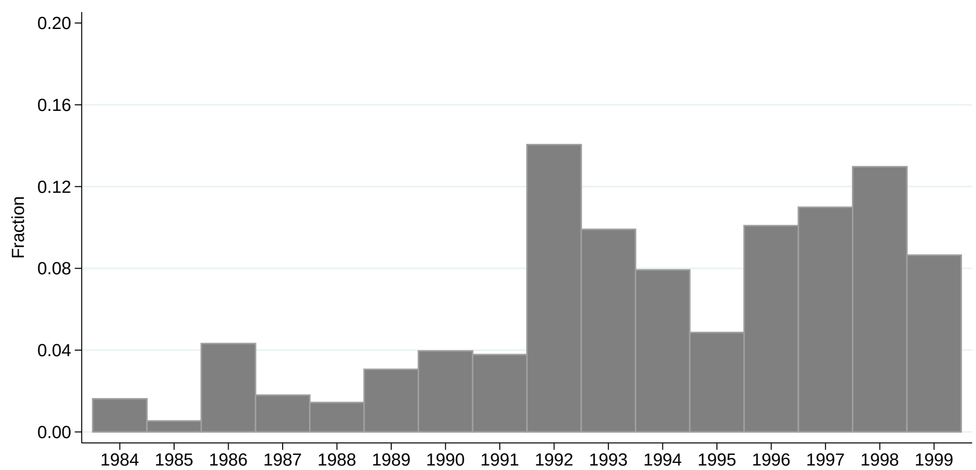
**[FOR PUBLICATION ONLINE]**

**Figure A.I: Distribution of acquired plants, by sector.**




Note: Industry classification is based on International Standard Industry Classificaton (ISIC) Rev2 2-digit level.
Source: Indonesian Census of Manufacturing

**Figure A.II: Distribution of acquisition cases, by year.**




Source: Indonesian Census of Manufacturing

**Table A.I: Goodness-of-Fit in estimating plant-level energy use (in physical units).**

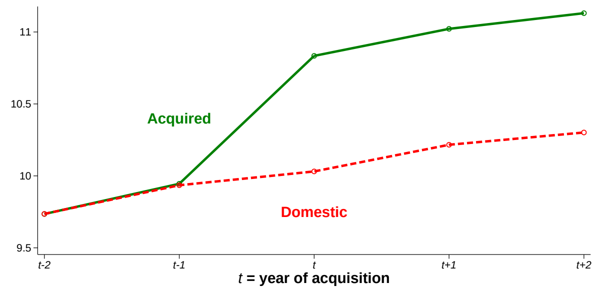
| | Obs. | R.sq. | Adj. R-sq. | RMSE |
|---|---|---|---|---|
| *Fuel and Lubricant (Total)* | | | | |
| Gasoline | 140,744 | 0.993 | 0.993 | 0.144 |
| Diesel | 198,309 | 0.992 | 0.992 | 0.208 |
| Diesel Oil | 30,279 | 0.966 | 0.966 | 0.564 |
| Kerosene | 104,509 | 0.696 | 0.695 | 1.164 |
| Lubricant | 213,705 | 0.944 | 0.944 | 0.520 |
| Bunker Oil | 2,049 | 0.999 | 0.999 | 0.102 |
| Coal | 1,370 | 0.975 | 0.973 | 0.640 |
| Coke | 2,912 | 0.942 | 0.940 | 0.633 |
| Public Gas | 9,598 | 0.931 | 0.930 | 0.812 |
| LPG | 11,906 | 0.993 | 0.993 | 0.175 |
| Firewood | 9,089 | 0.990 | 0.990 | 0.218 |
| Charcoal | 1,460 | 0.988 | 0.987 | 0.236 |
| *Fuel and Lubricant (Elec. Generation)* | | | | |
| Gasoline | 1,435 | 0.983 | 0.982 | 0.303 |
| Diesel | 37,683 | 0.987 | 0.987 | 0.285 |
| Diesel Oil | 2,538 | 0.966 | 0.965 | 0.580 |
| Kerosene | 317 | 0.981 | 0.974 | 0.449 |
| Lubricant | 22,606 | 0.972 | 0.972 | 0.357 |
| Bunker Oil | 179 | 0.996 | 0.995 | 0.258 |
| Coal | 29 | 0.997 | 0.988 | 0.401 |
| Coke | 6 | 1.000 | . | - |
| Public Gas | 93 | 0.991 | 0.983 | 0.402 |
| LPG | 110 | 0.985 | 0.969 | 0.488 |
| Firewood | 44 | 0.983 | 0.945 | 0.760 |
| Charcoal | 16 | 1.000 | . | - |
| *Electricity Use* | | | | |
| Sold | 702 | 0.978 | 0.974 | 0.489 |
| PLN | 216,193 | 0.979 | 0.979 | 0.349 |
| Non-PLN | 5,022 | 0.974 | 0.974 | 0.465 |

Note: The table reports the goodness-of-fit in estimating equation 1. Each variable is expressed in log. LPG denotes liquefied petroleum gas. PLN refers to amount of electricity bought from Indonesia's state-owned power company *Perusahaan Listrik Negar*, while non-PLN refers to those that are bought from independent power producers.
Source: Indonesian Census of Manufacturing

**Table A.II: Sources of Conversion Factors**

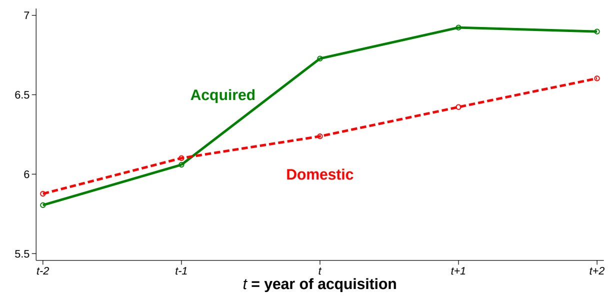
| | |
|---|---|
| *Conversion to Energy (in MBTUs)* | |
| Gasoline | Silverman, D. (Univ. of California, Irvine) |
| Diesel | US Energy Information Administration |
| Fuel Oil/Bunker Oil | US Energy Information Administration |
| Kerosene | US Energy Information Administration |
| Lubricants | US Energy Information Administration |
| Coal | US Environmental Protection Agency |
| Coke | US Energy Information Administration |
| Public Gas | US Bureau of Mines |
| Liquefied Petroleum Gas | US Environmental Protection Agency |
| Firewood | Silverman, D. (Univ. of California, Irvine) |
| Charcoal | Oak Ridge National Laboratory |
| Electricity | US Energy Information Administration |
| *Conversion to Carbon Dioxide (in Kg/C)* | |
| Gasoline | US Energy Information Administration |
| Diesel | US Environmental Protection Agency |
| Fuel Oil/Bunker Oil | US Environmental Protection Agency |
| Kerosene | US Environmental Protection Agency |
| Lubricants | US Energy Information Administration |
| Coal | US Energy Information Administration |
| Coke | US Energy Information Administration |
| Public Gas | US Energy Information Administration |
| Liquefied Petroluem Gas | US Energy Information Administration |
| Firewood | Partnership for Policy Integrity |
| Charcoal | Akagi et al. (2011) |
| Electricity | US Environmental Protection Agency |

**Figure A.III: Trajectories of output, energy expenditure and energy intensity: Acquired vs. domestic plants, excluding post-1997 crisis.**

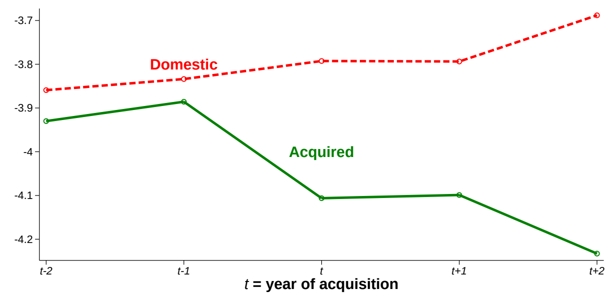



(a) Log(output)

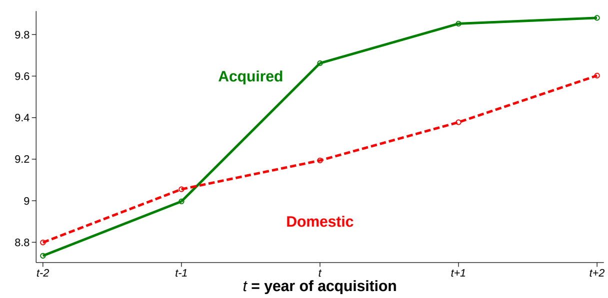
(b) Log(energy expenditure in Rps)



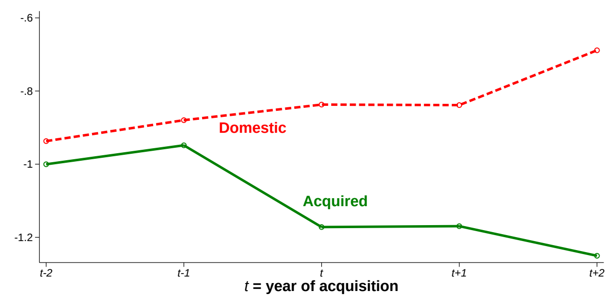

(c) Log(energy expenditure/output)



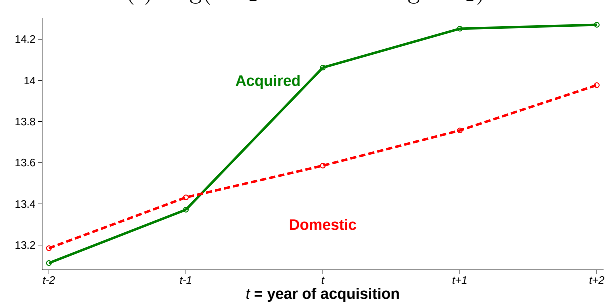

(d) Log(energy use in MBTUs)



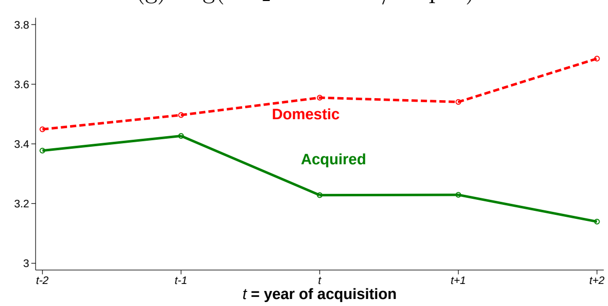

(e) Log(energy use/output)




(f) Log($CO_2$ emission in kg $CO_2$)




(g) Log($CO_2$ emissions/output)




The figure illustrates the average value of each variable of interest in a given time period for the treated (acquired) and control (domestic) group. The horizontal axes indicate the year relative to the period $t$ where treated plants are acquired.

**Table A.III: Matched difference-in-differences estimates: Excluding post-1997 financial crisis period.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | | Log(Output) | |
| Post*Acquired | **0.793*** ** | **0.777*** ** | **0.798*** ** |
| | **(0.125)** | **(0.134)** | **(0.156)** |
| R-sq. (within) | 0.236 | 0.281 | 0.291 |
| No. of Obs. | 714 | 654 | 614 |
| | | Log (Energy expenditure in Rps) | |
| Post*Acquired | **0.519*** ** | **0.647*** ** | **0.492*** ** |
| | **(0.133)** | **(0.152)** | **(0.184)** |
| R-sq. (within) | 0.134 | 0.174 | 0.136 |
| No. of Obs. | 714 | 654 | 613 |
| | | Log (Energy use in MBTUs) | |
| Post*Acquired | **0.486*** ** | **0.597*** ** | **0.474*** ** |
| | **(0.135)** | **(0.156)** | **(0.182)** |
| R-sq. (within) | 0.130 | 0.155 | 0.147 |
| No. of Obs. | 714 | 654 | 613 |
| | | Log ($CO_2$ emissions in kg $CO_2$) | |
| Post*Acquired | **0.494*** ** | **0.601*** ** | **0.473** ** |
| | **(0.136)** | **(0.157)** | **(0.184)** |
| R-sq. (within) | 0.142 | 0.167 | 0.158 |
| No. of Obs. | 714 | 654 | 613 |
| | | Log (Energy expenditure/Output) | |
| Post*Acquired | **-0.273** ** | -0.130 | **-0.310* ** |
| | **(0.131)** | (0.130) | **(0.160)** |
| R-sq. (within) | 0.019 | 0.012 | 0.031 |
| No. of Obs. | 714 | 654 | 613 |
| | | Log (Energy use/Output) | |
| Post*Acquired | **-0.307** ** | -0.180 | **-0.328** ** |
| | **(0.135)** | (0.138) | **(0.166)** |
| R-sq. (within) | 0.020 | 0.015 | 0.026 |
| No. of Obs. | 714 | 654 | 613 |
| | | Log ($CO_2$ emissions/Output) | |
| Post*Acquired | **-0.299** ** | -0.176 | **-0.329** ** |
| | **(0.133)** | (0.137) | **(0.164)** |
| R-sq. (within) | 0.017 | 0.011 | 0.022 |
| No. of Obs. | 714 | 654 | 613 |

Note: The table reflects the result of estimating equation 2 on the matched sample described in Section 4 but drops years after 1997. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

## Table A.IV: Constant sample over a longer time horizon.

| | Acquisition Year | 1 Year Later | 2 Years Later | 3 Years Later | 4 Years Later | 5 Years Later |
|---|---|---|---|---|---|---|
| | | | Log(Output) | | | |
| Post*Acquired | **0.728*** ** | **0.839*** ** | **0.813*** ** | **1.033*** ** | **1.104*** ** | **1.118*** ** |
| | **(0.135)** | **(0.139)** | **(0.150)** | **(0.170)** | **(0.180)** | **(0.192)** |
| R-sq. (within) | 0.247 | 0.316 | 0.281 | 0.299 | 0.292 | 0.278 |
| No. of Obs. | 462 | 462 | 462 | 462 | 462 | 462 |
| | | | Log (Energy Expenditure in Rps) | | | |
| Post*Acquired | **0.430*** ** | **0.593*** ** | **0.500*** ** | 0.306 | **0.420** ** | **0.647*** ** |
| | **(0.152)** | **(0.159)** | **(0.183)** | (0.198) | **(0.186)** | **(0.185)** |
| R-sq. (within) | 0.124 | 0.184 | 0.141 | 0.138 | 0.206 | 0.221 |
| No. of Obs. | 454 | 454 | 454 | 454 | 454 | 454 |
| | | | Log (Energy Use in MBTUs) | | | |
| Post*Acquired | **0.337** ** | **0.542*** ** | **0.429** ** | 0.227 | **0.318* ** | **0.598*** ** |
| | **(0.151)** | **(0.162)** | **(0.182)** | (0.200) | **(0.187)** | **(0.193)** |
| R-sq. (within) | 0.112 | 0.166 | 0.149 | 0.153 | 0.208 | 0.200 |
| No. of Obs. | 454 | 454 | 454 | 454 | 454 | 454 |
| | | | Log ($CO_2$ Emissions in kg $CO_2$) | | | |
| Post*Acquired | **0.314** ** | **0.524*** ** | **0.406** ** | 0.192 | 0.311 | **0.589*** ** |
| | **(0.154)** | **(0.164)** | **(0.184)** | (0.203) | (0.191) | **(0.194)** |
| R-sq. (within) | 0.118 | 0.171 | 0.154 | 0.161 | 0.219 | 0.212 |
| No. of Obs. | 454 | 454 | 454 | 454 | 454 | 454 |
| | | | Log (Energy Expenditure/Output) | | | |
| Post*Acquired | **-0.308** ** | **-0.272** ** | **-0.345** ** | **-0.718*** ** | **-0.675*** ** | **-0.489*** ** |
| | **(0.134)** | **(0.126)** | **(0.161)** | **(0.157)** | **(0.155)** | **(0.155)** |
| R-sq. (within) | 0.025 | 0.024 | 0.019 | 0.087 | 0.084 | 0.037 |
| No. of Obs. | 454 | 454 | 454 | 454 | 454 | 454 |
| | | | Log (Energy Use/Output) | | | |
| Post*Acquired | **-0.401*** ** | **-0.323** ** | **-0.416** ** | **-0.797*** ** | **-0.777*** ** | **-0.537*** ** |
| | **(0.136)** | **(0.135)** | **(0.164)** | **(0.168)** | **(0.164)** | **(0.164)** |
| R-sq. (within) | 0.041 | 0.030 | 0.025 | 0.091 | 0.099 | 0.040 |
| No. of Obs. | 454 | 454 | 454 | 454 | 454 | 454 |
| | | | Log ($CO_2$ Emissions/Output) | | | |
| Post*Acquired | **-0.424*** ** | **-0.341** ** | **-0.439*** ** | **-0.832*** ** | **-0.784*** ** | **-0.547*** ** |
| | **(0.139)** | **(0.136)** | **(0.166)** | **(0.172)** | **(0.168)** | **(0.165)** |
| R-sq. (within) | 0.039 | 0.028 | 0.026 | 0.095 | 0.101 | 0.042 |
| No. of Obs. | 454 | 454 | 454 | 454 | 454 | 454 |

Note: The table reflects the result of estimating equation 2 on the matched sample described in Section 4 but ensures that the included plants have non-missing observations in each time peiord. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

**Table A.V: Constant sample over a longer time horizon (matching outside the same county).**

| | Acquisition Year | 1 Year Later | 2 Years Later | 3 Years Later | 4 Years Later | 5 Years Later |
|---|---|---|---|---|---|---|
| | | | Log(Output) | | | |
| Post*Acquired | **0.707*** ** | **0.827*** ** | **0.803*** ** | **1.039*** ** | **1.126*** ** | **1.090*** ** |
| | **(0.134)** | **(0.136)** | **(0.149)** | **(0.170)** | **(0.179)** | **(0.192)** |
| R-sq. (within) | 0.242 | 0.315 | 0.276 | 0.302 | 0.295 | 0.267 |
| No. of Obs. | 454 | 454 | 454 | 454 | 454 | 454 |
| | | | Log (Energy Expenditure in Rps) | | | |
| Post*Acquired | **0.442*** ** | **0.589*** ** | **0.547*** ** | **0.363*** | **0.495*** ** | **0.714*** ** |
| | **(0.154)** | **(0.159)** | **(0.186)** | **(0.201)** | **(0.188)** | **(0.189)** |
| R-sq. (within) | 0.122 | 0.175 | 0.134 | 0.122 | 0.193 | 0.203 |
| No. of Obs. | 446 | 446 | 446 | 446 | 446 | 446 |
| | | | Log (Energy Use in MBTUs) | | | |
| Post*Acquired | **0.354** ** | **0.569*** ** | **0.467** ** | **0.268** | **0.392** ** | **0.663*** ** |
| | **(0.153)** | **(0.163)** | **(0.184)** | **(0.202)** | **(0.189)** | **(0.198)** |
| R-sq. (within) | 0.109 | 0.163 | 0.141 | 0.136 | 0.195 | 0.183 |
| No. of Obs. | 446 | 446 | 446 | 446 | 446 | 446 |
| | | | Log (CO2 Emissions in kg CO2) | | | |
| Post*Acquired | **0.328** ** | **0.551*** ** | **0.443** ** | **0.232** | **0.381** ** | **0.654*** ** |
| | **(0.156)** | **(0.166)** | **(0.187)** | **(0.206)** | **(0.193)** | **(0.198)** |
| R-sq. (within) | 0.115 | 0.167 | 0.146 | 0.144 | 0.206 | 0.195 |
| No. of Obs. | 446 | 446 | 446 | 446 | 446 | 446 |
| | | | Log (Energy Expenditure/Output) | | | |
| Post*Acquired | **-0.275** ** | **-0.263** ** | **-0.287*** | **-0.667*** ** | **-0.624*** ** | **-0.394** ** |
| | **(0.134)** | **(0.126)** | **(0.162)** | **(0.159)** | **(0.154)** | **(0.155)** |
| R-sq. (within) | 0.020 | 0.024 | 0.014 | 0.077 | 0.072 | 0.023 |
| No. of Obs. | 446 | 446 | 446 | 446 | 446 | 446 |
| | | | Log (Energy Use/Output) | | | |
| Post*Acquired | **-0.363*** ** | **-0.284** ** | **-0.368** ** | **-0.763*** ** | **-0.727*** ** | **-0.444*** ** |
| | **(0.136)** | **(0.133)** | **(0.165)** | **(0.169)** | **(0.163)** | **(0.165)** |
| R-sq. (within) | 0.034 | 0.025 | 0.019 | 0.085 | 0.088 | 0.026 |
| No. of Obs. | 446 | 446 | 446 | 446 | 446 | 446 |
| | | | Log (CO2 Emissions/Output) | | | |
| Post*Acquired | **-0.389*** ** | **-0.302** ** | **-0.392** ** | **-0.798*** ** | **-0.738*** ** | **-0.454*** ** |
| | **(0.139)** | **(0.134)** | **(0.167)** | **(0.173)** | **(0.167)** | **(0.166)** |
| R-sq. (within) | 0.033 | 0.023 | 0.020 | 0.087 | 0.091 | 0.027 |
| No. of Obs. | 446 | 446 | 446 | 446 | 446 | 446 |

Note: The table reflects the result of estimating equation 2 on the matched sample (not belonging to the same province or *kabupaten*) described in Section 4 but ensures that the included plants have non-missing observations in each time periodd. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

# AI Construction of the control group using coarsened exact matching

Coarsened exact matching (CEM) procedure (Iacus et al., 2009, 2011), unlike propensity score matching that relies on estimating a scalar (i.e., the propensity score), is a nonparametric method used to identify a control group for the treated observations. In our context, this is helpful because we do not observe the pollution abatement technology each plant has, which we think could be a factor that can help predict the probability of a plant being acquired. While it has some advantages over propensity score matching (e.g. balance on selected covariates *ex ante*), it suffers from the "curse of dimensionality" where the proportion of matched observations decreases rapidly with the number of strata (Azoulay et al., 2010).

The first step in implementing CEM is to identify a set of covariates on which we can balance the treated (i.e. acquired plants) and the control (i.e. domestic plants) observations. In our context, we used the same set of covariates that we used in the propensity score matching in order to maintain comparability. Similar to our baseline matching procedure, we implement CEM in each year-industry cell, thus creating 1,415 bins. In each bin, we coarsen the joint distribution of the selected covariates, resulting in about 200 strata in each bin on the average (ranging from 3 to 604 strata). Within each stratum, we identify a control plant for each of the treated plants. If there are multiple choices, ties are broken randomly. In this procedure, we are to identify a control plant for 264 acquired plants.

The first 4 columns of Table A.VI show that our matched treated and control plants are well balanced in the set of covariates that we used in the matching procedure. Similar to our baseline matching procedure, we also evaluate CEM on potential "selection on observables" bias by looking at mean differences between treated and control plants on a covariates that were not used in matching. In all of these covariates, we find no statistically significant mean differences. Meanwhile, Table A.VII shows that our baseline estimate is consistent even if we use a different matching procedure.

## Table A.VI: Balancing hypothesis under various matching procedures.

| Variables | CEM (N=418) | | | PSM (no same county) (N=440) | | | IPTW (N=143,216) | | Divestment (N=512) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Treated | Control | p-value | Treated | Control | p-value | F-Stat | p-value | Treated | Control | p-value |
| ***Used in matching*** | | | | | | | | | | | |
| Log (Real Output)$_{t-1}$ | 9.03 | 9.03 | 0.99 | 9.86 | 9.86 | 0.90 | 4.43 | 0.04 | 10.94 | 10.96 | 0.87 |
| Log (Energy Expenditure/Output)$_{t-1}$ | -3.71 | -3.71 | 0.99 | -3.82 | -3.82 | 0.65 | 0.80 | 0.37 | -4.21 | -4.19 | 0.86 |
| Log (Real Output)$_{t-2}$ | 9.59 | 9.62 | 0.90 | 9.86 | 9.86 | 0.90 | 5.91 | 0.02 | 10.83 | 10.76 | 0.60 |
| Log (Energy Expenditure/Output)$_{t-2}$ | -3.77 | -3.79 | 0.92 | -3.82 | -3.82 | 0.65 | 0.02 | 0.89 | -4.13 | -4.08 | 0.68 |
| ***Unused in matching*** | | | | | | | | | | | |
| Log (Energy Expenditure)$_{t-1}$ | 5.33 | 5.33 | 0.99 | 6.03 | 6.03 | 0.84 | 6.23 | 0.01 | 6.72 | 6.76 | 0.79 |
| Log (Energy Use)$_{t-1}$ | 8.25 | 8.26 | 0.95 | 8.99 | 8.99 | 0.77 | 5.42 | 0.01 | 9.66 | 9.69 | 0.80 |
| Log (CO2 Emission)$_{t-1}$ | 12.65 | 12.66 | 0.94 | 13.36 | 13.36 | 0.78 | 0.02 | 0.02 | 14.05 | 14.08 | 0.82 |
| Log (Employment)$_{t-1}$ | 4.85 | 4.72 | 0.26 | 5.26 | 5.26 | 0.40 | 4.59 | 0.00 | 5.76 | 5.69 | 0.46 |
| Exporter Dummy$_{t-1}$ | 0.15 | 0.18 | 0.30 | 0.18 | 0.18 | 0.80 | 14.42 | 0.03 | 0.33 | 0.35 | 0.64 |
| Share of Imported Materials$_{t-1}$ | 0.20 | 0.18 | 0.56 | 0.19 | 0.19 | 0.05 | 12.14 | 0.00 | 0.30 | 0.36 | 0.05 |
| Share of Skilled Workers$_{t-1}$ | 0.19 | 0.20 | 0.63 | 0.21 | 0.21 | 0.25 | 17.91 | 0.00 | 0.22 | 0.21 | 0.39 |
| Log(Investment in Machineries)$_{t-1}$ | 7.15 | 6.93 | 0.43 | 7.86 | 7.86 | 0.20 | 0.61 | 0.00 | 8.84 | 8.96 | 0.55 |
| Log(Energy Use/Output)$_{t-1}$ | -0.80 | -0.79 | 0.93 | -0.87 | -0.87 | 0.56 | 0.22 | 0.43 | -1.28 | -1.26 | 0.87 |
| Delta Log (Energy Expenditure)$_{t-1}$ | 0.14 | 0.08 | 0.19 | 0.15 | 0.15 | 0.55 | 0.03 | 0.90 | 0.03 | 0.08 | 0.51 |
| Delta Log (Energy Use)$_{t-1}$ | 0.17 | 0.09 | 0.19 | 0.18 | 0.18 | 0.72 | 0.00 | 0.87 | 0.02 | 0.10 | 0.40 |
| Delta Log (CO2 Emissions)$_{t-1}$ | 0.17 | 0.09 | 0.22 | 0.18 | 0.18 | 0.70 | 10.36 | 0.97 | 0.02 | 0.10 | 0.43 |
| Log(CO2 Emissions/Output)$_{t-1}$ | 3.61 | 3.62 | 0.92 | 3.51 | 3.51 | 0.57 | 7.45 | 0.64 | 3.11 | 3.13 | 0.89 |
| Log(Energy Exp./Materials)$_{t-1}$ | -2.80 | -2.81 | 0.93 | -3.03 | -3.03 | 0.32 | 0.39 | 0.01 | -3.54 | -3.37 | 0.19 |
| Delta Log (Real Output)$_{t-1}$ | 0.13 | 0.05 | 0.14 | 0.14 | 0.14 | 0.86 | 2.05 | 0.53 | 0.11 | 0.19 | 0.24 |
| Delta Log (Energy Expenditure/Output)$_{t-1}$ | 0.02 | 0.03 | 0.81 | 0.02 | 0.02 | 0.60 | 1.93 | 0.15 | -0.09 | -0.11 | 0.78 |
| Delta Log(Energy Use/Output)$_{t-1}$ | 0.05 | 0.04 | 0.87 | 0.04 | 0.04 | 0.81 | 1.48 | 0.16 | -0.09 | -0.09 | 0.95 |
| Delta Log(CO2 Emissions/Output)$_{t-1}$ | 0.04 | 0.04 | 0.96 | 0.04 | 0.04 | 0.78 | 1.66 | 0.22 | -0.09 | -0.10 | 0.91 |
| Delta Log(Energy Exp./Materials)$_{t-1}$ | 0.08 | -0.02 | 0.08 | 0.04 | 0.04 | 0.81 | 0.00 | 0.20 | -0.11 | -0.13 | 0.77 |

Note: CEM - coarsened exact matching; PSM - propensity score matching; IPW - inverse probability weighting procedure. The variables used in each matching procedure include lagged output, energy expenditure, energy use (in MBTUs) and $CO_2$ emission and the log difference on the last three variables.

**Table A.VII: Difference-in-differences estimates using coarsened exact matching procedure.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | | Log(Output) | |
| Post*Acquired | **1.392*** ** | **1.499*** ** | **1.530*** ** |
| | **(0.141)** | **(0.144)** | **(0.148)** |
| R-sq. (within) | 0.350 | 0.383 | 0.392 |
| No. of Obs. | 876 | 876 | 876 |
| | | Log (Energy Expenditure in Rps) | |
| Post*Acquired | **1.012*** ** | **1.189*** ** | **1.159*** ** |
| | **(0.140)** | **(0.149)** | **(0.158)** |
| R-sq. (within) | 0.221 | 0.248 | 0.253 |
| No. of Obs. | 871 | 868 | 868 |
| | | Log(Energy Use in MBTUs) | |
| Post*Acquired | **0.992*** ** | **1.149*** ** | **1.085*** ** |
| | **(0.145)** | **(0.157)** | **(0.165)** |
| R-sq. (within) | 0.209 | 0.232 | 0.229 |
| No. of Obs. | 871 | 868 | 868 |
| | | Log ($CO_2$ Emissions) | |
| Post*Acquired | **1.000*** ** | **1.158*** ** | **1.099*** ** |
| | **(0.145)** | **(0.156)** | **(0.165)** |
| R-sq. (within) | 0.214 | 0.240 | 0.234 |
| No. of Obs. | 871 | 868 | 868 |
| | | Log (Energy Expenditure/Output) | |
| Post*Acquired | **-0.372*** ** | **-0.297** ** | **-0.382*** ** |
| | **(0.113)** | **(0.121)** | **(0.123)** |
| R-sq. (within) | 0.059 | 0.054 | 0.048 |
| No. of Obs. | 871 | 868 | 868 |
| | | Log (Energy Use/Output) | |
| Post*Acquired | **-0.392*** ** | **-0.336** ** | **-0.456*** ** |
| | **(0.119)** | **(0.133)** | **(0.134)** |
| R-sq. (within) | 0.053 | 0.042 | 0.048 |
| No. of Obs. | 871 | 868 | 868 |
| | | Log ($CO_2$ Emissions/Output) | |
| Post*Acquired | **-0.383*** ** | **-0.327** ** | **-0.443*** ** |
| | **(0.119)** | **(0.131)** | **(0.133)** |
| R-sq. (within) | 0.051 | 0.039 | 0.045 |
| No. of Obs. | 871 | 868 | 868 |

Note: The table reflects the result of estimating equation 2 on the matched sample using CEM. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

# AII Estimation based on Inverse Probability of Treatment Weighting (IPTW)

As mentioned in the main text, one major drawback of the one-to-one propensity score matching is that we are limiting our conclusion to a very few matched observations. This may post an issue on the validity of our estimate if the majority of the dropped plants with acquisition cases are systematically different in our outcome variables but are marginally different in the set of covariates that we chose in the matching procedure. Moreover, there are also studies suggesting that the finite sample properties of one-to-one propensity score matching are inferior to other matching techniques (see, for example, Guadalupe et al., 2012; Busso et al., 2014).

To address this concern, we employ inverse probability of treatment weighting to identify the appropriate controls for each acquired plant. In particular, we transform the same propensity score estimated from the set of covariates in our baseline matching procedure into weights, following (Guadalupe et al., 2012). We weight each treated firm by $(1/\hat{p})$ and each control firm by $(1/(1-\hat{p}))$ where $\hat{p}$ is our estimated propensity score from the baseline matching procedure. We apply these weights for samples which includes acquired plants that we observe 2 and 5 years after acquisition case to test for the comparability of the estimated average effect effect (ATE) with our period-by-period baseline estimates.

In contrast to our baseline procedure and CEM, we find statistically significant mean difference between treated and control plants on some observable covariates (see Table A.VI). However, we find balanced sample in the trends of our variables of interests, which is a key assumption in performing difference-in-differences. The results from performing this alternative matching procedure are fairly consistent with our baseline estimates, suggesting that our baseline results are robust to different matching procedure (see Table A.VIII).

**Table A.VIII: Difference-in-differences estimates using inverse probability of treatment weighting.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | Log(Output) | | |
| Post*Acquired | **1.659*****| **1.763***** | **1.906***** |
| | **(0.184)** | **(0.218)** | **(0.221)** |
| R-sq. (within) | 0.803 | 0.807 | 0.809 |
| No. of Obs. | 138750 | 138750 | 138750 |
| | Log (Energy Expenditure in Rps) | | |
| Post*Acquired | **1.353***** | **1.421***** | **1.399***** |
| | **(0.176)** | **(0.199)** | **(0.220)** |
| R-sq. (within) | 0.806 | 0.802 | 0.800 |
| No. of Obs. | 138011 | 138009 | 138008 |
| | Log(Energy Use in MBTUs) | | |
| Post*Acquired | **1.284***** | **1.337***** | **1.324***** |
| | **(0.172)** | **(0.192)** | **(0.212)** |
| R-sq. (within) | 0.805 | 0.798 | 0.795 |
| No. of Obs. | 138011 | 138009 | 138008 |
| | Log ($CO_2$ Emissions) | | |
| Post*Acquired | **1.359***** | **1.400***** | **1.395***** |
| | **(0.170)** | **(0.192)** | **(0.211)** |
| R-sq. (within) | 0.806 | 0.799 | 0.794 |
| No. of Obs. | 138010 | 138008 | 138007 |
| | Log (Energy Expenditure/Output) | | |
| Post*Acquired | **-0.324***** | **-0.358***** | **-0.516***** |
| | **(0.120)** | **(0.133)** | **(0.159)** |
| R-sq. (within) | 0.640 | 0.649 | 0.638 |
| No. of Obs. | 138011 | 138009 | 138008 |
| | Log (Energy Use/Output) | | |
| Post*Acquired | **-0.392***** | **-0.443***** | **-0.590***** |
| | **(0.129)** | **(0.149)** | **(0.178)** |
| R-sq. (within) | 0.643 | 0.642 | 0.625 |
| No. of Obs. | 138011 | 138009 | 138008 |
| | Log ($CO_2$ Emissions/Output) | | |
| Post*Acquired | **-0.318***** | **-0.380***** | **-0.519***** |
| | **(0.117)** | **(0.134)** | **(0.165)** |
| R-sq. (within) | 0.653 | 0.653 | 0.629 |
| No. of Obs. | 138010 | 138008 | 138007 |

Note: The table shows the results of estimating equation 2 on the full dataset using inverse propensity of treatment weighting. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. Year and plant fixed-effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

**Table A.IX: Regression results on fuel and electricity expenditure, use and intensities.**

| | Price-based measures | | | Physical Units | | |
|---|---|---|---|---|---|---|
| | Acquisition Year | 1 Year Later | 2 Years Later | Acquisition Year | 1 Year Later | 2 Years Later |
| | Log(Total Fuel in Rps) | | | Log(Total Fuel in MBTUs) | | |
| Post*Acquired | **0.392*** ** | **0.596*** ** | **0.543*** ** | **0.343** ** | **0.513*** ** | **0.547*** ** |
| | **(0.149)** | **(0.158)** | **(0.172)** | **(0.165)** | **(0.173)** | **(0.189)** |
| R-sq. (within) | 0.044 | 0.069 | 0.058 | 0.028 | 0.045 | 0.045 |
| No. of Obs. | 812 | 815 | 805 | 812 | 815 | 806 |
| | Log(Net Electricity in Rps) | | | Log(Net Electricity in MBTUs) | | |
| Post*Acquired | **0.761*** ** | **0.775*** ** | **0.696*** ** | **0.781*** ** | **0.818*** ** | **0.679*** ** |
| | **(0.204)** | **(0.206)** | **(0.217)** | **(0.201)** | **(0.208)** | **(0.219)** |
| R-sq. (within) | 0.092 | 0.115 | 0.118 | 0.099 | 0.137 | 0.142 |
| No. of Obs. | 714 | 713 | 711 | 714 | 713 | 711 |
| | Log(Total Fuel/Output) | | | Log(Total Fuel/Output) | | |
| Post*Acquired | **-0.422*** ** | **-0.452*** ** | **-0.429*** ** | **-0.471*** ** | **-0.535*** ** | **-0.428** ** |
| | **(0.148)** | **(0.153)** | **(0.160)** | **(0.164)** | **(0.171)** | **(0.182)** |
| R-sq. (within) | 0.025 | 0.023 | 0.020 | 0.026 | 0.027 | 0.017 |
| No. of Obs. | 812 | 815 | 805 | 812 | 815 | 806 |
| | Log(Net Electricity/Output) | | | Log(Net Electricity/Output) | | |
| Post*Acquired | -0.103 | **-0.343* ** | **-0.389* ** | -0.083 | -0.300 | **-0.406* ** |
| | (0.203) | **(0.202)** | **(0.213)** | (0.201) | (0.204) | **(0.219)** |
| R-sq. (within) | -0.001 | 0.011 | 0.015 | -0.001 | 0.015 | 0.025 |
| No. of Obs. | 714 | 713 | 711 | 714 | 713 | 711 |

Note: The table reflects the result of estimating equation 2 on the matched sample described in Section 4. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors are in parentheses. *Post* dummy and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

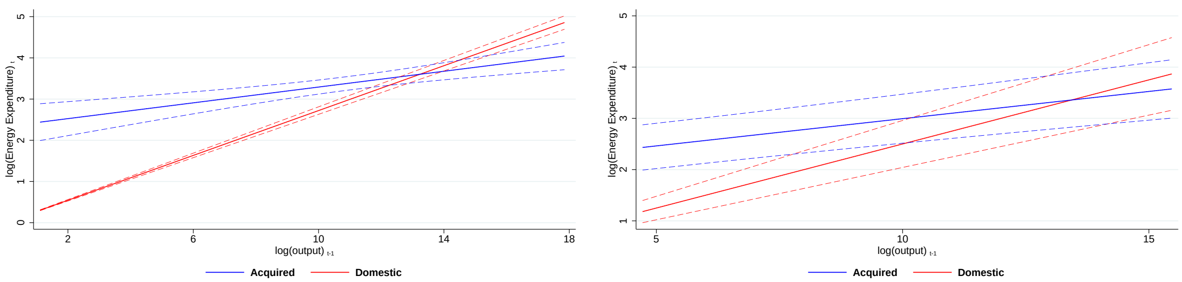
**Table A.X: Difference-in-differences analysis on matched sample: Energy input prices in levels and logarithms.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | | Fuel price | |
| Post*Acquired | -0.080 | 0.021 | -0.059 |
| | (0.090) | (0.014) | (0.063) |
| R-sq. (within) | 0.005 | 0.013 | 0.005 |
| No. of Obs. | 812 | 815 | 806 |
| | | Log(Fuel Price) | |
| Post*Acquired | 0.049 | 0.083 | 0.014 |
| | (0.057) | (0.054) | (0.057) |
| R-sq. (within) | 0.004 | 0.008 | 0.001 |
| No. of Obs. | 812 | 815 | 805 |
| | Acquisition Year | 1 Year Later | 2 Years Later |
| | | Electricity Price | |
| Post*Acquired | -0.001 | -0.003 | 0.006 |
| | (0.003) | (0.003) | (0.007) |
| R-sq. (within) | 0.001 | 0.026 | 0.004 |
| No. of Obs. | 714 | 713 | 711 |
| | | Log(Electricity Price) | |
| Acquired | -0.020 | -0.043 | 0.016 |
| | (0.040) | (0.044) | (0.051) |
| R-sq. (within) | 0.002 | 0.038 | 0.045 |
| No. of Obs. | 714 | 713 | 711 |

Note: The table reflects the result of estimating equation 2 on the matched sample using PSM. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. Year and plant fixed-effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

### Figure A.IV: Predicted energy expenditure and output.

(a) Unmatched sample (b) Matched sample




Note: The figures represent the estimated coefficient from regressing energy expenditure on foreign affiliate dummy (i.e. 1 if foreign-owned; 0 otherwise), lagged output and their interaction. Dashed lines represent 95-percent confidence intervals. Each variable is expressed in log.

### Table A.XI: Dependent Variable: Log(Energy Expenditure)

| | All Sample | | Matched Sample | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Post*Acquired | **0.836**** | **2.334***** | **0.997**** | **1.931***** |
| | **(0.329)** | **(0.250)** | **(0.404)** | **(0.462)** |
| ln(Output) | **0.571***** | | **0.621***** | |
| | **(0.005)** | | **(0.040)** | |
| ln(Output)$_{t-1}$ | | **0.272***** | | **0.250***** |
| | | **(0.005)** | | **(0.046)** |
| Post*Acquired*ln(Output) | **-0.060**** | | **-0.086**** | |
| | **(0.030)** | | **(0.038)** | |
| Post*Acquired*ln(Output)$_{t-1}$ | | **-0.176***** | | **-0.144***** |
| | | **(0.022)** | | **(0.043)** |
| Firm fixed effect | Yes | Yes | Yes | Yes |
| Year-fixed effect | Yes | Yes | Yes | Yes |
| R-sq. (within) | 0.261 | 0.097 | 0.389 | 0.134 |
| No. of Obs. | 255450 | 228733 | 2994 | 2571 |

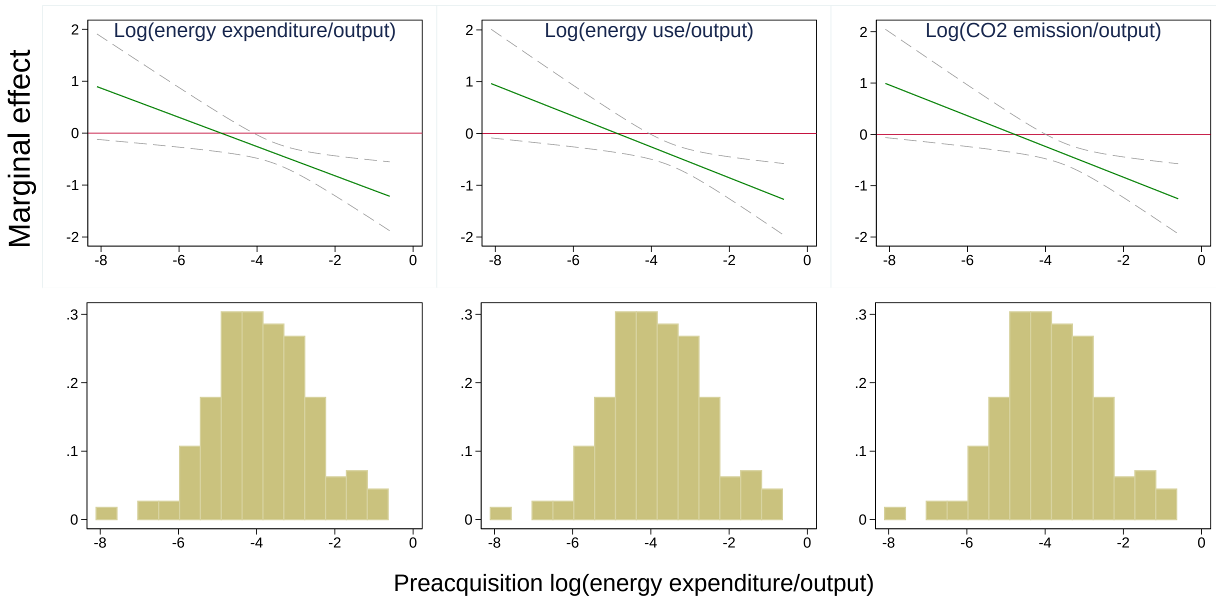
Note: The table reflects the result of regressing the outcome variable on the unmatched sample. Each column in each panel is a separate regression. Heteroskedasticity-robust standard errors are in parentheses. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

**Table A.XII: PSM-DID estimates on capital, employment and investments.**

| | Acquisition Year | 1 Year Later | 2 Years Later |
|---|---|---|---|
| | | Log(Capital) | |
| Post*Acquired | **0.622*** ** | **0.738*** ** | **0.794*** ** |
| | **(0.147)** | **(0.178)** | **(0.208)** |
| R-sq. (within) | 0.109 | 0.099 | 0.082 |
| No. of Obs. | 658 | 644 | 627 |
| | | Log(Employment) | |
| Post*Acquired | **0.319*** ** | **0.349*** ** | **0.361*** ** |
| | **(0.050)** | **(0.055)** | **(0.061)** |
| R-sq. (within) | 0.153 | 0.152 | 0.109 |
| No. of Obs. | 840 | 840 | 840 |
| | | Log(Capital-Labor Ratio) | |
| Post*Acquired | **0.349** ** | **0.406** ** | **0.449** ** |
| | **(0.145)** | **(0.174)** | **(0.201)** |
| R-sq. (within) | 0.034 | 0.030 | 0.030 |
| No. of Obs. | 658 | 644 | 627 |
| | | Log(Investment in Machinery) | |
| Post*Acquired | **0.745*** ** | **0.729*** ** | **0.861*** ** |
| | **(0.178)** | **(0.202)** | **(0.245)** |
| R-sq. (within) | 0.087 | 0.070 | 0.067 |
| No. of Obs. | 650 | 637 | 620 |
| | | Log(Total Investment, 5 categories) | |
| Post*Acquired | 0.324 | 0.449 | -0.062 |
| | (0.348) | (0.391) | (0.377) |
| R-sq. (within) | 0.006 | 0.008 | 0.000 |
| No. of Obs. | 489 | 460 | 444 |

Note: The table reflects the result of estimating equation 2 on the matched sample using PSM. The dependent variables are as listed in each panel. Each column in each panel is a separate regression for a particular outcome variable covering two time periods: the year relative to acquisition (as listed in each column) and a year before foreign-owned plants were acquired. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. Year and plant fixed-effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

**Figure A.V: Effect of acquisition on energy and emission intensities at varying pre-acquisition energy intensities.**




The figure illustrates estimated combined coefficients of foreign acquisition dummy and its interaction with pre-acquisition energy intensity in equation 2 using the matched sample. The dashed lines correspond to the 95-percent confidence interval. The period focuses at one year after the acquisition (i.e., $t+1$) and estimates are relative to the pre-acquisition period.

**Table A.XIII: Matched difference-in-differences estimates: Testing for non-linear effect of acquisition at varying pre-acquisition energy intensity.**

| | Log(Energy Expenditure/Output) | Log(Energy Use/Output) | Log($CO_2$ Emission/Output) |
|---|---|---|---|
| Post*Acquired | **-1.759*****<br>**(0.359)** | **-1.738*****<br>**(0.382)** | **-1.643*****<br>**(0.358)** |
| Post*Acquired*Pre-acq. Energy Intensity | **-0.409*****<br>**(0.092)** | **-0.392*****<br>**(0.097)** | **-0.378*****<br>**(0.093)** |
| R-sq. (within) | 0.213 | 0.191 | 0.185 |
| No. of Obs. | 814 | 814 | 814 |
| Threshold | -4.30 | 4.43 | -4.35 |
| Pre-acq. Energy Intensity¿threshold<br>(% share of treated plants) | 60.48 | 68.57 | 64.29 |

Note: The table reflects the result of estimating equation 2 on the matched sample described in Section 4. The period is one year after the acquisition (i.e., $t+1$) and estimates are relative to pre-acquisition period. The dependent variables are as listed in each panel and expressed in logarithms. Each column in each panel is a separate regression for a particular outcome variable covering the two time periods Except for the dummy variables, all variables are in logarithm. Heteroskedasticity-robust standard errors clustered at the plant level are in parentheses. *Post* dummy, its interaction with pre-acquisition energy intensity and plant fixed effects are included in all specifications. *, **, *** indicate statistical significance at 0.10, 0.05, and 0.01 level, respectively.

**Table A.XIV: Decomposition of changes in aggregate energy intensity.**

| Year | Aggregate Energy Intensity | Unweighted Energy Intensity | Covariance | Number of Foreign-owned |
|---|---|---|---|---|
| 1984 | -0.10 | -0.10 | -0.11 | -2 |
| 1985 | -0.18 | -0.25 | 0.00 | 103 |
| 1986 | -0.45 | -0.35 | -0.11 | 78 |
| 1987 | -0.26 | -0.29 | 0.04 | 102 |
| 1988 | -0.27 | -0.33 | 0.06 | 166 |
| 1989 | -0.23 | -0.35 | 0.07 | 169 |
| 1990 | -0.14 | -0.45 | 0.23 | 266 |
| 1991 | -0.17 | -0.37 | 0.20 | 410 |
| 1992 | -0.27 | -0.39 | 0.11 | 581 |
| 1993 | -0.41 | -0.32 | -0.09 | 674 |
| 1994 | -0.34 | -0.39 | 0.05 | 792 |
| 1995 | -0.43 | -0.40 | -0.03 | 864 |
| 1996 | -0.42 | -0.44 | 0.01 | 978 |
| 1997 | -0.60 | -0.60 | 0.00 | 1071 |
| 1998 | -0.39 | -0.48 | 0.08 | 1216 |
| 1999 | -0.18 | -0.37 | 0.08 | 1289 |
| 2000 | -0.08 | -0.34 | 0.24 | 1226 |
| 2001 | -0.31 | -0.43 | 0.07 | 1106 |

Note: Figures are relative to 1983 levels.