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Energy Efficiency And Exporting: Evidence From Firm-Level Data

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Abstract

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Roy, J. and M. Yasar (2015). "Energy efficiency and exporting: Evidence from firm-level data." Energy Economics 52: 127-135. https://doi.org/10.1016/j.eneco.2015.09.013. Publisher version of record available at: https://www.sciencedirect.com/science/article/pii/S0140988315002832

Energy efficiency and exporting: Evidence from firm-level data

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A B S T R A C T

While exporting firms and non-exporters have been compared across several dimensions, empirical comparisons on the basis of environmental performance are relatively few. Moreover, analyzing the environmental implications of firm-level exports is not trivial due to non-random selection into exporting. In this light, we examine the impact of exporting on firms' energy efficiency by resorting to an instrumental variables strategy based on a differencing approach (Pitt and Rosenzweig, 1990). Utilizing data from Indonesia, we find (i) exporting to reduce the use of fuels (relative to electricity) and (ii) concerns over endogeneity of exporting status to be relevant.

Keywords:
Exporting
Environment
Energy
Instrumental variables

1. Introduction

Exporting firms and non-exporters have been compared across dimensions such as productivity, size, wages, and capital intensity. Typically, exporters have been found to be larger, more productive, more skill and capital intensive, and paying higher wages (e.g., Bernard et al., 2007; Wagner, 2007). However, an empirical comparison in terms of environmental performance has received less attention. This is particularly striking given that trade's environmental impact has been extensively analyzed using data at the level of countries, states, and provinces (e.g., Antweiler et al., 2001; Chintrakarn and Millimet, 2006; Frankel and Rose, 2005; McAusland and Millimet, 2013). Accordingly, the trade-environment nexus is worth examining at the firm level.

The issue is especially relevant for Indonesia due to a number of reasons. First, Indonesia ranks among the top 30 countries in terms of merchandise exports.[2] Second, nearly 10% of its merchandise exports are for the European Union where about 90% of the citizens believe that buying environmentally friendly products can improve environmental quality.[3] Finally, the matter is of policy relevance given the Asian Development Bank's loans to the Indonesian government to improve energy efficiency (and thereby environmental performance) in export-oriented industries.[4] Thus, utilizing firm-level data from Indonesia, our objective is to investigate the *causal* effect of exporting on environmental performance as measured by energy efficiency.[5]

Intuitively, exporting may encourage energy efficiency. According to studies such as Yeaple (2005), Costantini and Melitz (2008), Verhoogen (2008), Aw et al. (2008), Bustos (2011), and Lileeva and Trefler (2010, p. 1095), "improved foreign market access induces innovation." Moreover, exporting may improve management practice (Bloom and Van Reenen, 2010) which in turn may encourage energy efficiency (Bloom et al., 2010).[6] Interestingly, this is especially likely in case of exports to

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[2] See http://stat.wto.org/CountryProfile/WSDBCountryPFView.aspx?Country=ID&Language=E.

[3] See http://europa.eu/rapid/press-release_IP-13-653_en.htm.

[4] See http://www.adb.org/news/adb-200-million-loans-support-trade-energy-financing-indonesia.

[5] In keeping with existing studies such as Cole et al. (2008) and Batrakova and Davies (2012), we utilize energy efficiency as an indicator of environmental performance. Also, see Cole (2006) and Chintrakarn (2013) for analyses relying on relatively aggregate data to examine the effect of trade on energy use.

[6] In this context, note that exporting may raise productivity and thereby facilitate the adoption of cleaner technology and investment in abatement (Cui, 2014; Forslid et al., 2015).

developed countries. Wagner (2012, p. 237) states, "Positive productivity effects of exporting (learning by exporting) can be expected to differ between (groups of) destination countries. Productivity improvements due to learning will be higher if the destination countries are highly developed and exporting firms have to compete with or supply to firms that operate next to the technological frontier and use the latest vintage of capital goods and best practices in management to produce innovative products."[7]

However, the identification of this causal effect is not trivial since an indicator of exporting status is potentially endogenous due to two reasons. First, it is plausible that relatively efficient firms may become exporters (Melitz, 2003). In the context of productivity, this is referred to as self-selection into exporting (as opposed to learning by exporting). As discussed in Bernard et al. (2007, p. 106), exporters may be more productive "not as a result of exporting, but because only the most productive firms are able to overcome the costs of entering export markets." The authors add, "Results from virtually every study across industries and countries confirm that high productivity precedes entry into export markets… Most studies also find little or no evidence of improved productivity as a result of beginning to export." Moreover, Kreickemeier and Richter (2014, p. 209) argue that "more productive firms are also environmentally more efficient." Thus, such concerns over reverse causation are also relevant in the context of energy efficiency.

Second, and related to the previous point, firms may select into exporting on the basis of unobservable (to the econometrician) factors such as research and development (R&D) activity, training and experience of chief executive officers, management quality, creditworthiness, communication with foreign markets, export spillovers and congestions, and customer preferences across destination countries (e.g., Alvarez and López, 2008; Bao et al., 2014; Barrios et al., 2003; Batrakova, 2011; Batrakova and Davies, 2012; Blalock and Gertler, 2004; Bloom et al., 2010; Cole et al., 2008; Holladay, 2015; Leonidou, 2004; Manova, 2013). In other words, such factors are plausibly associated with exporting behavior as well as energy use.

In light of these complexities, we proceed by briefly discussing some existing research on the environmental implications of firm-level trade. Apart from relying on various indicators of environmental performance, such analyses utilize data from developed as well as less developed economies. For example, Batrakova and Davies (2012) rely on a panel of Irish firms and examine the effect of exporting on energy intensity (i.e., the ratio of energy use to sales). Interestingly, the authors analyze the impacts at various quantiles of the distribution of energy intensity. They find exporting to be associated with greater (reduced) energy intensity at lower (higher) quantiles. Next, Cole et al. (2008) and Dardati and Saygili (2012) use data on Ghanaian and Chilean firms, respectively, to primarily analyze the energy intensity of foreign-owned firms. However, both studies also control for exporter status in some specifications and find exporting to be negatively related to energy intensity. Similarly, Albornoz et al. (2009) and Cole et al. (2006) find exporting and foreign ownership to encourage the adoption of environmental management systems among Argentinean and Japanese firms, respectively.

More recently, Holladay (2015) utilizes establishment-level data from the United States Environmental Protection Agency's Toxics Release Inventory Program and finds exporting to be associated with lower pollution emissions as well as emissions that are less toxic. In a similar vein, Forslid et al. (2015) rely on firm-level data from Sweden and find exporting to be negatively related to emissions of sulfur dioxide, carbon dioxide, and nitrogen oxide. Further, Cui et al. (2012) use facility-level data from the Environmental Protection Agency's National Emissions Inventory and arrive at a similar conclusion with respect to sulfur dioxide, carbon monoxide, ozone, and total suspended particulates. Finally, Girma and Hanley (2015) examine firm-level data from the U.K. and find exporters to be more likely to report their technology adoptions as energy-saving.

While the existing studies mostly recognize the endogeneity of exporting status, the issue merits greater attention. For example, Cole et al. (2006) acknowledge concerns over endogeneity but consider the problem to be less severe in firm-level studies (than analyses at the industry or country levels). Next, Batrakova and Davies (2012) allude to the selection issue and employ a propensity score matching with difference-in-differences approach. Nonetheless, as noted by the authors, this strategy does not control for unobserved firm characteristics that are time varying. In a similar vein, due to data constraints, Holladay (2015) refrains from identifying the causal mechanism by which exporters are found to be less polluting. That said, Girma and Hanley (2015) pursue an instrumental variables (IV) approach. The instruments for firms' exporting status are constructed from the contemporaneous and lagged values of the share of imported materials.[8]

In this study, we use firm-level data from Indonesia and examine the effect of exporting on energy efficiency. This contributes to the existing literature in a number of ways. First, our data (over the period 2001–2007) are more recent than most existing studies utilizing data on Indonesian firms. Second, in order to examine the effect of exporting on energy use, we primarily rely on theoretically motivated cost share equations derived from a variable cost function approximated by the translog form.[9] Finally, we attend to concerns over endogeneity of export status by relying on an IV strategy based on a differencing approach (Pitt and Rosenzweig, 1990). Under a set of reasonable assumptions, it enables us to identify the causal effect of exporting on fuel efficiency relative to electricity efficiency. Across our IV specifications, we find (i) exporting to reduce the use of fuels (relative to electricity) and (ii) concerns over endogeneity to be relevant. Since fuels are considered to be a more polluting form of energy (discussed below), exporting can be regarded as environmentally beneficial. The findings are consistent with studies that utilize relatively aggregate data and find international commerce to be mostly pro-environment (e.g., Frankel and Rose, 2005; McAusland and Millimet, 2013). Apart from complementing the existing firm-level research on exporting and environmental performance, our results also support the hypotheses that exporting may encourage innovation and productivity.

The rest of the paper is organized as follows. Section 2 describes the empirical methodology. Section 3 discusses the data. Section 4 presents the results, while Section 5 concludes.

2. Methodology

2.1. Theoretical model

In order to examine the effect of exporting on energy efficiency, we primarily resort to a cost share approach utilizing a transcendental logarithmic or translog cost function (Christensen et al., 1971, 1973). As discussed in studies such as Christensen et al. (1971), Christensen and Greene (1976), Guilkey et al. (1983), Berman et al. (1994), and Machin and Van Reenen (1998), the translog form is recommended in the absence of *a priori* information on the functional form. While Shah (1992, p. 29) alludes to this "flexibility in functional form," Pavcnik (2003, p. 317) states, "The translog cost function is very appealing because it provides a second order approximation to any cost function and it does not impose any restrictions on the substitutability of various inputs." Moreover, partial differentiation of the translog function with

[7] Note that consumers in developed countries are more likely to be environmentally conscious (e.g., Cole et al., 2008).

[8] While the dependent variable in Girma and Hanley (2015) is categorical, the authors rely on a linear specification for the IV strategy. Also, as discussed below, we control for imported materials in our specifications.

[9] Note that Cole et al. (2008) resort to specifications based on a translog production function. In Section 4.3, we discuss a similar approach.

respect to factor prices enables us to conveniently express the cost share of inputs in logarithmic form. Accordingly, we resort to such an approach and estimate share equations for energy. We treat capital as the quasi-fixed factor but labor, fuels, and electricity as variable inputs.

To fix ideas, we express the variable cost function as

$$\mathrm{VC} = f(Y, w, K, T) \tag{1}$$

where VC denotes variable cost, f is assumed to have a translog form, Y depicts the level of output, w is the vector of variable input prices, K is the quantity of the quasi-fixed input, and T represents technology. Firms minimize costs subject to their output objectives and a given amount of the quasi-fixed factor.

For a variable input m, logarithmic differentiation of the translog cost function (with respect to the input's price) followed by application of Shephard's (1970) lemma yields the corresponding cost share equation. In other words, the derived demand for the m^{th} input (X_m) is obtained as

$$X_m = \frac{\partial \mathrm{VC}}{\partial w^m} \tag{2}$$

where w^m corresponds to the factor's price. Next, the cost share of the input (S_m), i.e., the share of total variable cost attributable to the variable input, is derived as

$$S_m = \frac{w^m X_m}{\mathrm{VC}} = \frac{\partial \ln \mathrm{VC}}{\partial \ln w^m}. \tag{3}$$

For the translog form, the cost share of the mth input can be represented as

$$S_m = \alpha + \alpha_Y \ln Y + \alpha_K \ln K + \sum\nolimits_m \alpha_m \ln w^m + \alpha_T T. \tag{4}$$

For our analysis, we estimate cost share equations with respect to two sources of energy, i.e., fuels and lubricants (f) as well as electricity (e). Thus, in case of firm i in industry j and province p at time t, the cost share of fuels (S_{fijpt}) is given by

$$S_{fijpt} = \alpha_f + \alpha_{fY} \ln Y_{ijpt} + \alpha_{fK} \ln K_{ijpt} + \sum\nolimits_m \alpha_{fm} \ln w^m_{ijpt} + \alpha_{fT} T_{ijpt}. \tag{5}$$

Similarly, the cost share of electricity (S_{eijpt}) is given by

$$S_{eijpt} = \alpha_e + \alpha_{eY} \ln Y_{ijpt} + \alpha_{eK} \ln K_{ijpt} + \sum\nolimits_m \alpha_{em} \ln w^m_{ijpt} + \alpha_{eT} T_{ijpt}. \tag{6}$$

We next turn to the estimation of the cost share equations.

2.2. Estimation

2.2.1. Baseline approach

To proceed, our baseline estimating equation for fuels is

$$S_{fijpt} = \beta_{fY} \ln Y_{ijpt} + \beta_{fK} \ln K_{ijpt} + \beta_{fEXP} EXP_{ijpt} + \beta_{fIMP} IMP_{ijpt} + \beta_{fFOR} FOR_{ijpt} + \theta_{fjpt} + u_{fijpt}. \tag{7}$$

Further, the cost share of electricity is estimated as

$$S_{eijpt} = \beta_{eY} \ln Y_{ijpt} + \beta_{eK} \ln K_{ijpt} + \beta_{eEXP} EXP_{ijpt} + \beta_{eIMP} IMP_{ijpt} + \beta_{eFOR} FOR_{ijpt} + \theta_{ejpt} + u_{eijpt}. \tag{8}$$

At this juncture, a few comments are noteworthy. First, the cost share of fuels (electricity) is calculated as the ratio of aggregate value of fuels and lubricants (electricity) used to variable cost where the latter is obtained from the sum of total wage bill, value of fuels and lubricants used, and value of electricity purchased (net of sales). Second, Y denotes (real) value added and is obtained after subtracting the value of all raw materials used and other expenses (e.g., those pertaining to rental payments, taxes, and donations) from the value of production. Third, K is the (real) value of total capital goods. Fourth, industry-by-time dummies are used to control for the input prices as well as time-varying industry-specific unobservables such as industry-level tariffs.[10] Fifth, T is captured by EXP, IMP, and FOR; EXP is a binary variable denoting export status, IMP represents the share of raw materials imported, and FOR denotes the share of foreign equity. According to Pavcnik (2003), Yasar and Paul (2007), and others, such international linkages are potential channels of technology transfer. Finally, in order to control for time-varying region-specific unobservables and macroeconomic shocks, we also include province-by-time and time dummies; θ_{fjpt} and θ_{ejpt} capture the industry-by-time, province-by-time, and year fixed effects. The error terms consisting of potentially time-varying and time-invariant unobservables are denoted by u_{fijpt} and u_{eijpt}.

Next, as discussed in Pavcnik (2000), Cole et al. (2008), and Holladay (2015), among others, factors such as workforce composition and establishment vintage are also likely to be relevant determinants of energy efficiency. Accordingly, we also resort to an alternative specification by additionally controlling for firm age, share of skilled workers, and proportion of female employees. Here, the cost share equations for fuels and electricity are given by

$$S_{fijpt} = \beta_{fY} \ln Y_{ijpt} + \beta_{fK} \ln K_{ijpt} + \beta_{f\mathrm{EXP}} \mathrm{EXP}_{ijpt} + \beta_{f\mathrm{IMP}} \mathrm{IMP}_{ijpt} + \beta_{f\,\mathrm{FOR}} \mathrm{FOR}_{ijpt} + \beta_{f\mathrm{AGE}} \mathrm{AGE}_{ijpt} + \beta_{f\mathrm{SKILL}} \mathrm{SKILL}_{ijpt} + \beta_{f\mathrm{FEMALE}} \mathrm{FEMALE}_{ijpt} + \theta_{fjpt} + u_{fijpt} \tag{9}$$

and

$$S_{eijpt} = \beta_{eY} \ln Y_{ijpt} + \beta_{eK} \ln K_{ijpt} + \beta_{e\mathrm{EXP}} \mathrm{EXP}_{ijpt} + \beta_{e\mathrm{IMP}} \mathrm{IMP}_{ijpt} + \beta_{e\,\mathrm{FOR}} \mathrm{FOR}_{ijpt} + \beta_{e\mathrm{AGE}} \mathrm{AGE}_{ijpt} + \beta_{e\mathrm{SKILL}} \mathrm{SKILL}_{ijpt} + \beta_{e\mathrm{FEMALE}} \mathrm{FEMALE}_{ijpt} + \theta_{ejpt} + u_{eijpt}, \tag{10}$$

respectively. AGE denotes an establishment's age in years, and SKILL (FEMALE) represents the share of skilled or non-production (female) employees.

Before proceeding, it is worth noting that unobserved firm characteristics are likely to bias the estimates of $\beta_{f\mathrm{EXP}}$ and $\beta_{e\mathrm{EXP}}$ obtained from the estimating equations above. Accordingly, we also estimate Eqs. (7)–(10) by including firm fixed effects. This allows for correlation between exporting status and firm-specific unobserved characteristics to the extent that such unobservables are time invariant.[11] After incorporating such fixed effects, for the specification without controls for plant vintage or workforce composition, the cost share equations for fuel and electricity are represented as

$$S_{fijpt} = \beta_{fY} \ln Y_{ijpt} + \beta_{fK} \ln K_{ijpt} + \beta_{f\mathrm{EXP}} \mathrm{EXP}_{ijpt} + \beta_{f\mathrm{IMP}} \mathrm{IMP}_{ijpt} + \beta_{f\,\mathrm{FOR}} \mathrm{FOR}_{ijpt} + \phi_{fijpt} + \nu_{fijpt} \tag{11}$$

and

$$S_{eijpt} = \beta_{eY} \ln Y_{ijpt} + \beta_{eK} \ln K_{ijpt} + \beta_{e\mathrm{EXP}} \mathrm{EXP}_{ijpt} + \beta_{e\mathrm{IMP}} \mathrm{IMP}_{ijpt} + \beta_{e\,\mathrm{FOR}} \mathrm{FOR}_{ijpt} + \phi_{eijpt} + \nu_{eijpt}, \tag{12}$$

respectively. Thus, ϕ_{fijpt} and ϕ_{eijpt} include firm fixed effects in addition to industry-by-time, province-by-time, and year dummies. ν_{fijpt} and ν_{eijpt} represent the error terms comprised of time-varying unobservables.

[10] Note that the cost share equation in Pavcnik (2003) also excludes any direct measure of plant-level input price.

[11] Note that some firms change provinces and industries over the sample period (Newman et al., 2013).

Similarly, in case of the alternative specification, i.e., after incorporating the role of firm age, skill share, and proportion of female employees, the determinants of the two cost shares are given by

$$S_{fijpt} = \beta_{fY} \ln Y_{ijpt} + \beta_{fK} \ln K_{ijpt} + \beta_{f\text{EXP}}\text{EXP}_{ijpt} + \beta_{f\text{IMP}}\text{IMP}_{ijpt} + \beta_{f\,\text{FOR}}\,\text{FOR}_{ijpt} + \beta_{f\text{AGE}}\text{AGE}_{ijpt} + \beta_{f\text{SKILL}}\text{SKILL}_{ijpt} + \beta_{f\text{FEMALE}}\text{FEMALE}_{ijpt} + \phi_{fijpt} + \nu_{fijpt} \quad (13)$$

and

$$S_{eijpt} = \beta_{eY} \ln Y_{ijpt} + \beta_{eK} \ln K_{ijpt} + \beta_{e\text{EXP}}\text{EXP}_{ijpt} + \beta_{e\text{IMP}}\text{IMP}_{ijpt} + \beta_{e\,\text{FOR}}\,\text{FOR}_{ijpt} + \beta_{e\text{AGE}}\text{AGE}_{ijpt} + \beta_{e\text{SKILL}}\text{SKILL}_{ijpt} + \beta_{e\text{FEMALE}}\text{FEMALE}_{ijpt} + \phi_{eijpt} + \nu_{eijpt}. \quad (14)$$

Although we control for several relevant determinants of energy efficiency in these specifications, as detailed above, crucial unobservables are still likely to be correlated with exporting behavior as well as energy use. Given such time-varying unobservables, we resort to the IV approach proposed in Pitt and Rosenzweig (1990).[12]

2.2.2. *Pitt and Rosenzweig (1990) Approach*

In Pitt and Rosenzweig (1990), the authors examine the effect of an endogenous household-level variable on an outcome pertaining to children. Absent a traditional exclusion restriction or instrument, the authors identify the differential effect of the endogenous variable on boys relative to girls by assuming identical effects of some of the exogenous variables on both genders. In our context, we assume foreign share and (log) capital to have a similar impact on the cost shares of fuel and electricity in Eqs. (11) and (12) as well as in Eqs. (13) and (14). Moreover, in case of Eqs. (13) and (14), we also assume the share of female employees to have a similar impact on the two cost shares. In other words, we assume $\beta_{fK} = \beta_{eK}$, $\beta_{f\text{FOR}} = \beta_{e\text{FOR}}$, and $\beta_{f\text{FEMALE}} = \beta_{e\text{FEMALE}}$.

Before proceeding, the validity of this assumption merits additional discussion. According to Eskeland and Harrison (2003, p. 18) and Cole et al. (2008), "electricity is a 'clean'" form of energy at the point of its use and less polluting than solid and liquid fuels. Moreover, as discussed in Cole et al. (2008, p. 542), "exporters may be cleaner in order to serve export markets in the developed world where consumers are typically environmentally conscious." In addition, while Cole et al. (2006, p. 319) find Japanese firms that export or engage in foreign direct investment (FDI) to adopt environmental management practices, they consider exports to "have a larger, more significant, effect on environmental management than FDI" possibly due to "greater exposure to overseas competition faced by exporters." In fact, Kaiser and Schulze (2003, p. 7) also argue that it is essentially the firms exporting to developed countries (i.e., regardless of domestic versus foreign ownership) who are "concerned that consumers in these markets care for environmentally friendly production processes." Thus, although the effect of exporting is likely to be different across Eqs. (11) and (12) or between Eqs. (13) and (14), after controlling for exporting status and firm-specific fixed effects, it is reasonable to assume that foreign share has a similar effect on the two energy measures.[13] Similarly, given the set of controls, the assumption that (log) capital has the same effect on the cost shares of fuels and electricity seems reasonable. In case of Eqs. (13) and (14), it is also plausible that the proportion of female employees has a similar impact on the two cost shares. As discussed below, the validity of these assumptions can be further assessed using an overidentification test.

For the specification without controls for plant vintage or workforce composition, we subtract Eq. (12) from Eq. (11) to obtain

$$\Delta S_{ijpt} = \Delta\beta_Y \ln Y_{ijpt} + \Delta\beta_{\text{EXP}}\text{EXP}_{ijpt} + \Delta\beta_{\text{IMP}}\text{IMP}_{ijpt} + \Delta\phi_{ijpt} + \Delta\nu_{ijpt}. \quad (15)$$

The differencing eliminates firm-specific unobserved characteristics that are correlated with the exporting dummy and similarly associated with the cost shares of fuel and electricity. For example, if unobserved management quality reduces both cost shares by a similar extent, it drops out of the differenced equation. Thus, the estimates in Eq. (15) are not susceptible to bias arising due to such factors. Nonetheless, some crucial unobservables are likely to be differentially associated with the two cost shares and also correlated with exporting. For instance, for any firm, proximity to other exporters may generate productivity spillovers as well as export congestions (Alvarez and López, 2008; Bao et al., 2014). While the former is likely to reduce the use fuels relative to electricity, the latter may discourage firms from exporting. Similarly, as discussed in Batrakova (2011), exporting firms' energy use is potentially sensitive to destination characteristics (e.g., OECD status). Thus, demand fluctuations in foreign markets also constitute time-varying unobservables that may be correlated with exporting as well as the type of energy used. Further, R&D subsidies may encourage exporting and R&D aimed at improved logistics management (e.g., Lileeva and Trefler, 2010). However, the latter may crowd out energy R&D and increase ΔS_{ijpt} in the differenced equation (e.g., Popp and Newell, 2012). Accordingly, we resort to the IV strategy.

Here, ln *K* and FOR are available as exclusion restrictions for the potentially endogenous EXP. Interestingly, the presence of two excluded variables implies an overidentified model and the usual overidentification test can be used to examine the validity of our restrictions (i.e., $\beta_{fK} = \beta_{eK}$ and $\beta_{f\text{FOR}} = \beta_{e\text{FOR}}$). In other words, the lack of validity of our restrictions would imply the presence of $\Delta\beta_K \ln K_{ijpt}$ and $\Delta\beta_{\text{FOR}}\text{FOR}_{ijpt}$ in the error term in Eq. (15) resulting in a correlation between the instruments and the error term.

For the alternative specification, i.e., after controlling for firm age, skill share, and female share, we subtract Eq. (14) from Eq. (13) and arrive at

$$\Delta S_{ijpt} = \Delta\beta_Y \ln Y_{ijpt} + \Delta\beta_{\text{EXP}}\text{EXP}_{ijpt} + \Delta\beta_{\text{IMP}}\text{IMP}_{ijpt} + \Delta\beta_{\text{AGE}}\text{AGE}_{ijpt} + \Delta\beta_{\text{SKILL}}\text{SKILL}_{ijpt} + \Delta\phi_{ijpt} + \Delta\nu_{ijpt}. \quad (16)$$

In this case, ln *K*, FOR, and FEMALE are available as instruments (for EXP) whose validity can again be examined using the overidentification test.

However, it is worth noting that the Pitt and Rosenzweig (1990) approach only helps us arrive at a consistent estimate of $\Delta\beta_{\text{EXP}}$, i.e., the effect of exporting on the cost share of fuels *relative* to electricity.

3. Data

The majority of the data come from *Survei Tahunan Perusahaan Industri Pengolahan*, an annual survey of manufacturing establishments in Indonesia conducted by *Badan Pusat Statistik* (BPS), i.e., the Central Bureau of Statistics of Indonesia. Since it has been used in several firm-level studies (e.g., Amiti and Konings, 2007; Blalock and Gertler, 2004, 2008), we provide only limited details. Among other variables, for each year and manufacturing firm, the survey includes information on location (e.g., province), ownership (e.g., private or government or foreign), wages, fuels and lubricant usage, purchase and sale of electricity, domestic and imported raw material usage, expenses related to buildings and machinery, interest payments, export status, output, value of capital goods, age (in years), and number of employees

[12] See Millimet and Roy (2011) for another application of this approach.
[13] Note that Cole et al. (2008, p. 539) opine that foreign firms may utilize a relatively cleaner form of energy but perhaps due to the presence of "environmentally aware consumers" in "export markets" in developed countries.

differentiated by characteristics such as gender and skill level (i.e., production and non-production workers).[14,15]

Next, additional sources are relied upon to express the nominal variables (originally in thousands of rupiahs) in constant value (i.e., thousands of 2000 rupiahs). For instance, the value added measure is deflated using *Indeks Harga Perdagangan Besar*, i.e., the wholesale price indexes (WPIs) available in *Buletin Statistik Bulanan Indikator Ekonomi* or the Monthly Statistical Bulletin of Economic Indicators. Since the analysis corresponds to the two-digit level of classification, the WPIs are first obtained at the five-digit level using an unpublished concordance table from BPS and then averaged to arrive at deflators corresponding to the two-digit level. Moreover, the capital price deflators are obtained from the webpage of Bank Indonesia (the central bank of Indonesia).

Before proceeding, a few comments on preparing the dataset are noteworthy. First, the value of capital goods for 2006 is missing and obtained by simple interpolation.[16] Second, negative values of output, capital, wage bill, material use, other expenses, and energy, fuels, and electricity use (net of sales) are treated as missing. Finally, given some missing values in the survey, we conduct a number of sensitivity analyses below.

4. Results

4.1. Baseline approach

The summary statistics in Table 1 indicate that exporters are associated with a lower cost share of fuels and lubricants than non-exporting establishments. Moreover, the difference is nearly three percentage points. Also, exporting firms are characterized by a greater cost share of electricity; the difference is roughly three percentage points again. While the cost shares of fuels and electricity hardly differ among exporters, firms that only serve the domestic market devote a considerably greater proportion of their costs on fuels than on electricity. Interestingly, the values of energy use relative to production also paint a similar picture of exporters and non-exporters. The fuel-to-output and electricity-to-output ratios are greater for firms that do not export than for exporters. In addition, for a unit of output, non-exporters are associated with greater fuel use than electricity consumption; this is not witnessed in case of exporting firms.

However, exporters are also relatively new (as measured by age in years), larger in terms of (real) value added, labor employed, and (real) capital stock, and characterized by greater proportions of foreign equity, imported raw materials, skilled labor, and male employees. In other words, concerns over selection into exporting status appear well founded. Thus, in order to examine the causal effect of exporting on energy efficiency, further analysis is warranted.

In this light, we begin with the results presented in Table 2. Here, the estimates in columns (a) and (b) correspond to the cost share of fuels. Also, columns (c) and (d) pertain to the cost share of electricity. While the estimates in (a) and (c) relate to Eqs. (7) and (8), respectively, the results in (b) and (d) are obtained after additionally controlling for firm age and the shares of skilled and female employees; thus, columns (b) and (d) correspond to Eqs. (9) and (10), respectively. The estimates across all four columns are obtained after controlling for year, province-by-year, and industry-by-year fixed effects.

From (a) and (c), exporters are evidenced to have a lower (higher) cost share of fuels (electricity). To be more precise, the cost share of fuels for exporters is nearly one percentage point lower on average than that of non-exporters. Using the mean value of cost share of fuels (from Table 1), this corresponds to a difference of nearly 7%.[17] Moreover, the effect is statistically significant at the 99% level of confidence. Contrarily, exporting status increases the cost share of electricity by 0.2 percentage points. Again, the effect is statistically significant and pertains to an increase of roughly 2% based on the average cost share of electricity. Given Cole et al.'s (2008, p. 540) claim that "electricity use is cleaner than solid and liquid fuel," this is consistent with Kaiser and Schulze's (2003, p. 6) observation that exporting firms "may have better access to more modern and cleaner technology."

Next, the share of imported raw materials is found to have a significant negative impact on the cost shares of both forms of energy with a smaller (absolute) effect in case of electricity. Here, a 50 percentage point increase in the share of imported materials reduces the cost share of fuels by nearly one percentage point, i.e., about 7% with respect to the average cost share value. This is in accordance with the notion that imported raw materials may embody knowledge or technology that is likely to result in significant cost savings (e.g., Amiti and Konings, 2007; Yasar and Paul, 2007). The share of foreign ownership has a negative impact on the use of fuels but encourages the use of electricity.[18] Again, a 50 percentage point increase in the share of foreign ownership discourages (encourages) the use of fuels (electricity) to the tune of a 0.7 percentage point (0.5 percentage point) change, i.e., about 5% (4%) in terms of the average cost share of fuels (electricity). Unlike the variables that represent technology, value added and the value of capital are found to be associated with a greater use of both fuels and electricity.

The results in columns (b) and (d) are qualitatively similar to those in (a) and (c), respectively. Nonetheless, the coefficient estimate corresponding to the share of female employees is negative for both the energy efficiency measures. Similarly, the proportion of skilled labor discourages (encourages) the use of fuels (electricity). A 50 percentage point increase in the share of skilled employees reduces (increases) the cost share of fuels (electricity) by about two percentage points, i.e., roughly 17% (20%) on average. While most estimates across (b) and (d) are statistically significant, the impact of age is economically small.

The results presented in Table 3 correspond to the specifications in Table 2 apart from the inclusion of firm fixed effects. Thus, while columns (a) and (c) pertain to Eqs. (11) and (12), respectively, the estimates in (b) and (d) are obtained from Eqs. (13) and (14), respectively. Focusing on the specification without controls for establishment vintage or workforce composition, import share and proportion of foreign ownership are not found to have a statistically significant impact on either energy form. However, value added and the value of capital goods continue to significantly encourage the use of both fuels and electricity. Interestingly, exporting status decreases (increases) the cost share of fuels (electricity) by 0.2 (0.3) percentage points. The effect is significant only in case of electricity and corresponds to a magnitude of roughly 3% with respect to the sample average.

Again, the results in columns (b) and (d) are qualitatively similar to the estimates in (a) and (c), respectively. That said, exporting is no longer associated with a statistically significant impact on electricity. Also, import share is found to significantly encourage fuel use. While the proportion of female employees is significantly associated with reduced energy use, the estimates pertaining to firm age continue to be statistically insignificant. In addition, the share of skilled labor is evidenced to

[14] While the survey typically reports industrial classification at the five-digit International Standard of Industrial Classification (ISIC) Rev.3 level, in our data set, industries are classified at the two-digit ISIC level for 2001.

[15] The province codes are updated based on the information in http://www.statoids.com/uid.html.

[16] For each firm, real capital stock (K) during year t, is first obtained from $K(t) = (K(t_1) - K(t_0))(t - t_0) / (t_1 - t_0) + K(t_0)$; t_0 (t_1) corresponds to the period before (after) t for which the value is available. Then the values for 2006 are updated.

[17] Here, $-0.009 / 0.137 = -0.066$.

[18] In one of the ad hoc specifications in Cole et al. (2008), exporting is found to have an insignificant effect on fuel and electricity intensities where energy intensity is defined as energy use relative to value added. Nonetheless, foreign ownership is positively associated with the intensities. Another ad hoc specification finds exporting status (but not foreign ownership) to have a negative and significant association with fuel intensity; however, foreign ownership (but not exporting status) is associated with greater electricity intensity. None of these regressions control for firm-specific unobservables.

Table 1
Summary statistics.

Variable	Full sample *N*	Full sample Mean	Full sample SD	Exporter *N*	Exporter Mean	Exporter SD	Non-exporter *N*	Non-exporter Mean	Non-exporter SD
Exporter (1 = Yes)	111,390	0.201	0.401	22,418	1.000	0.000	88,972	0.000	0.000
Cost share of fuels	159,835	0.137	0.175	22,398	0.110	0.159	88,930	0.138	0.173
Cost share of electricity	159,835	0.105	0.153	22,398	0.109	0.141	88,930	0.078	0.125
Ratio of fuel to output	147,978	10.474	2120.207	21,364	0.263	33.531	82,015	11.215	2127.171
Ratio of electricity to output	147,844	85.775	31165.640	21,346	0.592	82.134	81,979	5.346	790.852
Foreign share	159,985	0.067	0.235	22,418	0.172	0.358	88,972	0.024	0.144
Import share	152,893	0.097	0.246	21,550	0.146	0.300	85,650	0.048	0.183
Share of skilled labor	159,985	0.155	0.153	22,418	0.156	0.151	88,972	0.142	0.153
Share of female labor	159,984	0.401	0.292	22,418	0.411	0.290	88,972	0.414	0.297
Age	127,477	15.791	11.906	18,164	15.375	12.310	71,461	16.615	12.117
ln(value added)	143,393	13.604	2.055	20,558	14.485	2.151	80,320	12.790	1.720
ln(labor)	159,985	4.194	1.190	22,418	4.956	1.359	88,972	3.853	0.934
ln(value of capital)	97,533	13.211	2.185	17,143	14.243	2.397	63,249	12.741	1.938

Note: Summary statistics obtained after cleaning the data. See text for further details.

significantly reduce the cost share of fuels; the positive estimate in case of electricity is insignificant at conventional levels of significance.

However, before putting too much stock in the estimates in Table 3, it is crucial to note that firms may select into exporting status on the basis of time-varying unobservables. Thus, we turn to the IV results.

4.2. Pitt and Rosenzweig (1990) Approach

Table 4 displays the results pertaining to the differencing strategy discussed above. Thus, the dependent variable is the cost share of fuels and lubricants minus that of electricity. While columns (a) and (b) correspond to OLS estimation of (15) and (16), respectively, the estimates in (c) and (d) rely on the IV strategy outlined above. In case of the specification without controls for firm age or workforce composition, the share of foreign ownership and (log) capital are used as excluded instruments. For the alternative specification, we also resort to the share of female employees as an additional exclusion restriction.

Turning to the OLS estimates, it is worth recalling that the differencing strategy enables us to eliminate unobservables which

Table 2
Determinants of cost share of energy without firm fixed effects.

	Cost share of fuels		Cost share of electricity	
	(a)	(b)	(c)	(d)
Exporter	−0.009***	−0.006***	0.002*	0.007***
	(0.002)	(0.002)	(0.001)	(0.002)
Foreign share	−0.013***	−0.009***	0.009***	0.009***
	(0.003)	(0.003)	(0.003)	(0.003)
Import share	−0.019***	−0.012***	−0.006**	−0.002
	(0.003)	(0.003)	(0.003)	(0.003)
Skill share		−0.046***		0.041***
		(0.005)		(0.005)
Female share		−0.050***		−0.054***
		(0.003)		(0.002)
Age		0.000***		−0.000***
		(0.000)		(0.000)
ln(value added)	0.003***	0.003***	0.007***	0.006***
	(0.000)	(0.001)	(0.000)	(0.000)
ln(capital)	0.004***	0.003***	0.012***	0.011***
	(0.000)	(0.000)	(0.000)	(0.000)
N	73433	57206	73433	57206

Note: Standard errors are heteroskedasticity-robust. Dependent variable is cost share of fuels or electricity. All regressions include time, industry-by-time, and province-by-time dummies. See text for further details.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 3
Determinants of Cost Share of Energy With Firm Fixed Effects.

	Cost Share of Fuels		Cost Share of Electricity	
	(a)	(b)	(c)	(d)
Exporter	−0.002	0.000	0.003*	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Foreign share	−0.004	−0.005	0.009	0.008
	(0.005)	(0.006)	(0.006)	(0.006)
Import share	0.007	0.010*	−0.005	−0.006
	(0.005)	(0.005)	(0.006)	(0.006)
Skill share		−0.015*		0.003
		(0.008)		(0.007)
Female share		−0.038***		−0.026***
		(0.007)		(0.005)
Age		−0.042		0.036
		(0.029)		(0.044)
ln(value added)	0.007***	0.007***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
ln(capital)	0.002***	0.002***	0.005***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
N	73433	57206	73433	57206

Note: Standard errors are heteroskedasticity-robust. Dependent variable is cost share of fuels or electricity. All regressions include time, industry-by-time, and province-by-time dummies as well as firm fixed effects. See text for further details.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

are time varying but have a similar impact on the cost shares of fuels and electricity. Accounting for such unobservables, the OLS estimate in column (a) finds the cost share of fuels relative to electricity to be 0.6 percentage points lower on average for exporters (relative to non-exporting firms). Since the mean difference between the cost shares of fuels and electricity is about three percentage points (from Table 1), this corresponds to a magnitude of about 19%.[19] In addition, while the share of imports does not have a significant effect on the cost share of fuels relative to electricity, (log) value added has a small but significant positive impact. Upon resorting to the alternative specification with controls for skill and female shares as well as facility age, the results are qualitatively similar. While the exporting dummy is no longer statistically significant, the share of skilled labor is found to significantly reduce the cost share of fuels relative to electricity. However, as discussed above, the OLS estimates are plausibly biased.

The IV results obtained utilizing generalized method of moments (GMM) are striking. Using the share of foreign equity and (log) capital as the excluded variables in (c), the cost share of fuels relative to the cost share of electricity is lower for exporters when compared to non-exporters. Moreover, the magnitude of this effect is about 13 percentage points. Based on the average value of the difference in cost shares, this amounts to an effect exceeding 400% in magnitude.[20] Thus, exporting substantially reduces the cost share of fuels relative to the cost share of electricity. The greater (absolute) value of the IV estimate may be attributable to unobservables that are positively correlated with exporting as well as the relative cost share of fuels.[21] The alternative specification uncovers an identical causal impact.

While the GMM estimates of $\Delta\beta_{\mathrm{EXP}}$ are considerably greater (in magnitude) than the corresponding OLS values, results from the IV specification tests give us confidence in this analysis. More precisely, the Kleibergen-Paap (2006) rk statistic rejects the null of underidentification at the 1% level of significance and the Kleibergen-Paap *F*-statistic is large. In addition, Hansen's *J*-test for overidentification fails to reject the validity of the instruments. Strikingly, the exogeneity of exporting status is rejected at the 95% level of confidence. Thus, even after accounting for all the fixed effects and differencing, our concerns over endogeneity of the exporting dummy are warranted. Also, the exporter indicator is statistically significant at conventional levels of significance even upon using the Anderson and Rubin (1949) test robust to weak instruments.

Table 4
Determinants of cost share of fuels relative to electricity: the Pitt and Rosenzweig (1990) approach.

	OLS		IV	
	(a)	(b)	(c)	(d)
Exporter	−0.006**	−0.004	−0.133**	−0.133**
	(0.003)	(0.003)	(0.052)	(0.056)
Import share	0.005	0.008	0.022**	0.026***
	(0.007)	(0.007)	(0.009)	(0.010)
Skill share		−0.017**		−0.016
		(0.009)		(0.011)
Age		−0.038		−0.085
		(0.045)		(0.053)
ln(value added)	0.003***	0.003***	0.008***	0.008***
	(0.001)	(0.001)	(0.002)	(0.002)
Underid test			0.000	0.000
F-stat			58.609	35.328
Overid test			0.621	0.869
Endogeneity			0.012	0.016
Joint sign. endog.	0.027	0.192	0.029	0.097
N	100662	80953	73433	57206

Note: Standard errors are heteroskedasticity-robust. IV estimation is via GMM. Dependent variable is cost share of fuels minus cost share of electricity. All regressions include industry-by-time and province-by time dummies as well as firm fixed effects. In case of (c), the excluded instruments are foreign share and ln(capital); (d) also uses female share as an instrument. Underid test reports the *p*-value of the Kleibergen-Paap (2006) rk statistic with rejection implying identification; *F*-stat reports the Kleibergen-Paap *F*-statistic for weak identification; Overid test reports the *p*-value of Hansen *J* statistic with rejection implying invalid instruments; Endogeneity reports the *p*-value of endogeneity test of the endogenous regressor; Joint sign. endog. reports the *p*-value of Anderson-Rubin (1949) chi-square test of endogenous regressor. See text for further details.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

4.3. Robustness checks

We undertake two additional sensitivity analyses to further examine the validity of our findings.

First, as discussed above, for some of the variables utilized in our study, the survey data consist of missing, zero, and negative values. Accordingly, we analyze whether our findings are sensitive to the inclusion of firms with such values. In the interest of brevity, we do not report the corresponding estimates but briefly discuss our findings.[22]

More precisely, we estimate our preferred specifications (i.e., the two IV models in Table 4) on five subsamples. We begin by completely omitting firms that report missing or zero wages, missing or negative values of fuel or electricity use, or missing, zero, or negative values of total energy use for any year. Next, firms with missing, zero, or negative values of output, raw materials, or other expenses during any year are dropped entirely. Further, we omit firms with any occurrence of missing values of import share or export status. Next, we drop firms with any instance of missing or zero values of capital stock. Finally, we omit all observations from 2006 since the value of capital for that year is obtained by interpolation. Strikingly, across all subsamples, exporting is found to significantly reduce the cost share of fuels relative to electricity. The IV specification tests continue to lend support to our identification strategy.

Second, we also examine the effect of exporting on energy efficiency by utilizing a measure of energy intensity as the dependent variable. The specification is motivated by Cole et al. (2008).[23] For our purpose, fuel (electricity) intensity is defined as the ratio of the value of fuels and lubricants (electricity) used to value added. In case of (log) fuel intensity ($\ln E_{fijpt}$), our estimating equation for firm *i* in industry *j* and province *p* at time *t* is given by

$$\ln E_{fijpt} = \gamma_{fL}\ln L_{ijpt} + \gamma_{fK}\ln K_{ijpt} + \gamma_{f\mathrm{EXP}}\mathrm{EXP}_{ijpt} + \gamma_{f\mathrm{IMP}}\mathrm{IMP}_{ijpt} + \gamma_{f\,\mathrm{FOR}}\mathrm{FOR}_{ijpt} + \lambda_{fijpt} + \eta_{fijpt}. \tag{17}$$

[19] Here, −0.006 / (0.137 − 0.105) = −0.1875.

[20] Again, −0.133 / (0.137 − 0.105) = −4.156.

[21] To put the OLS and IV estimates in context, consider a firm with the costs of fuels, electricity, and labor given by 600,000, 500,000, and 2,700,000 (thousands of rupiahs), respectively. If variable costs are comprised of these three inputs, the cost share of fuels minus the cost share of electricity is about 0.03. Our IV estimate suggests that the *ceteris paribus* effect of exporting reduces this difference by roughly 13 percentage points, i.e., to −0.10. While we do not identify how much of this change is separately attributable to fuels and electricity, a decrease (an increase) in the value of fuels (electricity) used to 250000 (600000) is consistent with this change; the expenditure on labor is assumed to remain the same. In contrast, the OLS estimate in column (a) suggests a decrease of about 0.6 percentage points. Again, assuming the wage bill to remain similar, a decrease (an increase) in the cost of fuels (electricity) to only 590,000 (510,000) is consistent with this change.

[22] The results are available upon request.

[23] Hamermesh and Grant (1979) and Maskus and Bohara (1985), among others, discuss why specifications based on cost functions may be preferred to those motivated by profit functions. Also, see Christensen and Greene (1976) and Morrison (1992).

Similarly, for (log) electricity intensity ($\ln E_{eijpt}$), we estimate

$$\ln E_{eijpt} = \gamma_{eL} \ln L_{ijpt} + \gamma_{eK} \ln K_{ijpt} + \gamma_{e\text{EXP}}\text{EXP}_{ijpt} + \gamma_{e\text{IMP}}\text{IMP}_{ijpt} + \gamma_{e\text{FOR}}\text{FOR}_{ijpt} + \lambda_{eijpt} + \eta_{eijpt}. \tag{18}$$

In Eqs. (17) and (18), L represents labor employed. λ_{fijpt} and λ_{eijpt} capture industry-by-time, province-by-time, year, as well as firm fixed effects in specifications that control for the latter. η_{fijpt} and η_{eijpt} denote the error terms. The remaining explanatory variables are as defined above.

In the alternative specification with controls for firm age and workforce composition, the fuel and electricity intensity equations are expressed as

$$\ln E_{fijpt} = \gamma_{fL} \ln L_{ijpt} + \gamma_{fK} \ln K_{ijpt} + \gamma_{f\text{EXP}}\text{EXP}_{ijpt} + \gamma_{f\text{IMP}}\text{IMP}_{ijpt} + \gamma_{f\text{FOR}}\text{FOR}_{ijpt} + \gamma_{f\text{AGE}}\text{AGE}_{ijpt} + \gamma_{f\text{SKILL}}\text{SKILL}_{ijpt} + \gamma_{f\text{FEMALE}}\text{FEMALE}_{ijpt} + \lambda_{fijpt} + \eta_{fijpt} \tag{19}$$

and

$$\ln E_{eijpt} = \gamma_{eL} \ln L_{ijpt} + \gamma_{eK} \ln K_{ijpt} + \gamma_{e\text{EXP}}\text{EXP}_{ijpt} + \gamma_{e\text{IMP}}\text{IMP}_{ijpt} + \gamma_{e\text{FOR}}\text{FOR}_{ijpt} + \gamma_{e\text{AGE}}\text{AGE}_{ijpt} + \gamma_{e\text{SKILL}}\text{SKILL}_{ijpt} + \gamma_{e\text{FEMALE}}\text{FEMALE}_{ijpt} + \lambda_{eijpt} + \eta_{eijpt}, \tag{20}$$

respectively.

Table A1 in the Appendix displays the results pertaining to our measures of energy intensity without firm fixed effects. Briefly, the results are consistent with our findings based on the cost share equations in Table 2. For instance, from (a), exporting is suggested to significantly discourage fuel intensity by roughly 7%.[24] Similarly, from (c), exporting is significantly associated with an increase in electricity intensity. The estimates obtained after including firm fixed effects are reported in Table A2 in the Appendix.

As in the case of cost share equations, we also resort to the differencing strategy and continue to assume foreign share, (log) capital, and the share of female employees to have a similar impact on fuel and electricity intensity. Thus, we assume $\gamma_{fK} = \gamma_{eK}$, $\gamma_{f\text{FOR}} = \gamma_{e\text{FOR}}$, and $\gamma_{f\text{FEM}} = \gamma_{e\text{FEM}}$. Given the assumptions, subtracting Eq. (18) from Eq. (17) yields

$$\Delta \ln E_{ijpt} = \Delta\gamma_L \ln L_{ijpt} + \Delta\gamma_{\text{EXP}}\text{EXP}_{ijpt} + \Delta\gamma_{\text{IMP}}\text{IMP}_{ijpt} + \Delta\lambda_{ijpt} + \Delta\eta_{ijpt}. \tag{21}$$

Here, the IV approach relies on $\ln K$ and FOR as instruments to identify $\Delta\gamma_{\text{EXP}}$, i.e., the effect of exporting on (log) fuel intensity relative to electricity intensity.

Moreover, subtracting Eq. (20) from Eq. (19) results in

$$\Delta \ln E_{ijpt} = \Delta\gamma_L \ln L_{ijpt} + \Delta\gamma_{\text{EXP}}\text{EXP}_{ijpt} + \Delta\gamma_{\text{IMP}}\text{IMP}_{ijpt} + \Delta\gamma_{\text{AGE}}\text{AGE}_{ijpt} + \Delta\gamma_{\text{SKILL}}\text{SKILL}_{ijpt} + \Delta\lambda_{ijpt} + \Delta\eta_{ijpt}. \tag{22}$$

Again, in this case, the exclusion restrictions used to identify $\Delta\gamma_{\text{EXP}}$ are $\ln K$, FOR, and FEMALE.

The results in Table A3 in the Appendix continue to support our identification strategy. However, the results in (d), i.e., pertaining to Eq. (22), perform better in terms of the IV specification tests. The GMM estimate finds exporting to reduce fuel intensity relative to electricity intensity to the tune of nearly 100%.[25] Again, the exogeneity of exporting status continues to be rejected supporting our concerns over endogeneity.

[24] Here, $\exp(-0.075) - 1 = -0.072$.

[25] Here, $\exp(-3.854) - 1 = -0.979$.

5. Conclusion

At the firm level, the effects of exporting on outcomes such as productivity and wages have been extensively analyzed. On the contrary, the causal impact of exporting on firms' environmental performance has received less attention. Moreover, the identification of such an effect is not trivial due to non-random selection into exporting. In this light, we examine the impact of exporting on energy efficiency and contribute to the firm-level literature on trade and the environment in a number of ways. First, we utilize relatively novel data from Indonesia. Second, we primarily resort to theoretically motivated cost share equations. Finally, due to the potential endogeneity of exporting status, we rely on an IV strategy based on a differencing method (Pitt and Rosenzweig, 1990). Under a set of reasonable assumptions, the approach enables us to identify the effect of exporting on the use of fuels (relative to electricity). Strikingly, our IV results find (i) exporting to reduce the use of fuels relative to electricity and (ii) concerns over endogeneity of the exporting indicator to be relevant. Accordingly, exporting can be regarded as environmentally beneficial.

Broadly, our findings are consistent with studies that utilize relatively aggregate data and find trade to be pro-environment. In addition to complementing the existing firm-level research on exporting and environmental performance, our results also support the hypotheses that exporting may encourage innovation and productivity. Although further research is warranted to examine the external validity of our results, the analysis suggests that export-promotion policies in developing countries may have unintended environmental benefits (e.g., Martincus and Carballo, 2010; Martincus et al., 2012).

Acknowledgments

The authors are very grateful to Daniel Millimet, Richard Tol, Stephen Chaudoin, two anonymous referees, and conference participants at the 2012 Southern Economic Association Meetings for helpful comments.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.eneco.2015.09.013.

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