The impact of ownership structure and corporate governance on energy intensity: evidence from Indian business groups

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Abstract

Purpose – Energy efficiency is critical for global sustainability (International Energy Agency, 2019). The purpose of this paper is to examine how agency conflicts arising from pyramidal ownership structures impact the energy intensity (EI) of group-affiliated Indian firms. Group-affiliated firms face unique governance challenges. For instance, parent owners (promoters) may transfer profits from one group-affiliated firm to another firm in which they have greater ownership. The authors hypothesize that such governance issues will lead to underinvestment in energy-saving projects among group firms in which promoters have a low ownership stake, resulting in their greater EI.

Design/methodology/approach – The authors measure EI as the ratio of total energy expense to total sales revenue (EI) and as the industry-adjusted version of this ratio. Group-affiliated Indian firms are divided into high- and low-stake firms based on the sample's median promoter ownership.

Findings – Results support the authors' prediction: group firms in which promoters have low ownership are more energy intensive, consistent with these firms being exposed to greater governance challenges and agency conflicts that result in operating inefficiencies and/or underinvestment in energy-saving projects.

Practical implications – Given energy efficiency will be key in addressing climate change, this study could raise awareness among activists, motivate regulators to consider agency problems among group-affiliated firms in emerging markets and may underscore the importance of environmental-related corporate disclosures.

Originality/value – To the best of the authors' knowledge, this study is the first to identify the significant impact that firm ownership structure and associated governance challenges have on corporate EI.

Keywords Energy intensity/efficiency, Business groups, Ownership structure, Agency costs, Corporate governance, Emerging markets, Energy intensity (energy efficiency)

Paper type Research paper

1. Introduction

Energy efficiency is a critical issue as the world battles climate change and moves toward greater global sustainability (International Energy Agency [IEA], 2019). Prior studies in the

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area of energy economics find that the energy consumption of a firm depends on its investments in energy-saving projects (DeCanio, 1998; De Groot *et al.*, 2001; Song and Oh, 2015) and its innovativeness in finding solutions to energy challenges (Margolis and Kammen, 1999; Costa-Campi *et al.*, 2015). Additionally, extant literature in corporate governance indicates that agency conflicts can affect both a firm's investments and its level of innovation (Cho, 1998; Hoskisson *et al.*, 2002; Lee and O'Neill, 2003; Sapra *et al.*, 2014). These two streams of literature lead us to hypothesize that an association exists between a company's governance (specifically as it relates to the firm's ownership structure) and its energy efficiency. To the best of our knowledge, this study is the first to investigate the impact of ownership structure – and its associated agency problems – on the energy intensity (EI) of firms.

Theoretically, there could be several, interrelated reasons why ownership structure and related governance issues could affect a firm's energy policies. Firms with weaker corporate governance are expected to have higher agency costs, higher capital costs and lower market values (Jensen and Meckling, 1976; Ang *et al.*, 2000; Singh and Davidson, 2003; Gedajlovic *et al.*, 2005), which may make it more difficult for such firms to obtain external financing to fund energy-efficient projects. Higher costs of capital would also result in fewer energy-saving investments meeting the firm's capital budgeting criteria (Hassett and Metcalf, 1993; DeCanio, 1993, 1998). Consequently, poorly governed firms are expected to suffer from relatively higher energy consumption. While governance challenges can take many forms, this study centers on the agency conflicts that often arise among group-affiliated firms where the controlling owner has a low ownership stake.

Specifically, we focus on why energy-saving projects might not be undertaken as a result of differential pay-off structures to different owners in group-affiliated firms. For example, a controlling owner (i.e. a promoter [1]) of a parent firm within a business group with only a 20% stake in a group-affiliated company may lack the incentive to invest in energy-saving projects within that nonparent company because much of the return from such investments would accrue to non-promoter shareholders (i.e. the shareholders of nonparent companies within the business group). Indeed, rather than investing in energy-saving projects in an affiliated firm, the promoter may tunnel cash flows from one affiliated company to another firm within the group where the promoter has a higher stake (Bertrand *et al.*, 2002; Kali and Sarkar, 2011). This "institutional agency problem" within business groups in India (Bao and Lewellyn, 2017) can adversely affect the efficacy of firm governance (Jamasb and Pollitt, 2015; Rexhäuser and Löschel, 2015), potentially leading to higher costs of capital and less than optimal managerial decisions relating to energy initiatives for group-affiliated firms in which the promoter has a low ownership stake.

Therefore, we use variation in organizational structure among group-affiliated firms (i.e. variation in promoter ownership) to capture these differences in corporate governance and their associated agency problems. Using this measure, group-affiliated firms are classified into two categories based on the group promoters' ownership rights [2]. Group-affiliated firms in which promoters hold relatively greater ownership rights are referred to as "high-stake firms," and affiliated companies in which controlling promoters have less ownership rights are referred to as "low-stake firms." By comparing the energy intensities of low-stake and high-stake firms, we are able to test the impact of a firm's ownership structure and, therefore, its corresponding governance challenges, on its energy policy. We predict that within group-affiliated firms, the EI of low-stake firms should be greater than that of high-stake firms since low-stake firms suffer more from the expropriation of wealth and inefficient capital budgeting, resulting in less investment in energy-saving projects.

The results align with this prediction: using energy expenditure per rupee of revenue, we find that low-stake firms are more energy-intensive than high-stake firms, consistent with low-stake firms being subject to greater governance challenges, such as the expropriation effects of profit tunneling [3]. This result holds after controlling for industry differences and leads us to conclude that ownership structure and related corporate governance issues have an important influence on the energy efficiency of firms.

Our study contributes to the existing literature in several ways. To the best of our knowledge, this study is the first attempt to investigate the effect that a firm's ownership structure and associated corporate governance challenges have on its energy policy. Existing literature examining energy policy often treats governance among sample firms as a constant factor, thus assuming a homogenous impact of governance on the energy policy of sample firms, which may not be the case. This study also broadens our understanding of corporate governance. Prior research has largely examined the impact of corporate governance on the financial, investment and other strategic policies of firms. We extend this literature by demonstrating that governance issues can significantly affect the energy policies of firms, as evidenced by differences in their energy intensities. Third, we contribute to the growing body of literature considering whether the context of emerging markets affects issues such as governance and monitoring. Such studies are important because emerging markets represent a significant part of the global economy (International Monetary Fund, 2018) and provide a unique socioeconomic and institutional framework to test hypotheses relative to developed economies [4]. Our study exploits the group-affiliation ownership structure, common in many emerging markets (Khanna and Palepu, 2000), to demonstrate that group firms' energy intensities differ depending on promoter ownership stakes, implying that unique governance issues such as profit tunneling can have an effect on group firms' energy-related investments. Thus, we also contribute to research examining group-affiliated businesses.

Our paper also has implications for practice and for society. Given energy efficiency will be key in addressing climate change (IEA, 2019), this paper raises awareness of the impact of governance and pyramidal ownership structures on energy efficiency. Our results may motivate regulators to further consider the role played by agency problems among group-affiliated firms in emerging markets. Finally, this study and future research in this area would not be possible without the reporting of energy-related data by Indian firms; therefore, the paper helps demonstrate to standard setters the value of environmental corporate disclosures, which is particularly noteworthy as the accounting profession continues to grow in its involvement in corporate social responsibility related reporting and assurance (KPMG, 2017).

The remainder of the paper is organized as follows. In Section 2, background information and a theoretical discussion of Indian business groups are provided, leading to our hypothesis. Section 3 describes the data and models used to test the hypothesis. Section 4 presents the results, and, finally, Section 5 draws the conclusions.

2. Literature review and hypothesis development

2.1 Energy (in) efficiency in India

From 2009 to 2019, India was consistently the world's third highest carbon dioxide emitting country behind only China and the USA (Global Carbon Project, 2020). During the same 10-year period, the increase in India's CO_2 emissions was striking, rising from approximately 1,613 to 2,616 million metric tons (Global Carbon Project, 2020). Although energy use declined in 2020 due to the COVID-19 pandemic, India's energy consumption levels are expected to surpass 2019 levels during or soon after the 2021 calendar year (International

Energy Agency [IEA], 2021). Academics and governments alike have recognized energy efficiency as a key aspect in combatting environmental degradation and climate change [5]. Indian Government, in particular, has repeatedly made energy efficiency and environmental policies a priority (Mukherjee, 2010; Haider *et al.*, 2019). For further details, Sahoo *et al.* (2016) provide a detailed discussion of the Indian Government's plans and initiatives, highlighting the achievements and challenges of the country's energy-related programs. Similarly, Haider *et al.* (2019) provide an insightful, brief review of four major policies that were recently implemented by the Indian Government, focusing on EI and conservation efforts.

Despite the government's efforts, researchers have found evidence that Indian firms are very energy-intensive relative to their potential efficiency. For example, the Indian paper industry is estimated to have a feasible energy savings potential of 40% (Haider *et al.*, 2019), and Indian iron and steel firms could reportedly reduce their energy consumption by half, according to Haider and Mishra (2021). Clearly, given the recent "code red for humanity" report of the Intergovernmental Panel on Climate Change (2021), understanding what factors may be contributing to the EI of Indian firms is critical not only for India's future but also for addressing global climate change.

Several studies have examined a particular sector's EI and its drivers: Kumar (2003) and Sahu and Narayanan (2009) examine Indian industrial firms; Goldar (2011) studies the Indian manufacturing sector; Dasgupta and Roy (2017) analyze seven energy-intensive Indian manufacturing industries; Haider *et al.* (2019) examine the Indian paper industry; and Haider and Mishra (2021) focus upon Indian iron and steel firms. However, according to Haider and Mishra (2021), "there is a substantial research gap in conducting an energy efficiency analysis at micro-level in the context of India." The present study helps to fill that gap by examining how promoter ownership affects the EI of business group-affiliated firms in India.

We build upon a handful of prior studies, which have considered the impact of ownership structure on energy efficiency. For instance, Yang and Li (2017) conduct a thorough analysis of energy efficiency in China, including whether the firms are state-owned or non-state-owned. Government ownership clearly differs from business group promoter ownership, and India's economy differs from China's, which Yang and Li characterize as a "'socialist market economy' with Chinese characteristics." Thus, our study extends Yang and Li's to a different type of ownership structure in a different economic context. In Indian-focused research, Kumar (2003) found EI was positively related to state ownership and negatively related to foreign ownership; the latter finding reinforces the work of Sahu and Narayanan (2009) who also document that foreign firms are more energy efficient. Goldar (2011) provides evidence of "energy efficiency spillover" from foreign ownership to local firms in developing countries. Yet, to the best of the authors' knowledge, no research to date has examined promoter ownership's effect on energy efficiency.

In a study that is particularly relevant to ours, Haider *et al.* (2019) estimate energy use and energy-saving potential of Indian iron and steel firms. In their analysis, the ownership categorization variable is insignificant in their Tobit regression of factors influencing energy efficiency scores. Our study differs from Haider *et al.*'s in terms of the dependent variable and the ownership categorization. Their dependent variable corresponds to the ratio of actual energy usage to estimated optimal energy use, while we use the ratio of total energy expense to total sales revenue to proxy for EI. In terms of the type of ownership being considered, Haider *et al.*'s ownership variable distinguishes between Indian private firms, foreign firms, group-affiliated firms and governmental undertakings, while our study categorizes group-affiliated firms based on promoter ownership. Therefore, our analysis provides a different, nuanced view of the effect that ownership structure can have on firms' energy intensities – building upon the foundation laid by Haider *et al.* and others.

2.2 Business groups in India

Any investigation of the impact of ownership structure in India on firm-level energy efficiency has to acknowledge the dominant role that business groups play in the country's economy. Basu and Sen (2015) find that about 35% of the firms listed on the Bombay Stock Exchange (BSE) in 2011 were affiliated with a business group. Furthermore, these group-affiliated companies held 60% of the total assets of BSE-listed firms (Basu and Sen, 2015). Prior studies have investigated the reasons for the existence and dominance of business groups in emerging markets in general and in India in particular. The dominant view is that the business group structure is a response to imperfections in the capital, labor and product markets (Khanna and Palepu, 2000). A business group has a key advantage in that information flows freely among its constituent firms, which aids the group in overcoming market imperfections through information and resource sharing (Gopalan *et al.*, 2007; Singla *et al.*, 2014). According to this perspective, business group formation is beneficial to constituent firms. This is supported by empirical evidence suggesting that group firms in financial distress receive support from other group members (Gopalan *et al.*, 2014; Basu and Sen, 2015).

A second, related stream of literature examines the structural elements of business groups and their impact on the functioning of these groups (Bertrand *et al.*, 2002; Gopalan *et al.*, 2014; Singla *et al.*, 2014; Basu and Sen, 2015). One of the most basic characteristics of a business group that has been studied extensively is the pyramidal ownership structure. In this type of structure, the controlling parent of the business group (i.e. the promoter) obtains de-facto control of constituent firms through a web of cross-ownership arrangements, such that promoters' ownership rights decrease while they maintain control of the group firms as one moves away from the top of the pyramid (Khanna and Palepu, 2000; Kali and Sarkar, 2011). As a result, promoters have greater *control* over the cash flows of group firms even though the *rights* to the cash flows belong to the owners of the constituent firms. The difference in ownership rights versus de-facto control among firms of the same group creates conflicts of interest between the controlling owners of a parent firm (i.e. promoters) and the shareholders of group-member firms further down the pyramid. Specifically, the promoter has an incentive to expropriate profit from the noncontrolling shareholders of firms toward the bottom of the pyramid (Masulis *et al.*, 2011). This expropriation is referred to as "tunneling." Bertrand *et al.* (2002) discuss in detail the various mechanisms of tunneling and provide empirical evidence of its existence in the Indian context [6]. The main conclusion of this stream of literature is that the extent of tunneling depends on the percentage of ownership held by the controlling promoter (Bertrand *et al.*, 2002; Kali and Sarkar, 2011; Basu and Sen, 2015).

These agency-related conflicts of interest between controlling promoters and the shareholders of other group-affiliated firms have important implications for their energy policies. These implications, however, differ for low-stake firms and high-stake firms. In low-stake firms toward the bottom of group pyramids, promoters have fewer claims on future cash flows, which decreases their incentive to make energy-saving investments (since promoters are due a smaller share of the benefit from such investments). In our sample, the average growth rate in total assets is much lower for low-stake group-affiliated firms (6.7%) than for high-stake group-affiliated firms (8.4%) [7]. Further, the average research and development (R&D) spending, scaled by total assets, is 0.8% for low-stake firms and 1.1% for high-stake firms [8]. These patterns in capital investments and R&D suggest that low-stake firms suffer from underinvestment and less innovativeness when compared to high-stake firms. Low investment in assets and R&D is likely to have a negative impact on the energy efficiency of these firms [9] (Costa-Campi *et al.*, 2015), given prior research has suggested that energy savings are closely linked to the innovativeness of firms (Bala Subrahmanya and Kumar, 2011).

Additionally, group promoters may lack the incentive to adequately monitor the managers of low-stake firms, since promoters do not receive a meaningful share of the benefit from the successes of such firms. Less active monitoring could result in missed investment opportunities and self-serving behavior by managers (e.g. "perks" or other traditional agency costs), which might adversely affect the energy efficiency of such firms.

Finally, due to the tunneling of profits and less monitoring by promoters, low-stake firms may find it difficult to finance energy-saving investments. Profit expropriation and managerial "perks" may not only result in poorer bottom-line numbers being reported by low-stake firms to the capital markets, but these are also symptoms of poor corporate governance, which may be recognized by investors and creditors. Lower reported profit and potential recognition of poor governance can make it more difficult to obtain external financing, resulting in a higher cost of capital. A higher cost of financing, in turn, makes energy-saving investments less attractive, and fewer projects will meet low-stake firms' capital budgeting criteria.

In summary, because promoters have incentives to tunnel the wealth of low-stake firm shareholders to high-stake firms (Bertrand *et al.*, 2002; Kali and Sarkar, 2011), rather than investing in energy-efficient projects in low-stake firms; and because promoters also have less incentive to monitor low-stake member firms, low-stake group-affiliated firms likely have weaker corporate governance and lower reported profits, which could lead to higher costs of capital and, consequently, fewer energy-efficient projects being acceptable. All of these interrelated factors (profit tunneling, less monitoring, inferior governance and higher costs of capital) lead to the prediction that low-stake firms will underinvest in energy-efficient projects [10].

In high-stake firms, where promoters have higher cash flow rights, the opposite effects can be expected. Promoters will have greater incentive to invest in energy-saving projects at firms in which they hold a higher ownership stake since a significant part of the benefit would accrue to them. Financing such investments should be less problematic since high-stake firms actually benefit from the wealth transfers that arise from the pyramidal business group ownership structure; that is, any tunneling of profits from other affiliated companies can actually increase the funds available to high-stake firms. In addition, promoters have greater incentive to monitor managers in high-stake firms since they reap a greater proportion of the benefits from successes in high-stake firms. Therefore, we expect the EI of high-stake firms to be lower compared to that of low-stake firms:

H1. Among group-affiliated firms, low-stake firms are more energy-intensive than high-stake firms.

3. Variables, data and methodology

3.1 Variables

3.1.1 Dependent variables. We construct two measures of energy efficiency using the accounting data available for Indian firms. In India, companies report their energy expense (the total amount spent on fuel, power and water) during the financial year in their annual reports. Among our sample firms, fuel and power constitute about 97% of this energy expense. The first measure used is the ratio of total energy expense to total sales revenue, which we refer to as "energy intensity" or *EI*. EI indicates how much energy is required, in monetary terms, to produce one rupee of sales revenue. *EI* is similar to the measures used by Reddy and Kumar Ray (2011), Elliott *et al.* (2013), Sahu and Sharma (2016) and Oak (2017) and can be assumed to vary inversely with energy efficiency (i.e. higher values of *EI* indicate less energy efficiency) [11]. One advantage of this EI measure over unscaled (raw total rupees) energy consumption is that it reflects the effects of energy-related investments such as adopting more energy-efficient production methods or installing solar panels to generate power that is off the utility grid and, therefore, lowers energy costs per unit of production. To adjust our measure for inter-industry differences, we construct an industry-adjusted energy intensity proxy (*IAEI*) by subtracting the industry-average *EI* ratio from the *EI* ratio of a given firm within that industry [12]. Thus, *IAEI* indicates the energy expenditure used to produce sales revenue for each firm relative to the average EI of the corresponding industry for each year in our sample period. A positive *IAEI* value indicates the firm spent more on energy to support its revenues than the industry average, thus implying the firm was less energy-efficient.

3.1.2 Independent variables. To test the hypothesis, we consider promoter ownership in each group-affiliated firm, defined as the percentage of firm-level ownership held by the controlling person or entity of the business group at the financial year-end. We use this percentage to categorize group firms into low- and high-stake firms as follows. First, we calculate each firm's average promoter ownership percentage across the entire sample period. Then, we take the median value of these firm-specific averages to arrive at the median value of promoter ownership across all years and all group-affiliated firms in our sample. If a company's average promoter ownership across the sample period is below this sample median value (54%) of promoter ownership, then the variable *Low-Stake-Firm* is assigned a value of one (zero otherwise) for that company [13], [14]. Since low-stake firms are hypothesized to be more energy-intensive than high-stake firms, we expect a positive coefficient for *Low-Stake-Firm*.

Apart from this test variable, we control for firm-specific factors that can affect the EI of a firm, following prior literature (Sahu and Narayanan, 2009; Costa-Campi, 2015; Oak, 2017). Specifically, we control for firm size, tangibility, leverage, firm performance (proxied by return on assets), relative investment in research and development, foreign trade intensity (FTI), growth opportunities (proxied by the market-to-book ratio) and firm age. In Table 1, we define each of the control variables and indicate the predicted sign as well as a brief rationale for these expectations.

3.2 Data

The data for our analysis are obtained from Prowess, a database maintained by the Center for Monitoring Indian Economy that is widely used in finance and accounting literature (Allen *et al.*, 2012; Jadiyappa *et al.*, 2016). The initial sample includes all firms listed on BSE, which is the oldest stock exchange in Asia and the largest stock exchange in India in terms of the number of firms listed. Then, we eliminate all financial sector firms and firms that do not have data necessary to run our model. Next, we exclude firms belonging to industries that have fewer than five firms in any given year to ensure the validity of the industry-adjusted EI measure. Finally, we eliminate "standalone" firms, which do not have a group affiliation, as well as firms that have negative market-to-book or leverage ratios. Our final sample comprises 4,967 firm-year observations corresponding to 798 unique group-affiliated firms [15], over the period from 2011 to 2017. Details of this sample selection process are presented in Table 2 [16].

Variable	Definition	Expected sign and rationale
Size	Log of total assets	Negative: Economies of scale should reduce energy spending per unit of sale
Tangibility	Ratio of net fixed assets to total assets	Positive: Greater investment in physical assets should correspond to greater EI
ROA	Firm performance proxy, calculated as the ratio of earnings before interest and taxes to total assets	Negative: Greater access to funds for energy-efficient investments
Leverage	Ratio of total debt to total assets	Negative or positive: Greater access to debt financing can facilitate energy-saving investments; alternatively, for firms with high leverage, the need to repay debt could constrain the company's ability to fund energy investments and such firms may be hesitant to borrow more funds to finance energy-saving projects
R&D_Ratio	Ratio of research and development expenditure to total assets	Negative: Investing in innovations should help reduce EI
FTI	FTI, measured as the ratio of the sum of foreign exports and imports to total sales	Negative: Firms that compete in foreign markets are expected to have competitive cost structures (more energy-saving investments)
MB	Firm growth proxy, calculated as the market-to-book ratio of equity	Negative: Firms that are growing are likely to be investing in more energy efficient projects, such as modern equipment that is less energy intensive
Age	Difference between current year and year of incorporation	Negative or positive: Mature firms are likely better positioned to engage in greater energy-efficient investments; alternatively, mature firms may be less innovative or more entrenched in their current practices, leading to less energy-saving projects being undertaken

Table 1.
Definitions and predicted signs for control variables

Criteria	No. of firm-year observations
BSE-listed firms in Prowess for the sample period (2011–2017)	33,019
Less: Financial firms (NIC codes 64920, 64191, 64192, 64920, 66190, 66301, 64990, 64300, iiiiiiiiii 65110, 64300, 66120)	*(6,685)*
Less: Firms with missing data for the model's control variables and/or promoter ownership in iiiiiiiiii a given year	*(12,082)*
Less: Firms in industries that have fewer than five firms in a given year	*(981)*
Less: Standalone firms (i.e. firms not affiliated with a business group)	*(8,251)*
Sample of group-affiliated firms	5,020
Less: Firms with negative market-to-book, leverage or R&D ratios in a given year	*(53)*
Final sample of group-affiliated firms used in regression analysis	4,967

Table 2.
Sample selection

The summary statistics for the variables used in our study are presented in Table 3 for high-stake and low-stake group-affiliated firms, which are divided according to a median split of the sample based on the firm-specific averages of promoter ownership stakes. The summary statistics presented in Table 3 reveal that the EI of low-stake firms – which are expected to have inferior corporate governance and to suffer from profit tunneling and other agency problems related to promoter ownership – is notably higher than that of high-stake firms (6.3% versus 5.2%, respectively). This difference (1.1%) demonstrates the economic significance: low-stake firms consume on average about 21% more energy to produce their sales relative to high-stake firms. Low- and high-stake firms also differ with respect to many firm-specific characteristics, as demonstrated by the "Difference" column in Table 3. Whether these characteristics attenuate the significance of the difference in EI observed here between low- and high-stake firms will be addressed in the multivariate tests of the hypothesis.

The correlation matrix is presented in Table 4. All of the correlations between the control variables and the *EI* measure are in the predicted direction. Most of the correlations, especially between the independent variables, are statistically significant, despite being small in magnitude. An untabulated variance inflation factor (VIF) analysis indicated that the average VIF for our model is 1.14 and that none of the individual VIFs exceed two, alleviating multicollinearity concerns.

3.3 Model specification

The baseline model used to test our hypothesis is presented below:

$$EI_{it} = \alpha_i + \beta_1 Low-Stake-Firm_i + \beta_2 Size_{it} + \beta_3 Tangibility_{it} + \beta_4 ROA_{it} + \beta_5 Leverage_{it} + \beta_6 R\&D\_Ratio_{it} + \beta_7 FTI_{it} + \beta_8 MB_{it} + \beta_9 Age_{it} + \varepsilon_{it} \quad (1)$$

where *EI* is the energy intensity measure, calculated as the cost of fuel, power and water per rupee of sales revenue for the i^{th} firm in the t^{th} year. We also use an industry-adjusted energy

Variables	Low-stake firms (inferior governance expected) N	Mean	SD	High-stake firms (superior governance expected) N	Mean	SD	Difference Mean
EI	2395	0.063	0.086	2572	0.052	0.068	0.011***
IAEI	2395	0.013	0.069	2572	0.005	0.050	0.007***
Size	2395	9.069	1.902	2572	8.658	1.711	0.410***
Tangibility	2395	0.309	0.192	2572	0.300	0.195	0.009
ROA	2395	0.082	0.083	2572	0.088	0.090	−0.006**
Leverage	2395	0.288	0.209	2572	0.277	0.208	0.011*
R&D_Ratio	2395	0.003	0.011	2572	0.004	0.013	−0.001
FTI	2395	0.330	0.367	2572	0.278	0.330	0.051***
MB	2395	1.121	2.544	2572	1.330	2.700	−0.210***
Age	2395	39.893	23.184	2572	36.717	22.592	3.177***

Notes: We divide group-affiliated firms into low-stake firms (which are expected to have inferior corporate governance) and high-stake firms (which are predicted to have better corporate governance) based on the median value of promoter ownership. *EI* is the cost of fuel, power and water per rupee of sales revenue. All other variables are defined in Table 1. Differences between the means are tested using t-statistics, with ***, ** and * indicating significance at the 1, 5 and 10% levels, respectively

Table 3. Summary statistics for group-affiliated firms

Table 4.
Correlation matrix

Variables	*EI*	*Size*	*Tangibility*	*ROA*	*Leverage*	*R&D_Ratio*	*FTI*	*MB*	*Age*
EI	1								
Size	−0.0356	1							
Tangibility	0.3911***	−0.0418	1						
ROA	−0.0880**	0.1539***	0.1138***	1					
Leverage	0.1976***	0.0934**	0.3597***	−0.1834***	1				
RD_Ratio	−0.0895**	0.0860**	0.0221	0.1593***	−0.0935***	1			
FTI	−0.0352	0.1601***	−0.0619**	0.1149***	−0.0189	0.1750**	1		
MB	−0.0872***	0.049	−0.0533**	0.2879***	−0.0803**	0.1212***	0.0336	1	
Age	0.0471	−0.0311	−0.0174	−0.0319	−0.1696***	−0.0614**	−0.0557**	−0.0019	1

Notes: This table presents the correlations between the study's continuous independent variables, which are defined in Table 1. The full sample of 798 firms (or 4,967 firm-year observations) is used to calculate these correlations. Significant correlations are denoted by *** and **, indicating significance at the 1 and 5% level, respectively intensity proxy (*IAEI*) measure as the dependent variable in model (1) to account for inter-industry differences. (*IAEI* is calculated by subtracting the industry-average *EI* ratio from the *EI* ratio of a given firm within that industry.) *Low-Stake-Firm* is the indicator variable (separating low- and high-stake group-affiliated firms) used to test the hypothesis. All other variables are defined in Table 1. Year-fixed effects are incorporated into the model for all pooled ordinary least squares (OLS) regressions, and industry-fixed effects are included in the pooled OLS regressions when the *EI* dependent measure is used (rather than the industry-adjusted *IAEI* dependent measure).

3.4 Estimation

There are two factors that guide our choice of which estimation method to use for our analyses. First, our test variable (*Low-Stake-Firm*) is a time-invariant classification variable, [17] which prohibits the use of firm fixed effects estimation for our analysis. Second, as suggested by the stable values over time reported in Table 5, untabulated tests confirm that the variation in our dependent variable (*EI*) across the sample period is insignificant [18]. Thus, with little variation in the dependent variable across time, we rely on the existence of cross-sectional variation in our dependent and independent variables. Therefore, we use the Fama and MacBeth (1973) estimation method and adjust the standard errors for heteroscedasticity and autocorrelation using the Newey and West (1986) robustness procedure with one lag [19]. The coefficients obtained from the pooled OLS estimation are also provided in the results to convey the robustness of the result to the use of different estimators.

4. Results and discussion

4.1 Univariate analysis

Our hypothesis predicts that group firms in which promoters hold lower ownership stakes will be less energy efficient, due to greater governance challenges (including profit tunneling and its ramifications). Thus, we expect the low-stake group firms to spend more on energy per rupee of sales revenue (i.e. low-stake firms will be more energy-intensive) compared to group firms in which promoters hold a greater stake. Before we test the hypothesis, we first

	Group-affiliated Firms overall		Low-stake Group firms		High-stake Group firms		
	N	Mean	N	Mean	N	Mean	Difference
Year	(1)	(2)	(3)	(4)	(5)	(6)	(7) = [(4) − (6)]
2011	702	0.057	383	0.065	319	0.048	0.017***
2012	709	0.056	368	0.061	341	0.050	0.011*
2013	720	0.059	353	0.066	367	0.053	0.013**
2014	714	0.059	341	0.069	373	0.050	0.019**
2015	718	0.061	322	0.063	396	0.059	0.004
2016	732	0.055	319	0.058	413	0.052	0.005
2017	725	0.056	311	0.059	414	0.053	0.006**
Overall	5020[a]	0.058	2397	0.063	2623	0.052	0.011***

Notes: The significance of the differences in *EI* (which is the cost of fuel, power and water per rupee of sales revenue) presented in column (7) is tested using t-statistics, with ***, ** and * denoting significance at the 1, 5 and 10% levels, respectively. [a] This table's sample (N = 5,020) includes firms with negative market-to-book or negative leverage ratios, since those ratios are not used in this univariate analysis of EI. (In contrast, *MB* and *Leverage* are used in the regression analyses, resulting in a smaller sample size)

Table 5. Univariate analysis of the dependent variable, *EI*

compute the average energy intensities (*EI*) for group firms overall, as well as for high-stake and low-stake group firms, in each year of the sample period, as shown in columns 2, 4 and 6 of Table 5. Column 7 reports the difference in average *EI* between low- and high-stake firms (column 4 *less* column 6). The difference is positive for all of the years in the sample period and is statistically significant in five of the seven years. This is consistent with our hypothesis that low-stake firms are more energy-intensive than high-stake firms, supporting further analysis [20].

4.2 Multivariate analysis

Table 3 reported that there are considerable differences between low- and high-stake group-affiliated firms with respect to time-variant firm-specific factors, which may have an effect on the results of the univariate analysis presented in Table 5. Therefore, we control for these characteristics using a multivariate regression framework to model *EI* and *IAEI* measures in our tests.

4.2.1 Test of the hypothesis. The pyramidal structure of business group ownership and control allows promoters to transfer wealth from firms in which they have low cash flow rights to firms in which they have greater cash flow rights (Khanna and Palepu, 2000; Singla *et al.*, 2014). The extent of profit tunneling has been shown to depend on the percentage of ownership promoters hold in a firm (Basu and Sen, 2015). Therefore, we expect promoters of group-affiliated firms to invest less in energy-saving projects in firms where their ownership stake is low, since the benefit of such projects would accrue primarily to other shareholders. Empirically, this predicted underinvestment in energy-saving projects should result in higher energy expenditures in proportion to revenue for low-stake firms compared to high-stake firms. To examine this prediction, we divide group-affiliated companies into low-stake and high-stake firms according to a median split of the sample based on the firm-specific averages of promoter ownership stakes. Regression results comparing these low- and high-stake firms to test our hypothesis are presented in Table 6.

Consistent with our prediction, the coefficient of *Low-Stake-Firm* is positive and significant in both the OLS model ($\beta = 0.009$, $p < 0.01$) and Fama–MacBeth model ($\beta = 0.009$, $p < 0.01$) when using *EI* as the dependent variable (see columns 1 and 2 of Table 6), as well as in the OLS model ($\beta = 0.008$, $p < 0.01$) and Fama–MacBeth model ($\beta = 0.008$, $p < 0.01$) when using the *IAEI* as the dependent variable (in columns 3 and 4). These results imply greater EI among low-stake firms relative to high-stake firms. Thus, our hypothesis is supported. The significant difference between low- and high-stake group-affiliated firms in the regression analyses is consistent with our conjecture that the differential ownership stake of promoters affects their incentives to participate in firm governance and, relatedly, to invest in energy-efficient projects (versus tunneling profits for their own benefit) [21].

Regarding the control variables included in our model, the results are generally as expected and consistent with prior literature. Examining the four columns of Table 6, the effect of *Size* is consistently negative and significant. Although some prior research finds nuances regarding the effect of firm size on energy efficiency, our finding is in-keeping with the findings of Kumar (2003) and Haider and Mishra (2021), as well as the full sample analysis in Goldar (2011). *Tangibility* is positive and significant in all four models, as predicted. Our proxy for financial performance is *return on assets (ROA)*; its coefficient is consistently negative and significant, aligning with the logic that superior financial performance increases access to funds for energy-efficient investments (Dhanora *et al.*, 2018) and supported by the findings of Haider *et al.* (2019). Just as higher *ROA* implies the firm is better able to fund energy-saving projects, the opposite could be true for firms with high leverage, since the need to repay debt could constrain the company's ability to fund energy

Table 6. Impact of promoter shareholdings on the EI of group firms

	EI (*energy intensity*)		*IAEI* (*industry adjusted energy intensity*)	
	Pooled OLS	Fama–MacBeth	Pooled OLS	Fama–MacBeth
Variables (predicted sign)	1	2	3	4
Low-Stake-Firm (+)	0.009*** (4.882)	0.009*** (4.275)	0.008*** (4.542)	0.008*** (6.932)
Size (−)	−0.005*** (−7.583)	−0.002** (−3.348)	−0.004*** (−6.336)	−0.004*** (−14.460)
Tangibility (+)	0.041*** (5.725)	0.137*** (38.830)	0.042*** (7.873)	0.042*** (12.037)
ROA (−)	−0.104*** (−7.174)	−0.125*** (−11.315)	−0.113*** (−7.614)	−0.115*** (−15.318)
Leverage (+/−)	0.003 (0.464)	0.013** (3.365)	−0.000 (−0.089)	−0.001 (−0.245)
R&D_Ratio (−)	−0.007 (−0.165)	−0.275*** (−8.422)	0.029 (0.856)	0.035 (1.508)
FTI (−)	0.003 (0.846)	−0.004 (−1.113)	−0.008*** (−2.604)	−0.008** (−2.980)
MB (+)	0.000 (0.273)	−0.001 (−1.076)	0.001 (1.220)	0.001* (1.956)
Age (+/−)	0.000 (0.360)	0.000*** (4.989)	−0.000 (−0.560)	−0.000 (−0.478)
Constant	0.412*** (8.565)	0.029*** (6.297)	0.040*** (5.736)	0.038*** (12.948)
Observations	4,967a	4,967	4,967	4,967
R-squared	0.504	0.163	0.066	0.072
Industry FE	Yes	No	No	No
Year FE	Yes	No	Yes	No

Notes: Two dependent variables are used in Table 6: *EI*, which is the cost of fuel, power and water per rupee of sales revenue, and *IAEI* (calculated as the difference between the *EI* of the firm and the average *EI* for the corresponding industry in a given year). The independent variable of interest is *Low-Stake-Firm*, which is an indicator variable that equals one if the group-affiliated firm has below-the-median promoter shareholding and zero otherwise. All other independent variables are defined in Table 1. ***, ** and * indicate significance at 1, 5 and 10% levels, respectively. [a] Observations that lacked all the data necessary for the model were excluded from the regression, resulting in a sample size of 4,967 investments (Cagno and Trianni, 2013). *Leverage* is positive and significant when using the *EI* measure in the Fama-MacBeth regression. This, combined with the consistently negative and significant coefficient for *ROA*, provides some limited support for slack resource theory's implication that having greater financial resources will result in greater investment in energy-efficient initiatives, while greater financial constraints (as in higher leverage) will result in less investment in energy-saving projects (Nagesha and Balachandra, 2006; Hochman and Timilsina, 2017; Haider *et al.*, 2019).

As suggested by Mandal and Madheswaran (2010) and the findings of Haider and Mishra (2021), a firm's research and development spending can lead to higher energy efficiency. This is consistent with our finding that *R&D_Ratio* has a negative and significant impact on *EI* in the Fama–MacBeth regression in Table 6 (column 2). *FTI* is negative and significant when using industry-adjusted EI as the dependent variable. This aligns with prior literature's findings that greater foreign influence can enhance energy efficiency since foreign firms that tend to be more advanced compared to local firms (Kumar, 2003; Sahu and Narayanan, 2009; Goldar, 2011; Haider *et al.*, 2019).

The rationale for the predicted negative sign for *MB*'s coefficient was that firms with high growth potential likely need to expand their operations and, therefore, will be investing in more modern equipment or technologies that are more energy efficient. The *MB* variable is significant but positive in the Fama–MacBeth regression of *IAEI*, in contrast to our expectations. Our rationale (see Table 1) and prior findings for the effect of firm age on EI are two-directional, supporting either a positive or negative relationship (Kumar, 2003 and Goldar, 2011 find a positive relation, while Haider *et al.*, 2019 find evidence supporting a negative relationship). The *Age* coefficient is positive and significant only when using the *EI* measure in the Fama–MacBeth model, providing limited evidence that mature firms may be less energy efficient than younger firms, perhaps because mature firms are less innovative or more entrenched in current practices. Yet, the *Age* coefficient is essentially zero in all models, so it is economically insignificant.

4.2.2 Supplemental analyses. It is possible that there are group-specific unobservable attributes that could impact firms' energy intensities. Since these are not controlled for in our main analysis, we introduce indicator variables for each business group in our sample to the main regression model. The results (untabulated) demonstrate that the *Low-Stake-Firm* indicator remains positive and significant, after including group indicator variables, as well as year and industry fixed effects. Since the results are robust, we are reassured that our conclusion is not driven by some omitted group-specific unobservable variable.

Our analysis classified companies as low- or high-stake firms based on each firm's average promoter ownership relative to the median (54%) of all firms' average promoter ownerships across the sample period. Hence, there is a chance that a firm classified as a low-stake firm may actually have greater promoter ownership relative to the other firms within its particular business group and vice-versa. To investigate this possibility, we use the data available in the Prowess database to calculate the median ownership of each business group and then used that group median to classify companies into a new variable of interest, *Low-Stake-Group_Median*, which equals one for firms with promoter ownership less than the business group's median promoter ownership and zero otherwise [22]. The results of the regression analysis are presented in Table 7. The coefficient of *Low-Stake-Group_Median* is positive and significant in both the pooled OLS regression (column 1: $\beta = 0.004$, $p < 0.01$) and Fama–MacBeth model (column 2: $\beta = 0.004$, $p < 0.05$). When using the *IAEI* as the dependent variable (in columns 3 and 4), the *Low-Stake-Group_Median* coefficient is again positive and significant in the both the OLS model ($\beta = 0.004$, $p < 0.10$) and the Fama–

Table 7. Impact of promoter shareholdings on the EI of group firms, using business group median promoter ownership to classify firms

Variables (predicted sign)	*EI* (*energy intensity*) Pooled OLS 1	Fama–MacBeth 2	*IAEI* (*industry adjusted energy intensity*) Pooled OLS 3	Fama–MacBeth 4
Low-Stake-Group_Median (+)	0.004*** (2.645)	0.004** (2.679)	0.004* (1.939)	0.004*** (3.972)
Size (−)	−0.005*** (−7.490)	−0.002** (−2.843)	−0.004*** (−6.091)	−0.004*** (−13.371)
Tangibility (+)	0.040*** (5.633)	0.137*** (38.539)	0.042*** (7.995)	0.043*** (11.802)
ROA (−)	−0.107*** (−7.343)	−0.129*** (−11.486)	−0.117*** (−7.705)	−0.118*** (−16.119)
Leverage (+/−)	0.003 (0.509)	0.013** (3.069)	−0.001 (−0.143)	−0.001 (−0.283)
R&D_Ratio (−)	−0.016 (−0.410)	−0.281*** (−8.961)	0.025 (0.705)	0.029 (1.384)
FTI (−)	0.003 (0.951)	−0.003 (−0.942)	−0.007** (−2.428)	−0.008** (−2.755)
MB (+)	0.000 (0.205)	−0.001 (−1.148)	0.001 (1.155)	0.001 (1.798)
Age (+−/−)	0.000 (0.736)	0.000*** (5.347)	−0.000 (−0.280)	−0.000 (−0.228)
Constant	0.411*** (8.534)	0.030*** (6.491)	0.041*** (5.815)	0.039*** (12.791)
Observations	4,967a	4,967	4,967	4,967
R-squared	0.502	0.160	0.062	0.068
Industry FE	Yes	No	No	No
Year FE	Yes	No	Yes	No

Notes: Two dependent variables are used in Table 7: *EI*, which is the cost of fuel, power and water per rupee of sales revenue, and *IAEI* (calculated as the difference between the *EI* of the firm and the average *EI* for the corresponding industry in a given year). The independent variable of interest is *Low-Stake-Group_Median*, which is an indicator variable that equals one if the group-affiliated firm has promoter ownership less than its affiliated business group's median promoter ownership and zero otherwise. All other independent variables are defined in Table 1. ***, ** and * indicate significance at 1, 5 and 10% levels, respectively. [a] Observations that lacked all the data necessary for the model were excluded from the regression, resulting in a sample size of 4,967

MacBeth model ($\beta = 0.004$, $p < 0.01$). These results are consistent with our prior analyses, reinforcing our conclusion that low-stake firms are more energy intensive.

Finally, we predict that tunnelling between high- and low-stake group firms has negative corporate governance implications. To check whether other governance characteristics could be influencing the relationship between promoter ownership and EI beyond the effects already captured by our *Low-Stake-Firm*, we add two governance-related variables to the regression models as additional controls: *Board_Ind.* (the proportion of independent directors on the board) and *Board_Size* (the total number of directors on the board). Results are reported in Table 8. When using *EI* as the dependent variable (see columns 1 and 2), the *Low-Stake-Firm* coefficient is positive and significant in both the OLS model ($\beta = 0.010$, $p < 0.01$) and Fama–MacBeth model ($\beta = 0.009$, $p < 0.01$). Similarly, when using *IAEI* as the dependent variable (in columns 3 and 4), the *Low-Stake-Firm* coefficient is again positive and significant in the both the OLS model ($\beta = 0.010$, $p < 0.01$) and the Fama–MacBeth model ($\beta = 0.009$, $p < 0.01$). These results demonstrate that the greater EI of low-stake firms continues to hold, providing additional support for our hypothesis. Of the two new governance-related controls, *Board_Ind.* and *Board_Size* are significant in the Fama–MacBeth regression of *EI* (column 2), and *Board_Size* is also weakly significant in the Fama–MacBeth regression of *IAEI* (column 4), implying that there may at times be a significant difference in EI due to the influence of a larger or more independent board. In another robustness analysis, the asset growth ratio (calculated as each firm's current year total assets less prior year total assets, divided by prior year total assets) is added to the model. Untabulated results indicate that *Low-Stake-Firm* coefficient remains consistently positive and significant in all of the models after controlling for the effect of the asset growth rate (which is insignificant across all of the models in the untabulated analysis).

5. Conclusion

This study is the first to examine the impact of group ownership structure – and its associated governance implications – on firms' energy efficiency. Motivated by the agency costs arising from conflicts of interests between promoters and noncontrolling shareholders, we examine the association between EI and business group affiliation among Indian firms. We hypothesize that group-affiliated Indian firms face governance challenges arising from "institutional agency problems" (Bao and Lewellyn, 2017) – such as profit tunneling – that can result in poorer monitoring, higher costs of capital and, consequently, underinvestment in energy-efficient projects. We expect this underinvestment to be most pronounced among group-affiliated firms in which the controlling promoter has a low ownership stake [23]. Consistent with our predictions, empirical results demonstrate that among the group-affiliated firms, companies in which the controlling promoter owns a lower stake are more energy-intensive compared to high-stake group-affiliated firms [24]. This result holds across a majority of the industries included in the sample (72 out of 87 industries) and is robust to the inclusion of variables capturing other corporate governance characteristics (i.e. after controlling for board size and board independence) as well as the inclusion of firms' asset growth rates.

One important caveat is the possibility of an alternative explanation for the results: if promoters prefer more energy-efficient firms, then the business group might acquire a higher stake in companies that are less energy intensive, and firms wishing to attract greater promoter investment could invest more in energy-saving projects. Unfortunately, data constraints prevent us from testing this alternative explanation. However, this concern is mitigated by the fact that many business groups in India are family-founded and were established well before our study's period, making it less likely that promoters' investment

Table 8. Impact of promoter shareholdings on the EI of group firms, controlling for board-related corporate governance characteristics

Variables (predicted sign)	*EI* (*energy intensity*) Pooled OLS 1	Fama–MacBeth 2	*IAEI* (*industry adjusted energy intensity*) Pooled OLS 3	Fama–MacBeth 4
Low-Stake-Firm (+)	0.010*** (5.275)	0.009*** (4.904)	0.010*** (5.251)	0.009*** (8.952)
Size (−)	−0.006*** (−7.435)	−0.002** (−3.518)	−0.006*** (−7.438)	−0.004*** (−10.528)
Tangibility (+)	0.032*** (4.261)	0.134*** (42.028)	0.030*** (4.114)	0.037*** (11.744)
ROA (−)	−0.100*** (−6.520)	−0.136*** (−11.966)	−0.094*** (−6.178)	−0.118*** (−13.821)
Leverage (+/−)	0.004 (0.670)	0.014** (2.743)	0.003 (0.523)	0.001 (0.376)
R&D_Ratio (−)	0.020 (0.510)	−0.309*** (−8.803)	0.011 (0.285)	0.050* (2.140)
FTI (−)	0.001 (0.322)	−0.005 (−1.342)	0.001 (0.367)	−0.010** (−3.139)
MB (+)	0.000 (0.004)	−0.000 (−0.681)	−0.000 (−0.001)	0.001 (1.458)
Age (+/−)	0.000 (0.919)	0.000*** (4.843)	0.000 (0.829)	−0.000 (−0.387)
Board_Ind.	0.009 (0.497)	0.053*** (4.741)	0.007 (0.391)	−0.001 (−0.126)
Board_Size	0.000 (0.709)	0.000*** (5.745)	0.000 (0.465)	0.000* (2.183)
Constant	0.415*** (8.506)	0.017* (3.466)	0.055* (1.707)	0.038*** (14.159)
Observations	4,722a	4,722	4,722	4,722
R-squared	0.513	0.163	0.179	0.074
Industry FE	Yes	No	No	No
Year FE	Yes	No	Yes	No

Notes: Two dependent variables are used in Table 8: *EI*, which is the cost of fuel, power and water per rupee of sales revenue, and *IAEI* (calculated as the difference between the *EI* of the firm and the average *EI* for the corresponding industry in a given year). The independent variable of interest is *Low-Stake-Firm*, which is an indicator variable that equals one if the group-affiliated firm has below-the-median promoter shareholding and zero otherwise. All other independent variables are defined in Table 1, except for *Board_Ind.* and *Board_Size*, which are defined as follows: *Board_Ind.* is the proportion of independent directors on the board, and *Board_Size* is the total number of directors on the board. ***, ** and * indicate significance at 1, 5 and 10% levels, respectively. [a] Observations that lacked all the data necessary for the model were excluded from the regression, resulting in a sample size of 4,722 preferences led to high-stake firms being less energy intensive. Still, this is a limitation of our study, and we hope that future research will address this issue when new data become available or a natural experiment arises.

While prior studies examining energy policy often treat corporate governance among sample firms as a constant factor, our study reveals that variation in ownership structure and related governance issues has a significant impact on firms' energy intensities and should be considered in future research. Our results also extend the documented influence of corporate governance from mostly financial and strategic policy-related effects to its role in the energy policies of firms. By examining our hypothesis in the Indian context and by specifically investigating group-affiliated firms, this study also contributes to the emerging markets–related literature and literature regarding the effects of various ownership structures.

These results are timely given the challenge of promoting global sustainability, particularly since India is the world's third leading source of carbon emissions (World Economic Forum, 2019) and energy efficiency will be key in addressing climate change (IEA, 2019). Our findings may help explain the apparent lack of initiative among some firms to invest in energy-saving projects: it is possible that governance problems related to the firms' ownership structures are contributing to their underinvestment. Thus, our study has significant implications for policymakers: any directive or program intended to manage energy-related issues through technological improvements or other corporate initiatives should consider firms' ownership structures and the corresponding governance issues. Additional research is needed to further examine the impact of specific corporate governance characteristics and mechanisms on the energy policies of firms, in both emerging and developed markets. For instance, since there is likely an association between the automation of operations, investment in energy-efficient equipment or technologies and energy efficacy, future studies could examine whether investment in high-tech machines acts as an alternative, more-specific dependent measure capturing the relationship between promoter ownership and EI documented in this study. Another avenue for future research would be to investigate whether the relationship between ownership structure and energy efficiency is similar across different geographic locations in India, as well as in other countries. Such research is only possible if firms disclose information related to their environmental impacts, like energy spending, which may motivate standard setters to further consider the value of such disclosures, particularly as accountants continue to contribute to corporate social responsibility related reporting and assurance (KPMG, 2017).

Notes

1. According to the Prowess database, the Securities and Exchange Board of India defines "promoter" as "the person or persons who are in control of the company, directly or indirectly, whether as shareholder, director or otherwise." In other words, the promoter is the person or entity in de-facto control of a business group, even if the ownership stake in some of the affiliated firms is low. Please refer to Section 2 for a discussion of the pyramidal ownership structure that commonly characterizes business groups in India.

2. Ownership rights depend on the percentage of shareholding in a given firm.

3. There is also a possibility that promoters prefer more energy-efficient firms. In this case, the business group might purposefully acquire a higher stake in firms that are less energy intensive, and firms wishing to attract greater promoter investment could invest more in energy-saving projects. We recognize that this is an alternative explanation for our predicted results; regrettably, data limitations prevent us from testing it. However, this concern is mitigated by the

fact that many business groups in India are family-founded and were established well before our study's period, making it less likely that promoters' investment preferences led to high-stake firms being less energy intensive. Still, we recognize the inability to test this alternative explanation that the results could be a consequence of an endogeneity effect (Cho, 1998) is an empirical limitation of our study. We also mention this as a limitation and area for future research in the Conclusion section.

4. For additional information regarding the institutional differences between India – which constitutes a large emerging market – and the developed world, readers may refer to Allen *et al.* (2012), Narayanaswamy *et al.* (2012) and Jadiyappa *et al.* (2016).
5. Yang and Li (2017); Moon and Min (2017); Haider and Mishra (2021); and others.
6. Bertrand *et al.* (2002) provide an excellent example of the pyramid structure and of tunneling for interested readers.
7. The average growth rate of low-stake firms is significantly less than that of high-stake firms ($p <$ 0.01).
8. The average R&D expenditure of low-stake firms is also significantly less than that of high-stake firms ($p < 0.01$). Missing R&D ratios have been replaced by zeros throughout all subsequent analyses; however, for this statistic, only positive R&D ratios are included in its computation.
9. Data on energy-specific investments are not available in the Prowess database.
10. Our prediction that low-stake firms will underinvest may at first appear to contrast with the theoretical model presented by Zhang (1998), who posits that firms with highly concentrated ownership will tend to be risk-averse and, therefore, tend to under-invest in risky projects. In Zhang's model, the use of debt can mitigate this problem. Our setting differs in that the pyramidal ownership structure of business groups in India permits the tunneling of profits to the high-stake firms, which leads to under-investment in energy-saving projects by low-stake firms and enables greater investment by high-stake firms.
11. If the cost per kilowatt of power purchased varied among companies, then the *EI* measure might not be perfectly inversely related to energy efficiency. For instance, if a firm was purchasing its power from more sustainable energy sources that may be more expensive and more efficient, this would increase the firm's *EI*, but the firm may actually be less energy-intense. This concern is mitigated in large part by the fact that in India all solar and wind power firms must sell their power to state electricity boards, which, in turn, supply power to firms at a fixed rate. Thus, firms do not pay a premium for more sustainable energy purchased in India. Further, in our sample, about 98.7% of firms purchase electricity from the grid, and only 6.8% have solar or wind energy that they produce themselves. Therefore, there is considerable institutional and statistical support for the assumption that *EI* is inversely related to energy efficiency in the Indian setting of our study.
12. We use the industrial classification system of the Prowess database which follows the National Industrial Classification (NIC) system of the Government of India. This system is very similar to the SIC classification system followed in the USA. For better accuracy on the reference point for calculation of relative energy intensity, we use a four-digit classification. We retain only those industries which have at least five firms in a given year. In total, our sample consists of firms belonging to 87 different industries.
13. The rationale for this classification is that promoter ownership is quite stable over time. In an untabulated analysis regressing promoter ownership against a time trend (considering only those firms that have observations for all the years in the study period), the time trend coefficient is insignificant ($p = 0.454$), demonstrating that promoter ownership is fairly stable over the study period. Further, as an untabulated robustness test, we use promoter ownership as a continuous variable (rather than using the *Low-Stake-Firm* indicator variable) and find consistent results: promoter ownership is significantly and negatively related to *EI*, meaning our conclusions would

not change if a continuous measure of promoter ownership were used instead. Finally, we also classify firms relative to their business group's median ownership, and the results remain robust (please see the Supplemental Analysis Section).

14. For low-stake firms, the average promoter ownership across our sample period is 38.73% (median = 42.59%), while for high-stake firms, the average promoter ownership is 66.02% (median = 65.67%).
15. These 798 group firms represent about 53% of the total number (1,495) of nonfinancial, BSE-listed group firms.
16. A supplemental table presenting industry-related summary statistics for our sample is available upon request.
17. As described in footnote 13, in an untabulated analysis regressing promoter ownership against a time trend, the time trend coefficient is insignificant (p = 0.454), demonstrating that promoter ownership is fairly stable over the study period. Hence, we use a firm's average promoter ownership and the entire sample period's median promoter ownership value to classify firms as high or low stake firms, making this variable time-invariant.
18. When each of the columns reporting mean *EI* from Table 5 (i.e., columns 2, 4 and 6) is regressed against a time trend, the time trend coefficient is insignificant, implying that there is not much variation in the dependent measure (*EI*) across the study period.
19. The results are qualitatively and quantitatively similar, and the conclusions drawn are not changed when using two or three lags.
20. We also observe from Table 5 that the average energy intensity of low- and high-stake group-affiliated firms is fairly stable across time. As mentioned in the Estimation Section, stability in the *EI* values contributed to the choice of the Fama–MacBeth methodology for our regression analyses.
21. Although the present study focuses on the influence of promoter ownership on the energy intensity of group-affiliated firms, it is natural to ask whether the energy intensity of group firms overall differs from that of standalone firms. To explore this question, we create a new indicator variable, which equals one if the firm is affiliated with a business group, and zero for all standalone firm observations. Regression results (untabulated) reveal that group-affiliated firms are more energy intensive than standalone firms. This finding is consistent with the logic underlying our main hypothesis – namely, that group firms suffer from unique agency issues that arise from their pyramidal promoter ownership structure, such as profit tunneling.
22. We recognize that not all group firms are included in the Prowess database, so the calculated group median ownership may be distorted as a result.
23. Since the Prowess database only captures data for a limited number of group-affiliated unlisted firms, we have only included listed group companies in our sample; this is one limitation of our study.
24. We considered examining the annual reports of our sample firms to see if we could gather more direct evidence of variation in firms' energy policies. However, we were concerned that annual reports may not divulge such information in a consistent or reliable manner. Some firms may report a focus on energy efficiency or specify that new investments are energy-saving projects, while other firms may not report whether the investments are more energy efficient than alternative projects. Interpreting such voluntary disclosures could lead to misguided conclusions because the decision to make a *voluntary, detailed disclosure* differs from the decision to invest in the firm's energy efficiency; hence, a lack of disclosure does not necessarily mean a lack of energy-efficient initiatives/investments within a given firm. Thus, our concern that analyzing voluntary disclosures in annual reports could lead to misleading conclusions about energy policies deterred us from conducting such an examination.

References

Allen, F., Chakrabarti, R., De, S. and Qian, J. (2012), "Financing firms in India", *Journal of Financial Intermediation*, Vol. 21 No. 3, pp. 409-445, doi: 10.1016/j.jfi.2012.01.003.

Ang, J.S., Cole, R.A. and Lin, J.W. (2000), "Agency costs and ownership structure", *The Journal of Finance*, Vol. 55 No. 1, pp. 81-106, doi: 10.1111/0022-1082.00201.

Bala Subrahmanya, M.H. and Kumar, R.S. (2011), "Technological innovations and energy intensity of machine tool SMEs in Bangalore: do process innovations contribute to energy efficiency?", *International Journal of Energy Technology and Policy*, Vol. 7 Nos 5/6, pp. 519-536.

Bao, S.R. and Lewellyn, K.B. (2017), "Ownership structure and earnings management in emerging markets – an institutionalized agency perspective", *International Business Review*, Vol. 26 No. 5, pp. 828-838.

Basu, D. and Sen, K. (2015), "Financial decisions by business groups in India: is it 'fair and square?'", *Journal of Contemporary Accounting and Economics*, Vol. 11 No. 2, pp. 121-137.

Bertrand, M., Mehta, P. and Mullainathan, S. (2002), "Ferreting out tunneling: an application to Indian business groups", *The Quarterly Journal of Economics*, Vol. 117 No. 1, pp. 121-148.

Cagno, E. and Trianni, A. (2013), "Exploring drivers for energy efficiency within small- and medium-sized enterprises: first evidences from Italian manufacturing enterprises", *Applied Energy*, Vol. 104, pp. 276-285, doi: 10.1016/j.apenergy.2012.10.053.

Cho, M.H. (1998), "Ownership structure, investment, and the corporate value: an empirical analysis", *Journal of Financial Economics*, Vol. 47 No. 1, pp. 103-121.

Costa-Campi, M.T., García-Quevedo, J. and Segarra, A. (2015), "Energy efficiency determinants: an empirical analysis of Spanish innovative firms", *Energy Policy*, Vol. 83, pp. 229-239.

Dasgupta, S. and Roy, J. (2017), "Analysing energy intensity trends and decoupling of growth from energy use in Indian manufacturing industries during 1973–1974 to 2011–2012", *Energy Efficiency*, Vol. 10 No. 4, pp. 925-943.

De Groot, H.L., Verhoef, E.T. and Nijkamp, P. (2001), "Energy saving by firms: decision-making, barriers and policies", *Energy Economics*, Vol. 23 No. 6, pp. 717-740.

DeCanio, S.J. (1993), "Barriers within firms to energy-efficient investments", *Energy Policy*, Vol. 21 No. 9, pp. 906-914.

DeCanio, S.J. (1998), "The efficiency paradox: bureaucratic and organizational barriers to profitable energy-saving investments", *Energy Policy*, Vol. 26 No. 5, pp. 441-454.

Dhanora, M., Sharma, R. and Khachoo, Q. (2018), "Non-linear impact of product and process innovations on market power: a theoretical and empirical investigation", *Economic Modelling*, Vol. 70, pp. 67-77, doi: 10.1016/j.econmod.2017.10.010.

Elliott, R.J., Sun, P. and Chen, S. (2013), "Energy intensity and foreign direct investment: a Chinese city-level study", *Energy Economics*, Vol. 40, pp. 484-494.

Fama, E.F. and MacBeth, J.D. (1973), "Risk, return, and equilibrium: empirical tests", *Journal of Political Economy*, Vol. 81 No. 3, pp. 607-636.

Gedajlovic, E., Yoshikawa, T. and Hashimoto, M. (2005), "Ownership structure, investment behaviour and firm performance in Japanese manufacturing industries", *Organization Studies*, Vol. 26 No. 1, pp. 7-35.

Global Carbon Project. (2020), "Carbon dioxide emissions in 2009 and 2019, by select country* (in million metric tons)", Available via Statista Inc, available at: www.statista.com/statistics/270499/co2-emissions-in-selected-countries/ (accessed 6 August 2021).

Goldar, B. (2011), "Energy intensity of Indian manufacturing firms: effect of energy prices, technology and firm characteristics", *Science, Technology and Society*, Vol. 16 No. 3, pp. 351-372.

Gopalan, R., Nanda, V. and Seru, A. (2007), "Affiliated firms and financial support: evidence from Indian business groups", *Journal of Financial Economics*, Vol. 86 No. 3, pp. 759-795.

Gopalan, R., Nanda, V. and Seru, A. (2014), "Internal capital market and dividend policies: evidence from business groups", *The Review of Financial Studies*, Vol. 27 No. 4, pp. 1102-1142.

Haider, S. and Mishra, P.P. (2021), "Does innovative capability enhance the energy efficiency of Indian iron and steel firms? A Bayesian stochastic frontier analysis", *Energy Economics*, Vol. 95, pp. 105-128.

Haider, S., Danish, M.S. and Sharma, R. (2019), "Assessing energy efficiency of Indian paper industry and influencing factors: a slack-based firm-level analysis", *Energy Economics*, Vol. 81, pp. 454-464.

Hassett, K.A. and Metcalf, G.E. (1993), "Energy conservation investment: do consumers discount the future correctly?", *Energy Policy*, Vol. 21 No. 6, pp. 710-716.

Hochman, G. and Timilsina, G.R. (2017), "Energy efficiency barriers in commercial and industrial firms in Ukraine: an empirical analysis", *Energy Economics*, Vol. 63, pp. 22-30.

Hoskisson, R.E., Hitt, M.A., Johnson, R.A. and Grossman, W. (2002), "Conflicting voices: the effects of institutional ownership heterogeneity and internal governance on corporate innovation strategies", *Academy of Management Journal*, Vol. 45 No. 4, pp. 697-716.

Intergovernmental Panel on Climate Change (IPCC). (2021), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, in Masson-Delmotte, V., Piranid, P., Connors, S.L. *et al.* (Eds), Cambridge University Press, Cambridge.

International Energy Agency (IEA). (2019), "Multiple benefits of energy efficiency, IEA, Paris", available at: www.iea.org/reports/multiple-benefits-of-energy-efficiency (accessed 29 May 2021).

International Energy Agency (IEA). (2021), "Global energy review 2021, IEA, Paris", available at: www.iea.org/reports/global-energy-review-2021 (accessed 10 September 2021).

International Monetary Fund (IMF). (2018), "World economic outlook, October 2018: challenges to steady growth", available at: www.imf.org/en/Publications/WEO/Issues/2018/09/24/world-economic-outlook-october-2018 (accessed 29 May 2021).

Jadiyappa, N., Vanga, N.R. and Krishnankutty, R. (2016), "Financial liberalisation and capital structuring decisions of corporate firms: evidence from India", *Economics Letters*, Vol. 149, pp. 33-37.

Jamasb, T. and Pollitt, M.G. (2015), "Why and how to subsidise energy R+D: lessons from the collapse and recovery of electricity innovation in the UK", *Energy Policy*, Vol. 83, pp. 197-205.

Jensen, M.C. and Meckling, W.H. (1976), "Theory of the firm: managerial behavior, agency costs and ownership structure", *Journal of Financial Economics*, Vol. 3 No. 4, pp. 305-360.

Kali, R. and Sarkar, J. (2011), "Diversification and tunneling: evidence from Indian business groups", *Journal of Comparative Economics*, Vol. 39 No. 3, pp. 349-367.

Khanna, T. and Palepu, K. (2000), "Is group affiliation profitable in emerging markets? An analysis of diversified Indian business groups", *The Journal of Finance*, Vol. 55 No. 2, pp. 867-891.

KPMG. (2017), "The road ahead – the KPMG survey of corporate responsibility reporting 2017", KPMG International Global Sustainability Services, available at: https://home.kpmg.com/content/dam/kpmg/campaigns/csr/pdf/CSR_Reporting_2017.pdf (accessed 29 May 2021).

Kumar, A. (2003), "Energy intensity: a quantitative exploration for Indian manufacturing", working paper, Indira Gandhi Institute of Development Research, Mumbai.

Lee, P.M. and O'Neill, H.M. (2003), "Ownership structures and R&D investments of U.S. and Japanese firms: agency and stewardship perspectives", *Academy of Management Journal*, Vol. 46 No. 2, pp. 212-225.

Mandal, S.K. and Madheswaran, S. (2010), "Environmental efficiency of the Indian cement industry: an interstate analysis", *Energy Policy*, Vol. 38 No. 2, pp. 1108-1118.

Margolis, R.M. and Kammen, D.M. (1999), "Underinvestment: the energy technology and R&D policy challenge", *Science*, Vol. 285 No. 5428, pp. 690-692.

Masulis, R.W., Pham, P.K. and Zein, J. (2011), "Family business groups around the world: financing advantages, control motivations, and organizational choices", *Review of Financial Studies*, Vol. 24 No. 11, pp. 3556-3600.

Moon, H. and Min, D. (2017), "Assessing energy efficiency and the related policy implications for energy-intensive firms in Korea: DEA approach", *Energy*, Vol. 133, pp. 23-34.

Mukherjee, K. (2010), "Measuring energy efficiency in the context of an emerging economy: the case of Indian manufacturing", *European Journal of Operational Research*, Vol. 201 No. 3, pp. 933-941.

Nagesha, N. and Balachandra, P. (2006), "Barriers to energy efficiency in small industry clusters: multi-criteria-based prioritization using the analytic hierarchy process", *Energy*, Vol. 31 No. 12, pp. 1969-1983, doi: 10.1016/j.energy.2005.07.002.

Narayanaswamy, R., Raghunandan, K. and Rama, D.V. (2012), "Corporate governance in the Indian context", *Accounting Horizons*, Vol. 26 No. 3, pp. 583-599.

Newey, W.K. and West, K.D. (1986), "A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix", available at: www.nber.org/papers/t0055.pdf (accessed 29 May 2021).

Oak, H. (2017), "Factors influencing energy intensity of Indian cement industry", *International Journal of Environmental Science and Development*, Vol. 8 No. 5, pp. 331-336.

Reddy, B.S. and Kumar Ray, B. (2011), "Understanding industrial energy use: physical energy intensity changes in Indian manufacturing sector", *Energy Policy*, Vol. 39 No. 11, pp. 7234-7243.

Rexhäuser, S. and Löschel, A. (2015), "Invention in energy technologies: comparing energy efficiency and renewable energy inventions at the firm level", *Energy Policy*, Vol. 83, pp. 206-217.

Sahoo, S.K., Varma, P., Lall, K.P. and Talwar, C.K. (2016), "Energy efficiency in India: achievements, challenges and legality", *Energy Policy*, Vol. 88, pp. 495-503.

Sahu, S. and Narayanan, K. (2009), "Determinants of energy intensity: a preliminary investigation of Indian manufacturing", Munich Personal RePEc Archive (MPRA) Paper No. 16606, available at: http://mpra.ub.uni-muenchen.de/16606/ (accessed 29 May 2021).

Sahu, S. and Sharma, H. (2016), "Productivity, energy intensity and output: a unit level analysis of the Indian manufacturing sector", *Journal of Quantitative Economics*, Vol. 14 No. 2, pp. 283-300.

Sapra, H., Subramanian, A. and Subramanian, K.V. (2014), "Corporate governance and innovation: theory and evidence", *Journal of Financial and Quantitative Analysis*, Vol. 49 No. 4, pp. 957-1003.

Singh, M. and Davidson, W.N. III. (2003), "Agency costs, ownership structure and corporate governance mechanisms", *Journal of Banking and Finance*, Vol. 27 No. 5, pp. 793-816.

Singla, C., Veliyath, R. and George, R. (2014), "Family firms and internationalization-governance relationships: evidence of secondary agency issues", *Strategic Management Journal*, Vol. 35 No. 4, pp. 606-616.

Song, C. and Oh, W. (2015), "Determinants of innovation in energy intensive industry and implications for energy policy", *Energy Policy*, Vol. 81, pp. 122-130.

World Economic Forum. (2019), "Chart of the day: these countries create most of the world's CO_2 emissions", Written by Sean Fleming, Senior Writer, available at: www.weforum.org/agenda/2019/06/chart-of-the-day-these-countries-create-most-of-the-world-s-co2-emissions/ (accessed 29 May 2021).

Yang, W. and Li, L. (2017), "Energy efficiency, ownership structure, and sustainable development: evidence from China", *Sustainability*, Vol. 9 No. 6, pp. 912-938, doi: 10.3390/su9060912.

Zhang, G. (1998), "Ownership concentration, risk aversion and the effect of financial structure on investment decisions", *European Economic Review*, Vol. 42 No. 9, pp. 1751-1778.

Further reading

Fisher-Vanden, K., Jefferson, G.H., Liu, H. and Tao, Q. (2004), "What is driving China's decline in energy intensity?", *Resource and Energy Economics*, Vol. 26 No. 1, pp. 77-97.

Herrerias, M.J., Cuadros, A. and Orts, V. (2013), "Energy intensity and investment ownership across Chinese provinces", *Energy Economics*, Vol. 36, pp. 286-298.

Manikutty, S. (2000), "Family business groups in India: a resource-based view of the emerging trends", *Family Business Review*, Vol. 13 No. 4, pp. 279-292.

Pattnaik, C., Chang, J.J. and Shin, H.H. (2013), "Business groups and corporate transparency in emerging markets: empirical evidence from India", *Asia Pacific Journal of Management*, Vol. 30 No. 4, pp. 987-1004.

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