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Integrity of financial information and firms' access to energy in developing countries

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ABSTRACT

There are strong international pressures on developing countries to achieve the universal energy access 2030 goal and to establish stricter monitoring mechanisms of firms' financial information to attract energy investment. We argue that energy access is both a technical and an economic issue, and hence the integrity of firms' financial information is a key monitoring mechanism. We analyze the impact of financial information integrity on firms' access to energy in 138 developing countries. Our results show that the integrity of financial information is a robust predictor of firm's access to energy. The decision of a firm to have its financial accounts externally audited is associated with a higher probability of better access to energy. The effect depends on country size, but not country development. Other important aspects of business operation, such as financing and corruption, also affect energy access. The financial information integrity effect on energy access depends on the firm's size, industry and geographical location. Country-level macroeconomic, auditing and energy infrastructure conditions play a role too. Economic and financial development, economic openness, the accounting and auditing environment and the technical conditions of energy generation in a country are important controlling factors of the financial information integrity effect. Policy considerations in the developing world aiming at improving firms' access to energy must pay attention to the role of external monitoring mechanisms and the conditions that induce firms to embrace higher level and quality of external auditing.

1. Introduction

The United Nation (UN) has been actively promoting the energy sustainability agenda by launching the UN-Energy initiative in 2004 (UNEnergy 2010). This initiative was further supported by the announcement of 2012 as the Year of Sustainable Energy for All (SEforALL) and of the Rio + 20 Summit with the objective of achieving universal access to sustainable and efficient energy by 2030 (Gualberti et al., 2014). The SEforALL plan is largely endorsed by developing countries, which accordingly strive for large scale energy investments in the expansion of energy generation capacity, the transmission/distribution infrastructure and the refurbishment of obsolete facilities (International Energy Agency (IEA), 2012; UN AGECC, 2010).

A key concern of these policy initiatives is the inadequacy of energy access by firms and households. Energy access worldwide has improved, but not as much as needed to keep countries along the sustainability path. For example, Castellano et al. (2015) show that in Africa it took 25 years on average to increase the electrification rate from 20 to 80%; Brazil took 40 years; whilst Vietnam took only 9 years. They argue that, at this rate, many countries will not be able to achieve the Sustainable Development Goal target by 2030. Both demand and supply factors affect the pace of energy access. For example, Blimpo et al. (2018) analyze 31 African countries and find that demand factors account for about 40% of the energy access gap, lower middle-income countries experience a 56% gap and low-income countries experience a 30% gap.

The 2012 UN Rio + 20 Summit has been criticized for not developing monitoring mechanisms of energy efficiency and access (Bazilian et al., 2012; Halle, 2014; United Nations Development Programme (UNDP), 2012). Monitoring mechanisms and governance considerations play an important role in determining firms' access to energy (Mertzanis, 2018). Recent literature stresses the efficiency requirement to monitor firms' information, in particular with respect to measurement of energy cost (e.g. carbon levies, CO_2 emissions and taxes) and infrastructure consumption (e.g. energy distribution networks, etc.) (Bierer and Götze, 2012). Monitoring mechanisms are also important for tracking energy sustainability. Given the large investments needed in the energy sector to achieve the universal energy access 2030 goal, international pressures on developing countries to pursue this goal successfully

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have intensified. The Regulatory Indicators for Sustainable Energy presented in the 2017 Global Tracking Framework (GTF)[1] report aim at providing policy makers with progress updates on the achievement of the universal energy access 2030 objective. The report indicates a rather poor development with only fractions of the requirements being achieved (SE4ALL (Sustainable Energy for All), 2017). Interestingly, the GTF report indicates that developing countries with robust monitoring mechanisms are marked as leaders in sustainable energy. On the contrary, countries with weak monitoring mechanisms experience larger energy access gaps. Effective monitoring considerations also underlie the recent initiative by the World Energy Council to create an index that aligns with UN Sustainable Development Goal 7 (SDG7) and measures energy equity (accessibility and affordability) in all countries. The Council concluded that developing countries have improved energy access from relatively low baselines (World Energy Council (WEC), 2019). Nevertheless, the UN SDG7 reports that 800 million people still remain without adequate electricity (United Nations Economic and Social Council, 2019).

While emphasizing the need for effective monitoring, none of the previous reports stress specifically the integrity of financial information as an effective monitoring mechanism. Little empirical evidence is available on the relation between financial information quality and energy access. This is especially important since energy access depends both on technical and economic factors. Indeed, the capacity and quality of the energy generation system affects the supply of energy to user firms. Nevertheless, economic considerations associated with competition and market reforms in the energy market and the financing and corruption conditions experienced by individual firms play an important role in energy provision (Bazilian et al., 2011; Bird et al., 2011; Rimšaitė, 2019). Moreover, while technical and weather conditions affect their energy demand, the firms' energy needs are also affected by their chosen scale and composition of output in response to swings in market demand as well as their energy efficiency strategy (Schleich, 2004). All these non-technical supply and demand factors stress the role of information quality in energy-related economic decisions of firms.

Our study contributes to filling this gap in the literature regarding the efficacy of monitoring and the role of economic factors in energy access by exploring the impact of firms' integrity of financial information on their access to energy in developing countries. We focus on the economic and not on the technical determinants of firms' energy access. We respond to recent calls for new data, which incorporate both demand- and supply-side indicators when it comes to monitoring energy access (Pachauri and Spreng, 2011; Nussbaumer et al., 2011; Rehman et al., 2017). We analyze data drawn from the World Bank's Enterprise Surveys. Our data contain 132,903 non-financial firms from 138 developing countries, during 2006–2016. A key strength of the data is its focus on small and medium firms and on privately-held firms. The former are the bloodline of economic activity in developing countries. The latter make decisions driven less by market pressures and more by internal considerations and institutional influences. Further, the large size of the data allows us to study in detail the role of firm size, sector of activity and location. Given the scarcity of previous relevant studies and the difficulty in assessing financial information quality in developing countries, we measure the integrity of financial information by the extent to which firms' financial accounts were checked and certified by external auditors.

Our study contributes to the literature in several ways: first, it adds to the analysis of the microeconomic determinants of energy access of firms in the developing countries. The specific characteristics of firms and the sectoral classification of firms are important predictors of energy access (Mertzanis, 2018). These characteristics affect the firms' demand for and cost of energy depending on the technology used (Lee et al., 2017). They also affect the investment choice of energy-using assets in different sectors of activity in accordance with the firms' needs (e.g. quantity vs quality considerations) (Gertler et al., 2017). Second, it adds to the literature on the monitoring mechanisms of energy generation and access. Firms with reliable financial information appear to secure better support from both finance and energy providers, which makes them better able to compete in the market for energy, to improve the efficiency of energy use (Plane, 1999) and to enhance their structural transformation (Jamash et al., 2004). The auditing of financial information is a key external monitoring tool that affects energy cost accounting and the availability of external finance for energy investment, thereby directly contributing to the firms' competitive position. Third, it highlights the role of institutions in mitigating the impact of financial information integrity on energy access. For example, Jessoe and Rapson (2014) show that the nature and extent of information sharing among households affects their energy price elasticity of demand. Ito (2014) shows that households do not often respond competitively to marginal and average energy price change depending on local conditions. However, such studies are mostly confined to a single or few countries and rely on data that are hard to find in developing countries. The latter are typically characterized by poor organizational and governance effectiveness. Billed energy consumption amounts may be inaccurate or fabricated; consumers may have limited knowledge about the energy tariff structure; utility staff may demand bribes in exchange for basic services, or collude directly with consumers to facilitate theft; and consumers may have different perceptions about the extent to which energy should be subsidized by the government. By accounting for the impact of information-enhancing institutions, our study sheds some light on their role in the energy market. Fourth, our study focuses on the development of countries as a whole, thereby providing a more robust basis for informing policy reform.

In what follows, Section 2 reviews the related literature; Section 3 describes the data and the empirical methodology used for the analysis; Section 4 explores the predictive power of the external auditing of accounts and other firm-specific characteristics on the extent to which firms experience energy constraints; Section 5 considers the mitigating role of economic and non-economic factors at the country level; and finally Section 6 concludes the paper. The Appendix includes a description of the data and provides the results from implementing an extensive sensitivity and endogeneity analysis.

2. Related literature

2.1. Importance of the integrity of financial information

The key role of financial information is to provide decision makers with an effective tool for making economic decisions (Meigs and Meigs, 1993). A firm's financial accounts are important for monitoring managerial performance and for assisting external stakeholders' oversight of their business relationship with the firm. Specifically, the essential goal of audited financial accounts is to assist management in making decisions (Bushman and Smith, 2001), owners in mitigating agency problems (Watts, 1977) and external stakeholders in enforcing the contracts they have with the firm (Jensen and Meckling, 1976). Even in the absence of market pressure, privately-held firms are induced to have their financial accounts externally audited so as to meet business regulation requirements, limited liability considerations and external financing needs (Allee and Yohn, 2009).

Financial accounts and reports comprise properly standardized and consistent measures of performance, governance, financial structure and flows of the firm (Allee and Yohn, 2009). This information is instrumental in reducing information asymmetries associated with firm risk (Bushman and Smith, 2001). Financial accounts and reports also provide useful information to external stakeholders about the efficiency

[1] The report is produced by data partners, working through the SEforALL knowledge hub. It is co-led by the International Energy Agency and the World Bank Group (SEforAll 2017). The GTF is the first report that prescribes the Regulatory Indicators for Sustainable Energy.

of management thereby improving market knowledge about the firm's eligibility to receive external finance and other services (Blackwell et al., 1998). Firms that choose to have their financial accounts audited provide assurance to current and potential stakeholders about the risk of misstatement of transactions (Watts and Zimmerman, 1986). In response, external auditors use risk-based approaches to assess the effect of risk on material misstatement of transactions and to provide reasonable assurance on their integrity (Knechel, 2007; Nguyen and Le, 2019).

The International Federation of Accountants (IFAC) has established guidelines and standards for the auditing of financial accounts of firms by an external auditor who reviews the financial information and expresses an opinion on whether the financial accounts are prepared in all material respects in accordance with the prescribed standards (International Federation of Accountants (IFAC), 2009). Hence, the choice of having financial accounts externally audited is a case for the integrity of financial information.

Recently, the auditing of financial accounts is linked to sustainability (ESG) considerations. Empirical evidence shows that ESG factors are relevant to firms' economic performance and investment decisions (Orlitzky et al., 2003). They account for cases of corruption and abuse and reflect the economic consequences of various forms of environmental degradation, including the misuse of energy. However, the dubious quality of sustainability reporting has been an important reason for skepticism towards integrating ESG factors into firms' performance presentation and energy investment decisions (Juravle and Lewis, 2008). Recently, however, the quality of firms' sustainability reporting has improved significantly. The improvement is the result of a greater awareness of the importance of ESG considerations, which has led to an increase in relevant disclosures (Kolk, 2008) and the development of mandatory sustainability frameworks around the world (Ioannou and Serafeim, 2011). Nevertheless, the substance and structure of proper sustainability reporting is still an open question (Eccles et al., 2011). Thus, financial information integrity is, in addition, closely linked with ESG disclosures with direct implications for energy use by firms.

2.2. Integrity of financial information and energy access

There is no agreement on the definition of what constitutes “energy access” (Chen et al., 2015). The IEA defines access to energy as follows: “a household having reliable and affordable access to clean cooking facilities, a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average” (Mertzanis, 2018, p. 962). The Global Energy Assessment report divides access to energy into two aspects: the availability of modern energy carriers (i.e. facilities for energy provision from all sources) and the availability of improved end-use facilities at affordable cost (Global Energy Assessment (GEA), 2012). Accordingly, energy access can be meaningfully assessed from the supply side (energy facilities) and the demand side (end-user).

Taking the supply side, the secure and accessible energy provision is crucial for the development and sustainability of modern societies (Asif and Muneer, 2007). Technical factors related to the capacity and quality of the energy generation system affect the availability of energy. Insufficient capacity and investment, low capacity utilization rates or bottlenecks in the supply chain due to the use of different sources of energy, are often the cause of supply shortages in developing countries (Alam, 2014; Allcott et al., 2016). Network fragility can cause energy breakdowns along the transmission, distribution and transformation structures, which can be caused by natural disasters or equipment failure (Anderson and Dalgaard, 2013).

Institutional and structural factors also affect the volume, quality and distribution of energy supplied. Such factors include the influence of politics, legislation and public investment (Correlje and Van der Linde, 2006); the competitive diversification of energy suppliers (Le Coq and Paltseva, 2009); the evolving requirements in the transport, education and health sectors (Schäfer et al., 2011); the risks associated with energy transit and distribution (Blyth and Lefevre, 2004) and the evolution of technology (Popp, 2001).

Corruption is an especially important institutional factor affecting energy supply (Rimšaitė, 2019). Most energy providers are state-owned enterprises. Corruption often permeates their procurement policies through bid-rigging and price-fixing schemes, resulting in higher operation costs and retail prices. Oil and gas firms are especially vulnerable to corruption because governments, especially in less developed countries, are directly involved in the industry through state-owned enterprises and joint ventures (Nies, 2008). These firms operationally rely on networks of third party intermediaries, i.e. agents and consultants, who often work as lobbyists (International Energy Agency (IEA), 2012). Third party intermediaries are often an important source of information for firms making decisions on energy efficiency, as they coordinate transactions between energy providers and business users (Nolden et al., 2016). Yet, the contribution of these intermediaries depends on the degree of asymmetric information between energy providers and users, which can be further exacerbated by corruption (Li, 1998).

Economic reform is another important determinant of energy supply. During the institutional reforms of the 1990s', many energy providers had undergone privatization for improving efficiency (Ramamurti, 1992; Williams and Ghanadan, 2006). A 1998 survey of 115 developing countries found that about 40% of countries transformed the legal and commercialization status of state energy providers, 29% passed law to unbundle and/or privatize the sector, whilst 20% of countries actually privatized energy providers (Bacon and Besant-Jones, 2001). Subsequently, the restructured energy providers faced considerable challenges as they had to deal with stronger market pressure, rising competition from new market entrants, all of which resulted in distortions in the provision of energy services at affordable cost (Pombo and Taborda, 2006). In the new conditions, energy providers with reliable financial information were better able to meet performance requirements, to gain market share and to enhance the efficiency of energy supply (Jamash et al., 2004; Plane, 1999). Further, regulatory authority and policies (Zhang and Wen, 2008), political aspirations (Edomah et al., 2017), local geospatial conditions (Lindner, 2011), primary production levels (Reinmüller and Adib, 2003) and the lack of user information (Sandgren, 2001) also affect energy supply. To the extent that financial information plays a role in decision-making that relates to these factors, information integrity emerges as a key determinant of energy supply.

Moreover, in the developing countries, the supply of energy depends on government factors, given that the state often operates and regulates the energy system (Jamash et al., 2004; Intergovernmental Panel on Climate Change (IPCC), 2011). Several developing countries are large providers of fossil-based energy (e.g. OPEC group), who see their rent-seeking growth models coming eventually to a halt, and this induces their governments to engage in production diversification reforms, thereby affecting energy supply. Governance institutions also affect the supply of energy. Politically motivated government subsidies can have unintended consequences by trapping energy users into non-paying and low quality market behavior, discouraging required energy investment (McRae, 2015). For example, in India, cross-subsidized agricultural producers enjoying politically-imposed flat energy cost caused financial losses to energy providers leading them to ration supply (Harish et al., 2014). Politicians in India manipulated the poor households' access to energy to increase their chance of re-election (Min and Golden, 2014).

Financing conditions also affect the firms' access to energy. The impact is manifested along various dimensions. For example, Bazilian et al. (2011) analyze the role of financing for energy production and stress the mismatches between financing needs and financing flows on a global scale. Foreign direct investment in energy production has benefited rather few developing countries and only to a limited extent.

Bird et al. (2011) argue that most funding for energy generation comes from domestic sources, but it is severely curtailed due to the budget-constrained governments and unwilling private sectors. Bhattacharyya (2013) argues that, in recent years, financing for energy generation has been linked to climate-related considerations, but it has been inadequate and unevenly distributed, as well as to the environmental compliance requirements, which firms rarely meet, especially in low-tech developing countries. Glemarec (2012) stresses the importance of the private sector firms in the financing of own energy projects, but with limited success in meeting their own demand. Monroy and Hernandez (2005, 2008) highlight the important role of stakeholders in securing needed financing for electrification especially in developing countries, which varies in accordance with local conditions. Finally, Woerlen (2011) stresses the lack of cost effectiveness in both energy providing and energy using firms. Along all these dimensions, the availability of credible information is key to these financing decisions, thereby affecting energy supply. The auditing of financial statements "hardens" the quality of financial information due to its verification by an independent auditor, thereby reducing information asymmetries and hence the cost of finance (Maines and Wahlen, 2006; Ball et al., 2012). Overall, auditing acts as a screening mechanism separating the creditworthy firms from others (Minnis, 2011; Kausar et al., 2016). Firms with audited accounts stand a better chance to obtain adequate and low-cost external financing of energy-efficient investments resulting in lower energy constraints.

Taking the demand side, transitory or longer-term, environmental, technical and economic factors affect the use of energy. Weather conditions (hot summers, cold winters) are important determinants of firms' energy demand (Fisher-Vanden et al., 2015). Energy theft can lead to higher and more frequent power outages by increasing its inefficient use, since free access increases abuse (Jamil, 2013). Insufficient transactions information, informal dealings and inadequate property rights exacerbate energy theft, especially in poor urban areas (Duflo et al., 2012).

The use of energy follows the economic cycle and competition. Many economies are growing at a faster pace than has been initially projected, which has created a spur in energy demand. Wolfram et al. (2012) argue that forecasts of energy demand in developing countries failed to capture increases in the quantity of energy needed by innovative firms and the poorer segments of the population. Islam et al. (2013) found a bi-directional causality between economic growth and energy demand. In the developing countries, energy demand by firms remains a major development policy issue due to the structural deficiencies in the energy systems (Urban et al., 2007) as well as inadequate investment spending and technological diffusion (Pandey, 2002). Hence, a large number of firms demand more and better quality energy to maintain their rising and diversifying production of commodities. To this end, information is important. The most profitable firms are better able to receive energy services of adequate quantity and quality, especially when the cost is rising. Moreover, the specific needs of firms based on their technology, structure of production and sectoral specialization, affect their demand for energy (Schäfer et al., 2011) and the extent of energy-saving investment (Lahr et al., 2010) especially in regions with rising populations and incomes (Blumberg, 2015).

In general, prior studies that examined the determinants of the firms' demand for energy have yielded inconclusive results, depending on various factors, such as the stage of economic transformation and development, the availability of relevant data, and the analytical methodology used (Samuel et al., 2013; Khanna and Rao, 2009). These studies indicate that energy demand is variously affected by per capita real GDP (Khalid and Khalid, 2010; Udo et al., 2011; Kumarasinghe and Gunathilake, 2009); industrial growth (Alter and Syed, 2011; Kumarasinghe and Gunathilake, 2009); cost of energy production (Zhao et al., 2012); and demographic conditions (Udo et al., 2011; Kumarasinghe and Gunathilake, 2009).

The quest for energy efficiency also affects firms' demand for energy. Oh and Lee (2004), Ghali and El-Sakka (2004) and Lee and Chang (2008) analyze the determinants of energy efficiency by positing that energy is a factor of production. Hence, firms are required to optimize their consumption of energy using reliable monitoring tools of energy flows based on proper information. Non-credible information may, especially as regards energy-intensive firms, lead to inefficient planning and performance costs for the firm. In this context, externally audited financial accounts provide an extra layer of information integrity, allowing management to achieve energy efficiency and meet performance targets. Further, credible financial information facilitates energy efficiency and improves the effectiveness of a firm's own energy audit. The latter is a key tool for addressing existing information asymmetries by producing and sharing knowledge that facilitate energy cost saving (Schleich, 2004). Energy auditing helps optimize dependence on energy by identifying areas for operational improvement and devising energy efficiency solutions within existing structures of business operation (Paramonova and Thollander, 2016). However, in developing countries, energy efficiency can only be achieved if energy regulators act on utilities and other co-regulatory agencies (Berg, 2015). Utilities can improve the cost-effectiveness of energy supply by improving load patterns and system reliability, decision-relevant customer billing information, energy audits, and smart grids. Other government agencies should set proper operational standards and provide financial support. The sector regulator must then factor in the interdependencies among economic and non-economic information required for determining the cost-effectiveness of these programs. Egwunatum and Akpokodje (2019) argue that energy efficiency at the firm-level requires efficient allocation of energy budgets and carrying out economic optimization of energy use, to evaluate compliance with statutory energy standards and to assess alternative system designs. Energy auditing generally compares the projected estimates based on the accounting data drawn from the management information system. The latter needs to be fed by the projected cash flows made in the original capital budget and the actual cash flows realized during the elapsing period. The energy auditor needs to collect total cost information that should be audited before comparisons are made. Significant time gaps and other factors, not considered at the budgeting stage, may force the restating of information. Thus, credible information is key for efficient energy auditing.

The firms' demand for energy is also affected by the regulatory requirements on efficient energy management and use. The decisions of firms to invest in energy-efficient projects are often suboptimal due to information asymmetry between firms and energy providers, especially government-controlled utilities in developing countries (Zhu and Chertowb, 2017). Further, energy investment subsidies and/or tax reliefs on firms are typically tailored to energy-efficient projects proven by proper and timely information regarding their financing and execution. To contain information asymmetry, energy regulators require more reliable information on supervised firms' energy efficiency management and investment (Liua et al., 2019). Moreover, regulators increasingly appear to require sustainability-related information disclosure by firms, which can only be made available once the firms' accounts are properly audited. To meet these requirements, lower the cost of compliance as well receive energy-investment benefits, firms are induced to improve the quality of their disseminated financial information. As a result, better quality information appears to facilitate firms' energy investment directly by lowering the discounting factor, thereby raising the net present value (and hence the attractiveness) of alternative energy-efficient investments, as well as indirectly though regulatory monitoring and approval of energy management strategies. Moreover, better quality information is necessary for applying risk-based auditing as a means to contain information asymmetry, for it can help both energy providers and users refocus their compliance efforts according to highly-prioritized risks, such as price-fixing and illicit payments (Pieth, 1999). These direct and indirect effects of information quality affect the energy constraints of firms.

Overall, demand and supply factors as well as institutions affect firms' energy access, calling for proper intervention, infrastructure improvement and energy investment design. Better access to energy can only result if proper impact assessment of intervention and improvement is made. Efficient impact assessment in the energy sector rests crucially on the quality of information (Torero, 2015). Key elements of such information are the cost, reliability and consumption of energy. Their measurement can be properly made within a high-integrity information framework. For example, Moriarty and Honnery (2010) argue that the current energy accounting methods, based on the distinction between primary versus final energy consumption, suffer inconsistencies. These will get larger as the energy production structure evolves towards renewable sources that require a better accounting of intermittent stages associated with variable flows. Similarly, Mayumi and Tanikawa (2012) argue that an efficient tracing of the transformation of the energy generation system from fossil fuels to renewable sources can only be realized by the use of proper input: output models that properly account for the intermediate energy inputs, which in turn require proper measurement of inflows and outflows. Ang et al. (2010) stress that the current accounting frameworks for tracking energy efficiency require more standardization, uniformity and comparability across countries. Bertran et al. (2012) argue that improved accounting methods and information are needed to enable energy providers to charge energy costs to their customers more accurately in accordance with varying market conditions.

Information helps better assess not only firms' access to energy but also the sustainability of the energy system. While broadly referred to as important elements in energy sustainability analysis, external monitoring mechanisms of energy access are not thoroughly studied. Our paper makes a contribution by studying the role of an important such mechanism: whether the extent to which firms have their financial accounts externally checked and certified affects their access to energy services. This research question has not been studied in the literature and especially with respect to developing countries. Our analysis takes into consideration the specific characteristics of firms as well as the controlling influence of economic and non-economic factors at the country-level. It also applies a wide range of sensitivity and endogeneity tests to ensure the robustness of the results.

3. Data, identification strategy and empirical methodology

The data on firms' energy access is produced by the Enterprise Surveys (ES hereafter) of the World Bank. The basic data comprises 132,903 non-financial firms operating in 138 developing countries during the 2006–16 period, collected over several surveys, and representing developing, emerging and a very few developed countries Successive surveys reflect independent cross-section rounds repeated periodically with a fraction of the firms participating consistently in all survey rounds. The different waves of data are integrated in a unified dataset, which is cleaned from inconsistencies in variable measurement. The dataset presents a consistent identification of firms' responses across all survey years and across the entire group of developing countries. Thus, it captures variation in firm-level responses in each country and over time across countries. The ES data reflect the individual firms' perception and experience of their operating environment. The ES facilitate the association of the firm characteristics and performance with the surrounding business environment. A key strength of the data is the separate classification of small, medium and large firms by the level of employment and the inclusion of representative random samples of firms from the different sectors of economic activity. Private contractors are responsible for information collection, safeguarding wide participation and confidentiality. Survey administrators carry out random checks to detect inconsistencies. The ES apply complete and updated sampling frames per country. We use different sub-samples to account for potential biases due to inconsistent sampling across countries or omitted variables.

A potential drawback of the data might be that some firms may have overstated their energy constraints they actually experience (Bertrand and Mullainathan, 2001). Indeed, the firms' responses are unaudited private information. This concern could be addressed by utilizing audited census data. However, such data is not available for many developing countries. The difficulty to rely on balance sheet data in developing countries due to questionable consistency and quality defends the importance of micro-survey data. The latter reflect the firms' experience and perceptions of their energy access more directly and hence it may be more valuable in the developing countries. As long as firms' propensities are not significantly correlated with our key independent variable, there is little reason to expect that they will affect the estimation results.

Our outcome variable is ENERGY. The ES codification defines ENERGY as an ordinal variable that reflects the extent to which firms experience energy constraints on their business operations during the fiscal year corresponding to each survey. It represents the answer of firms to the question: “How problematic is access to electricity for the operation and growth of your business?” The firm's answer varies between 0 (no constraint), 1 (minor constraint), 2 (moderate constraint), 3 (major constraint), and 4 (severe constraint). It is conceivable that these answers may not reflect the full reality of firms' experience or they may understate or overstate this experience, since firms may only face temporary power outage distress. Table 1 reports the mean value relative to the standard error of ENERGY per country, documenting a large variation among developing countries. Firms operating in Eritrea (0.18), and Azerbaijan (0.53) experience the lower energy constraints; firms operating in Iraq (3.06), and Pakistan (3.02) experience the highest energy constraints; whilst firms operating in Kyrgyz Republic (2.03), Belize (2.07), and Guatemala (2.10) take the moderate position. Interestingly, firms operating in resource-rich countries are not necessarily the least energy-constrained. Thus, the specific characteristics of firms as well as other factors play an important role.

The key independent variable is AUDIT; that is, the extent to which the firm has had its financial accounts checked and certified by an external auditor in the previous year. Based on the ES explanations, the binary variable AUDIT takes the value of 1 if firms had their accounts audited and 0 otherwise. We take this decision to reflect the firm's choice for increasing the integrity of its financial information. We conjecture that the external auditing of financial accounts reduces the risk of material misstatement of transactions and earnings management and hence it is a key factor ensuring the integrity of financial information (Hogan et al., 2008). The external auditing of accounts is more important in developing countries, where external expertise can be instrumental in further reducing the likelihood of error in recording transactions, summarizing accounts and reducing disagreements due to different judgment and estimation methods and external influences (Saudagaran, 2013). Table 1 shows the distribution of the mean value relative to the standard error of AUDIT across countries. The differences are large. Firms operating in Guinea Bissuau (0.08), Nigeria (0.21) and Myanmar (0.23) exhibit the lower levels of external auditing of their accounts; firms operating in Lebanon (0.90), Philippines (0.88) and El Salvador (0.87) experience the highest levels of external auditing of their accounts.

However, we cannot observe directly the firms' internal operating conditions that affect their energy need. Hence, we control for the role of various firm-specific characteristics as proxies of the firms' operating conditions (Mertzanis, 2018). Thus, we include information on firm size, age, legal status, sector of business activity, ownership structure and export status. Bhattacharyya (2013) emphasizes the role of changing financing conditions for the firms' energy access. In order to capture the effect of financing conditions, we include a firm-level variable to control for the extent to which the firm experiences financing constraints. Further, Rimšaitė (2019) stresses the role of corruption in energy access and emphasizes the political association between corruption, regulation and energy access. In order to capture the role of corruption conditions, we include a firm-level variable to control for the extent to which the firm experiences corruption as a problem to its business operations. Moreover, in order to capture the role of firms' internal technical

Table 1
Access to energy and external auditing of accounts (mean country values).

Country (firms)	ENERGY		AUDIT		Country (firms)	ENERGY		AUDIT	
	Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.
Afghanistan (945)	2.76	1.28	0.35	0.48	Liberia (301)	2.37	1.22	0.30	0.46
Albania (664)	1.88	1.50	0.25	0.43	Lithuania (546)	1.61	1.68	0.35	0.48
Argentina (2117)	1.70	1.54	0.71	0.45	Madagascar (977)	2.20	1.38	0.48	0.50
Armenia (734)	0.88	1.26	0.22	0.41	Malawi (673)	1.81	1.26	0.57	0.50
Azerbaijan (770)	0.53	0.96	0.46	0.50	Malaysia (1000)	1.36	1.03	0.46	0.50
Bahamas (150)	1.40	1.28	0.60	0.49	Mali (1035)	2.13	1.45	0.40	0.49
Bangladesh (2946)	2.68	1.02	0.43	0.49	Mauritania (387)	1.96	1.42	0.29	0.46
Barbados (150)	2.00	1.42	0.83	0.37	Mauritius (398)	1.96	1.62	0.63	0.48
Belarus (633)	1.22	1.51	0.44	0.50	Mexico (2960)	1.88	1.55	0.46	0.50
Belize (150)	2.07	1.23	0.69	0.47	Micronesia (68)	1.69	1.10	0.25	0.44
Benin (300)	2.69	1.26	0.61	0.49	Moldova (723)	1.43	1.60	0.28	0.45
Bhutan	0.99	1.05	0.50	0.50	Mongolia (722)	1.03	1.13	0.80	0.40
Bolivia (1339)	1.53	1.50	0.78	0.42	Montenegro (266)	0.96	1.13	0.48	0.50
Bosnia & Herzeg (721)	0.82	1.23	0.62	0.49	Morocco (407)	1.22	1.38	0.52	0.50
Botswana (610)	1.19	1.31	0.70	0.46	Mozambique (479)	1.35	1.38	0.41	0.49
Brazil (1802)	2.08	1.62	0.23	0.42	Myanmar (1239)	1.37	1.12	0.23	0.42
Bulgaria (1596)	1.29	1.43	0.42	0.49	Namibia (909)	0.92	1.29	0.76	0.43
Burkina Faso (394)	2.64	1.14	0.51	0.50	Nepal (850)	2.70	1.31	0.80	0.40
Burundi	2.73	1.34	0.27	0.44	Nicaragua (1147)	2.16	1.44	0.50	0.50
Cambodia (845)	1.53	1.26	0.25	0.43	Niger (301)	2.55	1.36	0.50	0.50
Cameroon (724)	2.40	1.23	0.64	0.48	Nigeria (4567)	2.55	1.27	0.21	0.41
Cape Verde (156)	2.42	1.39	0.36	0.48	Pakistan (2182)	3.02	1.20	0.34	0.47
Central African Rep (150)	2.91	1.17	0.54	0.50	Panama (969)	1.60	1.41	0.73	0.45
Chad (150)	3.13	1.13	0.60	0.49	Papua New Guinea (65)	2.32	0.94	0.68	0.47
Chile (2050)	2.08	1.68	0.51	0.50	Paraguay (1338)	1.76	1.36	0.40	0.49
China (2700)	0.49	0.74	0.71	0.45	Peru (1632)	1.28	1.46	0.36	0.48
Colombia (1942)	1.84	1.57	0.58	0.49	Philippines (2661)	1.13	1.29	0.88	0.33
Congo (151)	2.97	1.20	0.62	0.49	Poland (997)	1.28	1.55	0.25	0.43
Costa Rica (538)	2.62	1.58	0.60	0.49	Romania (1081)	1.44	1.57	0.39	0.49
Croatia (993)	2.38	1.48	0.35	0.48	Russia (5224)	1.32	1.53	0.27	0.45
Czech Rep. (504)	0.68	1.20	0.45	0.50	Rwanda	1.81	1.33	0.48	0.50
Cote d'Ivoire (887)	2.13	1.67	0.52	0.50	Samoa (109)	2.15	1.33	0.72	0.45
Dem. Rep. Congo (1228)	2.56	1.39	0.24	0.43	Senegal	2.41	1.31	0.26	0.44
Djibouti	2.17	1.17	0.46	0.50	Serbia (748)	0.95	1.32	0.58	0.49
Dominica (150)	2.75	1.11	0.48	0.50	Sierra Leone (302)	2.23	1.12	0.28	0.45
Dominican Rep. (719)	2.14	1.36	0.74	0.44	Slovak Rep. (543)	1.51	1.59	0.53	0.50
Ecuador (1385)	1.65	1.48	0.55	0.50	Slovenia (546)	0.88	1.36	0.38	0.49
Egypt (4711)	1.64	1.55	0.80	0.40	Solomon Islands (151)	1.51	0.95	0.86	0.35
El Salvador (1772)	1.62	1.48	0.87	0.33	South Africa (937)	1.25	1.35	0.75	0.43
Eritrea (179)	0.18	0.50	0.83	0.38	South Sudan (738)	2.38	1.34	0.29	0.45
Estonia (546)	0.80	1.27	0.58	0.49	Sri Lanka (610)	1.63	1.19	0.65	0.48
Ethiopia (1492)	2.16	1.24	0.68	0.47	St Kitts & Nevis (150)	2.65	1.19	0.69	0.46
FYR Macedonia (726)	1.17	1.44	0.44	0.50	St Lucia (150)	2.57	1.15	0.47	0.50
Fiji (164)	1.52	1.26	0.90	0.30	St Vincent & Gren (154)	1.44	1.27	0.79	0.41
Gabon (179)	2.53	1.32	0.43	0.50	Sudan (662)	0.87	1.02	0.56	0.50
Gambia (174)	2.84	1.25	0.32	0.47	Suriname (152)	1.29	1.17	0.52	0.50
Georgia (733)	1.53	1.56	0.37	0.48	Swaziland (457)	1.12	1.09	0.75	0.43
Ghana (1214)	2.79	1.16	0.51	0.50	Sweden (656)	0.58	0.65	0.96	0.19
Grenada (153)	1.05	1.29	0.61	0.49	Tajikistan (719)	1.63	1.48	0.33	0.47
Guatemala (1112)	2.10	1.46	0.64	0.48	Tanzania (1232)	2.78	1.29	0.45	0.50
Guinea (373)	2.79	1.30	0.19	0.40	Thailand (1000)	1.14	1.40	0.25	0.44
Guinea Bissau (159)	2.94	1.42	0.08	0.28	Timor Leste (276)	1.85	1.44	0.30	0.46
Guyana (165)	1.96	1.41	0.91	0.28	Togo (305)	2.26	1.30	0.58	0.49
Honduras (1128)	1.90	1.34	0.64	0.48	Tonga (150)	1.49	0.67	0.51	0.50
Hungary (601)	0.84	1.31	0.62	0.49	Trinidad & Tobago (370)	1.18	1.10	0.82	0.38
India (9281)	1.53	1.25	0.83	0.37	Tunisia (592)	0.55	1.07	0.78	0.41
Indonesia (2764)	1.10	1.29	0.20	0.40	Turkey (2496)	1.14	1.44	0.56	0.50
Iraq (756)	3.06	1.22	0.42	0.49	Uganda (1325)	2.58	1.36	0.47	0.50
Israel (483)	0.42	1.01	0.94	0.25	Ukraine (1853)	1.15	1.49	0.29	0.46
Jamaica	1.92	1.22	0.76	0.43	Uruguay (1228)	1.72	1.58	0.38	0.49
Jordan (573)	0.77	1.13	0.56	0.50	Uzbekistan (756)	1.22	1.35	0.43	0.49
Kazakhstan (1144)	1.59	1.53	0.24	0.42	Vanuatu (128)	1.72	1.32	0.45	0.50
Kenya (1438)	1.85	1.32	0.78	0.41	Venezuela (820)	1.84	1.49	0.76	0.42
Kosovo (472)	2.70	1.35	0.22	0.41	Vietnam (2049)	0.85	1.03	0.34	0.47
Kyrgyz Rep. (505)	2.03	1.54	0.40	0.49	West Bank & Gaza (434)	2.32	1.40	0.74	0.44
Lao PDR (998)	1.39	1.32	0.26	0.44	Yemen (830)	2.75	1.21	0.33	0.47
Latvia (607)	1.07	1.50	0.56	0.50	Zambia (1204)	1.54	1.24	0.62	0.49
Lebanon (561)	2.31	1.30	0.90	0.30	Zimbabwe (1199)	1.96	1.28	0.60	0.49
Lesotho	1.88	1.38	0.69	0.46	*Total average*	*1.71*	*1.49*	*0.52*	*0.50*

Source: Enterprise Surveys.

conditions, our sensitivity analysis includes technical variables, such as the duration of power outages and the existence of internal energy generators. Finally, we control for the role of national factors that capture the economic, institutional and infrastructure conditions of countries. The country-level controls reflect different time-varying and time-invariant influences across countries, aiming at capturing spurious relationships. The regression estimates represent the within-country variation in the association between firms' energy constraints and the exogenous variables. Each individual firm is assumed to be not large enough to influence the country-level controls. The Appendix describes in detail all the variables used in the study. Table 2 reports summary statistics of the variables, which document considerable variation across countries, based on the mean values relative to their standard errors.

Since ENERGY is an ordinal outcome variable, we use an ordered probit model for estimating the regression (Greene, 2012). We therefore use the standard maximum likelihood estimator. We only consider observations with non-missing values. When we study the impact of only the firm-specific characteristics, we use country-year fixed effects to control for country-year specific heterogeneity. We correct standard errors for heteroscedasticity. Subsequently, we add country-year-level control variables in separate groups to study the impact of different conditions and institutions and contain collinearity. Then we cluster standard errors at the country level to allow for arbitrary correlation of the error term within the country-year cells and avoid overstating estimation values (Moulton, 1990). We use one year lagged values of the time-varying control variables to minimize contemporaneous causality bias. We further perform a sensitivity analysis using alternative measures of the key variables, alternative sample sizes and alternative estimation methods. We also perform an endogeneity analysis using an instrumental variable approach that is a suitable for probit estimation. Our estimation model posits that the firm's underlying response is described by the following equation:

$$ENERGY_{ijt} = AUDIT_{ijt}\,\beta_1 + X_{1ijt}\,\beta_2 + X_{2jt}\,\beta_3 + \mu_{ijt} \qquad (1)$$

In the above equation, $\text{ENERGY}_{\text{ij}}$ expresses the extent to which firm *i* in country *j* in year *t* perceives access to energy to be no, low, moderate, major or severe constraint; $\text{AUDIT}_{\text{ijt}}$ is whether the firm *i* in country *j* in year *t* has had its financial accounts externally checked and certified in the previous year; $\text{X}_{1\text{ijt}}$ is the vector of all firm-specific control variables per firm *i* in country *j* in year *t*; and $\text{X}_{2\text{jt}}$ is the vector of all country-level control variables per country *j* in year *t*. The expression μ_{ijt} shows the composite error term that includes the sum of γ_{j}, δ_t and e_{ijt}, where γ_j captures unobservable country effects, δ_t captures year effects and the ε_{ijt} is a disturbance parameter that varies across years and countries and assumed to follow the normal distribution.

Note that when analyzing categorical data using a probit estimator, there is not an equivalent to the OLS R^2 statistic for assessing the goodness-of-fit. The coefficients reflect maximum likelihood estimates, arrived at through an iterative process. The estimates are not calculated to minimize variance, so the OLS approach to goodness-of-fit does not apply. We therefore use an approximate pseudo R^2 measure, which also ranges from 0 to 1, with higher values indicating better model fit. However, we cannot interpret this measure as we would interpret the OLS R^2 since the pseudo R^2 can produce very different, often very low, values. Wooldridge (2002) argues that, if the outcome variable in the probit estimation is a binary variable, McFadden's pseudo R^2 estimates might be interpreted in a similar way with the OLS R^2 estimates. Finally, we understand the difficulty in interpreting the estimated correlations as causal effects. We therefore interpret our estimates as strength of association rather than causation, and we use the expressions “impact”, “predict”, or “affect” to simplify exposition. Table 3 shows the pairwise correlations between the firms' firm-specific characteristics used in the baseline estimation. The correlations do not document severe collinearity between the firm-specific characteristics, as the estimated correlation coefficients are below the 0.5 value and the VIF value is 1.40.

Table 2
Descriptive statistics for the variables.

Variable	Obs.	Mean	S.D.	Min	P25	Mdn	P75	Max
ENERGY	130,801	1.71	1.49	0	0	2	3	4
AUDIT	129,224	0.52	0.50	0	0	1	1	1
FINCON	127,377	0.67	0.47	0	0	1	1	1
CORRUPT	127,261	0.69	0.46	0	0	1	1	1
AGE	129,520	7.57	0.02	7.55	7.56	7.56	7.58	7.61
SIZE	131,968	1.72	0.76	1	1	2	2	3
SECTOR	131,968	1.45	0.5	1	1	1	2	2
LEGAL	131,964	0.45	0.5	0	0	0	1	1
EXPORT	131,968	0.08	0.27	0	0	0	0	1
OWNP	131,458	87.81	30.88	−9	100	100	100	100
OWNF	131,435	7.85	25.29	−9	0	0	0	100
OWNG	131,444	0.55	6.52	−9	0	0	0	100
OUTAGE	131,276	0.58	0.49	0	0	1	1	1
GENERAT	110,539	0.35	0.48	0	0	0	1	1
GDPCAP	129,344	4854.14	5667.16	205.07	1308.75	2707.98	7054.91	52,723.09
CREDIT	125,954	40.28	30.15	1.2	17.21	35.88	52.39	156.98
INFLATION	129,344	6.32	7.55	−20.63	2.77	4.77	8.27	98.05
GLOBAL	125,895	56.25	15.82	10.94	45.09	56.59	66.14	98.29
ENERCONS	104,579	2012.67	2011.32	39.89	570.25	1380.66	3100.39	13,480.15
INTENSCO	104,747	2.15	0.88	0.09	1.63	2.34	2.71	7.37
OVERSGHTB	77,656	0.2	0.4	0	0	0	0	1
AUDITEXP	60,958	2.88	0.63	1	2.5	3	3	5
APPLIFRS	123,666	0.24	0.43	0	0	0	0	1
AUDITQUAL	130,244	0.83	0.37	0	1	1	1	1
S_COAL	75,374	18.59	25.49	0	0	6.89	26.98	100
S_GAS	74,721	24.52	25.55	0	0.41	17.69	44.88	99.72
S_HYDRO	75,374	34.43	29.12	0	12.23	27.1	52.66	101
S_NUCLR	75,374	4.42	11.17	0	0	0	2.17	74.11
S_OIL	75,374	12.91	19.62	0	0.59	2.95	19.16	99.32
S_RENEW	75,374	3.75	6.3	0	0.05	1.23	4	30.21
LABORSIZE	118,920	96.17	792.7	0	8	19	57	170,010

Table 3
Correlation matrix.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
AUDIT (1)	1										
FINCON (2)	0.03***	1									
CORRUPT(3)	−0.04***	0.25***	1								
AGE (4)	−0.15***	−0.03***	0.03***	1							
SIZE (5)	−0.31***	−0.05***	0.03***	0.23***	1						
SECTOR (6)	0.03***	−0.02***	−0.04***	−0.06***	−0.18***	1					
LEGAL (7)	−0.08***	−0.08***	−0.03***	0.28***	0.21***	−0.00	1				
EXPORT (8)	−0.08***	−0.03***	−0.01**	0.06***	0.19***	−0.10***	0.05***	1			
OWNP (9)	0.09***	0.03***	−0.01**	−0.11***	−0.13***	−0.01***	−0.03***	−0.15***	1		
OWNF (10)	−0.12***	−0.05***	−0.01**	0.03***	0.16***	0.00	0.10***	0.15***	−0.77***	1	
OWNG (11)	−0.04***	−0.02***	−0.03***	−0.01***	0.06***	0.01**	0.02***	0.00	−0.12***	0.01***	1
VIF	1.41										
N	125,415										

Pairwise correlation values among the firm-specific characteristics. VIF values above 4 (small sample) or 10 (large sample) indicate multicollinearity.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Therefore, the firm-specific characteristics can all enter the regression analysis.

4. Analysis of results

4.1. Baseline effect

We estimate several maximum likelihood regression models sequentially to assess the baseline association. In order to take into account the role of country development and size, we distinguish between low-income and high-income countries as well as between low-population and high-population countries, based on the median levels of GDP per capita and of population, respectively. However, interpreting coefficients of probit models presents serious challenges that do not exist for linear models (Breen et al., 2018). We cannot meaningfully interpret the absolute magnitude of probit coefficients as effect sizes because they depend arbitrarily on residual variation or omitted covariates. However, we can interpret their sign and statistical significance because the coefficients are always attenuated (Allison, 1999). We can also compare the magnitude of probit coefficients within the same model, because the effect of omitted covariates operate in the same way on all coefficients (that is, they are affected by a common scale factor). We can also compare the size of the coefficients of different covariates within the same probit model, because the attenuation bias is the same for all of them (Train, 2009). Table 4 reports the results of the baseline estimation. The coefficient of AUDIT is significant and negative

Table 4
External auditing of accounts and access to energy - baseline models.

	All countries	High-income countries	Low-income countries	High population countries	Low population countries
AUDIT	−0.056***	−0.050***	−0.065***	−0.115***	−0.006
	(0.008)	(0.011)	(0.011)	(0.012)	(0.011)
FINCON	0.378***	0.379***	0.377***	0.454***	0.304***
	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
CORRUPT	0.308***	0.335***	0.270***	0.350***	0.273***
	(0.008)	(0.011)	(0.012)	(0.013)	(0.011)
AGE	0.027	0.213	−0.375	−0.068	0.224
	(0.238)	(0.318)	(0.357)	(0.336)	(0.340)
SIZE	0.030***	0.026***	0.037***	0.025***	0.036***
	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)
SECTOR	−0.224***	−0.171***	−0.297***	−0.234***	−0.216***
	(0.007)	(0.010)	(0.011)	(0.011)	(0.010)
LEGAL	−0.003	−0.021	0.022	−0.013	0.002
	(0.010)	(0.013)	(0.015)	(0.015)	(0.013)
EXPORT	−0.004	0.013	−0.023	0.005	−0.011
	(0.013)	(0.018)	(0.019)	(0.018)	(0.019)
OWNP	0.001**	0.001	0.001***	0.001**	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
OWNF	0.001***	0.001	0.001***	0.001**	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
OWNG	−0.001	0.001	−0.001	0.002*	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Year dummies	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.091	0.077	0.096	0.090	0.092
Wald Chi^2	29,947.231	13,377.626	14,466.199	14,687.208	15,208.072
N	112,416	59,706	52,710	53,723	58,693

Notes: The table reports the baseline results. Heteroscedasticity-robust standard errors are presented in parentheses. The outcome variable is access to energy, ENERGY. The key independent variable is whether the firm has had its financial accounts externally audited, AUDIT. Control variables include the firm-specific characteristics. The pool sample period is 2006–2016. The whole sample is split between high- and low-income countries and between high- and low-population countries to account for country size and development. An ordered probit model is used. The marginal effects of the regressions are presented. Country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$, $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

in all models, except for low-population countries, where it is insignificant. It appears that across all developing countries the decision of a firm to have its financial accounts externally audited is associated with a generally more significant likelihood of improved access to energy. The significance of the effect appears to be stronger in large countries. It is conceivable that large countries have, on the one hand, a wider range of on-grid and off-grid sources of energy generation and, on the other hand, auditing services are more efficient in facilitating firms' deployment of all means necessary to improve energy access. In contrast, small countries seem to lack the benefits of scale and expertise. Further, there is little difference in the significance of the audit effect between high- and low-income countries. The firm-specific characteristics are also important predictors. Whether the firm experiences a financing constraint is significantly and positively associated with its energy constraint. It appears that higher financing constraints reflect distressed financing conditions of firms, which most likely adversely affect their creditworthiness/reputation and hence the supply of energy services to those firms. Further, whether the firm experiences corruption as a problem to its business operation is also significantly and positively associated with its energy constraint. It appears that higher corruption adversely impacts the provision of adequate and low-cost energy services to firms. These are new and interesting findings. They document that access to energy is not merely a technical issue but also associated with the economic and institutional aspects of business operation, such as financing and corruption. These findings support the suggestions by Bhattacharyya (2013) and Rimšaitė (2019). Moreover, while the firm's age is not a significant predictor of firm's access to energy, except in small countries, firm size matters: large firms experience more stringent energy constraints. Firms in the manufacturing sector experience higher difficulties in energy access, whilst joint-stock companies experience easier access. Exporting firms in low-income countries also experience better access to energy. This evidence on the role of firm-specific characteristics is in line with previous cross-country studies on energy access (Mertzanis, 2018). Overall, the results provide new evidence that documents a strong beneficial effect of better financial information on firms' access to energy in developing countries. Finally, the high value of the Wald test shows that the fixed effects are significant.

4.2. Firm size effect

All firms in developing countries face some energy constraint. However, the size of the firm matters for the extent to which firms have access to energy (Costa-Campi et al., 2015). On the one hand, large firms are more often publicly listed and hence must comply with stricter accounting and auditing standards (e.g., IAS/IFRS) and disclosure requirements, which ensure better information integrity (Zehri and Chouaibi, 2013). Further, large firms might be more successful in influencing politicians and regulatory authorities in order to obtain more favorable access to energy (Schiffer and Weder, 2001). On the other hand, small firms are often unregulated or weakly regulated. Thus, they are not mandated to audit or publish audited financial accounts, which raise concerns about their integrity. Small firms might easily "dress up" their accounts to avoid paying taxes (Schiffer and Weder, 2001). They are also in a weaker position to secure energy supply due to the government bureaucratic discretion (Schiffer and Weder, 2001). The differences between large and small firms in producing audit financial accounts will affect their relative access to energy. The distribution of the small, medium and large firms in the sample is 47.21%, 33.66% and 19.13%, respectively. We split the total sample into small, medium and large firms and re-estimate the baseline model for each firm size. The distinct estimation of the different sub-samples by firm size captures non-linearities and it is a first robustness check against potential measurement error in the outcome variable. Table 5 reports the marginal effects. The coefficient of AUDIT is negative and significant for all firm sizes. Thus, the decision to have financial accounts externally audited will improve the likelihood of better energy of all firms. However, the

Table 5
External auditing of accounts and access to energy by firm size.

	Small firms	Medium-size firms	Large firms
AUDIT	−0.035***	−0.079***	−0.090***
	(0.011)	(0.013)	(0.020)
FINCON	0.333***	0.403***	0.444***
	(0.012)	(0.013)	(0.018)
CORRUPT	0.297***	0.312***	0.318***
	(0.012)	(0.015)	(0.020)
AGE	−0.108	0.082	−0.273
	(0.388)	(0.388)	(0.500)
SECTOR	−0.230***	−0.224***	−0.180***
	(0.010)	(0.013)	(0.019)
LEGAL	0.009	0.006	−0.037*
	(0.016)	(0.016)	(0.022)
EXPORT	−0.017	0.030	0.007
	(0.027)	(0.023)	(0.022)
OWNP	0.001*	0.001	−0.001
	(0.001)	(0.001)	(0.001)
OWNF	0.001*	0.001	0.001
	(0.001)	(0.001)	(0.001)
OWNG	0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)
Year dummies	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes
Pseudo R^2	0.100	0.089	0.085
Wald Chi^2	15,385.087	10,251.816	11,949.995
N	53,554	38,395	20,467

Notes: The table reports the baseline results after the whole sample is split by firm size. Heteroscedasticity-robust standard errors are presented in parentheses. The outcome variable is access to energy, ENERGY. The key independent variable is whether the firm has had its financial accounts externally audited, AUDIT. Control variables include the firm-specific characteristics. The pool sample period is 2006–2016. An ordered probit model is used. The marginal effects of the regressions are presented. Country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$, $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

significance of the effect appears to be stronger in large firms compared to small firms. Similarly, both the financing and corruption constraints of the firm remain positive and significant and they are stronger for large firms. This is new evidence that shows that large firms tend to benefit relatively more from improving the integrity of their financial information. It appears that large firms have higher needs for energy and face higher challenges in securing it. Moreover, larger firms experience relatively larger cost from energy disruptions. Lee and Yu (2019) argue that the association of energy usage and energy cost is much stronger for large firms than small firms. They attribute this to the large firms' higher rigidity in adjusting the composition of energy sources and of the energy-using output. On the other hand, small firms can mitigate their energy needs by other means, such as the use of internal energy generators, which large firms cannot easily or economically do.

4.3. Sector of activity effect

Access to energy is important for firms in all sectors of economic activity. However, firms across sectors differ in their reliance on the energy generating system for technological, organizational and product-related reasons. Faridi and Murtaza (2013) document a significant variation of electricity consumption of firms among different economic sectors of activity, highlighting the highest needs in agriculture and the lower needs in the fossil fuels sector. Rehman and Bashir (2015) also argue that agricultural output is positively associated with energy consumption. Bashir et al. (2016) find that higher electricity generation is associated with higher real exports. Bashir et al. (2018) find an insignificant link between energy use and the services sector, which constitutes more than 40% in the developing economies. The distribution of the different core sectors of activity in the sample is 52.93% (manufacturing), 17.07% (retail and wholesale trade), 25.59% (services) and 4.41%

(construction, real estate and others). We re-estimate the baseline model separately for each of the four different sectors of activity in order to examine the sectoral implications of financial information integrity on firms' access to energy. As above, the distinct estimation of the different sub-samples by sector captures non-linearities is a first robustness check against potential measurement error in the outcome variable. Table 6 reports the marginal effects. The coefficient of AUDIT is negative and significant for all sectors, except for construction and real estate. As it is intuitively expected, given the considerably different energy needs of the firms in the two sectors, the significance of the effect appears to be stronger in the manufacturing sector. It appears that the firms in the construction and real estate sectors do not see significant improvement in energy access by having their financial accounts externally audited. The financing and corruption constraints remain positively and strongly associated with the firm's energy constraint.

4.4. Regional effect

Access to energy has a regional dimension too. Different geographies, infrastructures and energy-related security considerations around the world affect firm's access to energy in different ways (Proninska, 2007). Further, the developing countries' decision to adopt IFRS and other accounting institutions varies considerably, depending on economic dependence, pressure from international institutions and investors and weak domestic enforcement mechanisms (Judge et al., 2010). Al-mulali et al. (2012) document a positive long-run relationship between urbanization, energy consumption and CO_2 emissions across the different world regions. In order to examine the regional dimension of financial information integrity effect on firms' energy constraints, we estimate the baseline model for each of the six UN-classified regions. In our sample, the distribution of firms across regions is as follows: East Asia and Pacific (12.95%), Europe and Central Asia (22.01%), Latin America and Caribbean (21.42%), Middle East and North Africa (7.28%), South Asia (13.12%) and Sub-Saharan Africa (23.21%). Similarly, the distinct estimation of the different sub-samples is a first robustness check. Table 7 reports the results. The results show a significant and negative of AUDIT in all regions, except for Latin America and Caribbean and the Middle East and North Africa, where it is insignificant. The significance is stronger in the East Asia and Pacific region and weaker in Europe and Central Asia. The difference could be explained by the relatively advanced technologically countries in the East Asia and Pacific region and the worldwide divergence in the extent of implementation of internationally recognized accounting and auditing standards. Interestingly, the financing and corruption constraints of firms are also higher in the East Asia and Pacific region, confirming the strong geographical association between them.

The robustness of our baseline results is further checked by applying a wide range of sensitivity and endogeneity tests. These tests confirm the stability of the baseline results. To save on space, we report the results in the Appendix B.

Table 6
External auditing of accounts and access to energy by sector of activity.

	Manufacturing	Wholesale & retail	Services	Construction & real estate
AUDIT	−0.069***	−0.046**	−0.046***	0.101
	(0.011)	(0.019)	(0.015)	(0.084)
FINCON	0.409***	0.341***	0.375***	0.377***
	(0.011)	(0.019)	(0.016)	(0.088)
CORRUPT	0.312***	0.339***	0.289***	0.365***
	(0.012)	(0.020)	(0.017)	(0.095)
AGE	−0.349	−0.327	0.672	3.537
	(0.328)	(0.583)	(0.482)	(2.269)
SIZE	0.021***	0.070***	0.023**	0.089*
	(0.007)	(0.014)	(0.010)	(0.048)
LEGAL	−0.003	0.013	−0.006	−0.111
	(0.013)	(0.025)	(0.020)	(0.121)
EXPORT	0.013	−0.081	−0.008	0.400
	(0.016)	(0.053)	(0.030)	(0.245)
OWNP	0.001	0.001	0.001*	−0.001
	(0.001)	(0.001)	(0.001)	(0.002)
OWNF	0.001**	−0.001	0.001**	−0.002
	(0.001)	(0.001)	(0.001)	(0.004)
OWNG	0.001	−0.001	−0.002*	−0.001
	(0.001)	(0.002)	(0.001)	(0.005)
Year dummies	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Pseudo R^2	0.091	0.093	0.101	0.139
Wald Chi^2	16,501.359	9762.126	8474.641	441.219
N	59,995	18,900	28,160	1137

Notes: The table reports the results after the whole sample is split by sector of business activity. Heteroscedasticity-robust standard errors are presented in parentheses. The outcome variable is access to energy, ENERGY. The key independent variable is whether the firm has had its financial accounts externally audited, AUDIT. Control variables include the firm-specific characteristics. The pool sample period is 2006–2016. An ordered probit model is used. The marginal effects of the regressions are presented. Country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

5. Country-level factors and further robustness checks

The different countries are going through different phases of the business cycle and they are affected by diverse technological and institutional conditions of energy generation and use. These differences can mitigate the financial information integrity effect on the individual firms' energy access. By accounting for the impact of these different country-level factors, the financial information integrity effect may be more or less pronounced. We apply additional robustness tests to account separately for the impact of various economic, institutional and technological factors on our basic research question. We classify our control variables into different groups and use different variables within each group to contain measurement error and potential collinearity problems - correlation checks preceded the choice of control variables for each group. Further, we lag our time-varying control variables one year to contain contemporaneous causality problems. We use institutional variables based on different calculation methods and information sources drawn from different types of procedures and respondents (Arndt and Oman, 2006). We acknowledge that reality may differ from formal description. However, the typical firm (standardized for cross-country comparability) cannot possibly reflect reality of all firms operating in different environments. For example, the standardized firm is assumed to operate in a stable and growing economy, but firm behavior differs across the different environments. We re-estimate Eq. (1) to include the separate impact of a country's: (a) financial and macroeconomic conditions; (b) the accounting and auditing environment; and (c) the energy generation infrastructure. The corresponding variables are described in the Appendix. Interaction effects are not included to keep the analysis simpler. The results of each group estimation are presented below.

5.1. Impact of macroeconomic conditions

Financial development, economic development and energy consumption are important demand-side factors that affect firms' energy constraints directly and indirectly through their mitigation of the integrity of financial information requirements. The literature has highlighted the role of economic growth, energy consumption, urbanization, CO_2 emission, financial development, and GDP per capita as important determinants of energy use (Salahuddin et al., 2018). Behera and Dash (2017) documented a significant relation between energy consumption, urbanization, foreign direct investment, and CO_2 emission in South-East Asian countries. Saboori et al. (2014) find a positive, significant and bidirectional relationship between road sector energy consumption and economic growth in the OECD countries (Organization of Economic Cooperation and Development (OECD), 2010). Salahuddin et al. (2015)

Table 7
External auditing of accounts and access to energy by UN-classified region.

	Sub-Saharan Africa	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia
AUDIT	−0.074***	−0.102***	−0.045***	0.011	0.011	−0.073***
	(0.016)	(0.023)	(0.017)	(0.016)	(0.029)	(0.021)
FINCON	0.329***	0.520***	0.356***	0.297***	0.475***	0.495***
	(0.018)	(0.022)	(0.017)	(0.017)	(0.028)	(0.020)
CORRUPT	0.223***	0.458***	0.346***	0.297***	0.236***	0.255***
	(0.017)	(0.021)	(0.017)	(0.019)	(0.035)	(0.025)
AGE	−0.242	−0.450	−1.373***	0.936**	2.594***	0.934
	(0.539)	(0.726)	(0.507)	(0.469)	(0.848)	(0.648)
SIZE	0.095***	0.109***	0.050***	0.011	0.062***	0.006
	(0.011)	(0.014)	(0.011)	(0.010)	(0.019)	(0.013)
LEGAL	0.054***	−0.070**	−0.014	0.047***	−0.196***	−0.034
	(0.020)	(0.032)	(0.022)	(0.018)	(0.035)	(0.029)
EXPORT	0.004	0.003	0.056*	0.057*	0.043	0.010
	(0.031)	(0.035)	(0.030)	(0.030)	(0.044)	(0.033)
OWNP	0.001**	0.001*	−0.001**	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
OWNF	0.001*	0.002***	−0.001**	0.001	−0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
OWNG	−0.001	0.005***	−0.006***	0.004	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.088	0.083	0.062	0.029	0.111	0.099
Wald Chi^2	6053.124	3167.807	3964.157	2240.485	2538.896	4457.997
N	25,220	14,209	23,611	24,843	8528	16,005

Notes: The table reports the results after the whole sample is split by UN-classified region. Heteroscedasticity-robust standard errors are presented in parentheses. The outcome variable is ENERGY. The key independent variable is whether the firms' financial accounts are externally audited, AUDIT. Control variables include the firm-specific characteristics. The pool sample period is 2006–2016. An ordered probit model is used. The marginal effects of the regressions are presented. Country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

study the relation between electricity consumption, CO_2 emissions, economic growth, and financial development in the Gulf Cooperation Council (GCC) region. They find that electricity consumption and economic growth stimulate CO_2 emissions, but financial development reduces it. Taking these conjectures into consideration, we expand Eq. (1) to include regressors capturing the impact of economic and financial conditions in the developing countries. Table 8 presents the results of the expanded baseline model after controlling for the impact of economic development (GDPCAP), financial development (CREDIT), inflation (INFLATION), the extent of economic globalization (GLOBAL), the consumption of electric power per capita (ENERCONS) and the intensity of CO_2 emissions (INTENSCO). The results show that the coefficient of AUDIT remains negative and significant in all models, except for low population countries, where it is insignificant. The significance is stronger in high-population countries and weaker in high-income countries. Higher levels of economic development are associated with lower energy constraints

Table 8
Impact of macroeconomic conditions.

	All countries	High-income countries	Low-income countries	High population	Low population
AUDIT	−0.067***	−0.049***	−0.098***	−0.106***	−0.026
	(0.018)	(0.019)	(0.034)	(0.028)	(0.018)
GDPCAP	−0.001***	−0.001***	0.001	−0.001	−0.001**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
CREDIT	−0.006	0.002	−0.023**	0.010	−0.008*
	(0.006)	(0.006)	(0.009)	(0.027)	(0.004)
INFLATION	0.023*	0.030**	−0.053***	0.039	0.003
	(0.013)	(0.015)	(0.018)	(0.046)	(0.011)
GLOBAL	−0.020***	−0.004	−0.051***	−0.014*	−0.017**
	(0.005)	(0.010)	(0.010)	(0.007)	(0.007)
ENERCONS	−0.001**	−0.001	−0.001***	0.001	−0.001**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
INTENSCO	0.074	−0.534**	0.738***	−2.215	0.127***
	(0.056)	(0.271)	(0.277)	(1.689)	(0.041)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.089	0.079	0.092	0.088	0.092
N	85,711	50,350	35,361	45,940	39,771

Notes: The table reports the results after controlling for the impact of macroeconomic conditions. The outcome variable is access to energy, ENERGY. The key independent variable is whether the firm has had its financial accounts externally audited, AUDIT. The pool sample period is 2006–2016. The whole sample is split between high- and low-income countries and between high- and low-population countries. Standard errors are clustered at the country level and are reported in parentheses. Control variables are the firm-specific characteristics, and the one-year lagged values of GDP per capita (log) (GDPCAP), credit to the private sector (% GDP)(log) (CREDIT), inflation rate (INFLATION), the extent of economic globalization (GLOBAL), the electric power consumption per capita (ENERCONS) and the intensity of CO_2 emissions (INTENSCO). An ordered probit model is used. The marginal effects of the regressions are reported. The effects of the firm-specific characteristics and the country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

of firms, except in low-income and higher-population countries where it is insignificant. Poor countries are often characterized by anemic levels of manufacturing activity, regulatory deficiencies and technological backwardness. Under these conditions, changes in income often translate into increases in unproductive activity or imports rather than manufacturing activity, which is energy-intensive. Moreover, large countries often experience larger structural inequalities (e.g. Nigeria) and therefore changes in income may not translate into energy-intensive economic activity. Finally, many large and relatively poor countries (e.g. Egypt) provide considerable energy subsidies, so changes in income do not significantly affect energy use (World Bank, 2010). Financial development improves energy access for firms operating only in low-income and low-population countries. Inflation exerts a weak negative effect on energy access. Higher globalization is associated with easier energy access of firms in all models, except in high-income countries. Higher energy consumption levels in the country facilitate firms' access to energy. This is probably because higher energy consumption levels lead to more energy production and infrastructure improvements. Finally, higher levels of intensity of CO_2 emissions are associated with higher energy constraints on firms, except in high-income countries. It may be the case that higher CO_2 emissions are associated with higher energy costs on both the firms and the countries in which they operate.

5.2. Impact of the accounting and auditing environment

A question arises as to whether the financial information integrity effect is stronger in developing countries with stronger accounting and auditing environments. Most developing countries have implemented IFRS along with International Standards on Auditing (IAS) in order to improve financial information transparency and accountability thereby contributing to economic efficiency (International Accounting Standards Board (IASB), 2018; International Federation of Accountants (IFAC), 2017). Standardized financial accounts enable stakeholders to assess and properly compare the firms' financial performance (Ball, 2006). However, actual implementation differs. Some developing countries require the implementation of standards, while others merely permit its usage (International Accounting Standards Board (IASB), 2018). Moreover, competent regulators have different mandates, structures and sanctioning powers. Finally, the audit profession may by subject to different licensing and oversight requirements, thereby affecting the quality of audit. Taking these conjectures into consideration, we expand Eq. (1) to include regressors capturing the impact of the accounting and auditing environment in the sample countries. Table 9 presents the results of the expanded baseline model after controlling for the impact of whether an accounting oversight body exists (OVERSGHTB), the average professional experience (years) of external auditors (AUDITEXP), whether non-listed firms apply IFRS (APPLIFRS) and the extent of audit environment quality (AUDITQUAL). The results show that the coefficient of AUDIT remains negative and significant in all models, except for low population countries. Its significance is broadly stronger in high-population countries. The establishment of an accounting oversight board does not appear to help firms improve their energy access much, except in low-income and high-population countries. The professional experience of auditors may help firms improve their access to energy only in smaller and poorer countries. The mandated implementation of the IFRS can only weakly help firms improve access to energy. These findings only partly corroborate the findings of the IFRS and IFAC reports (International Accounting Standards Board (IASB), 2018; International Federation of Accountants (IFAC), 2017). Finally, the improvement of the audit environment quality is associated with considerable improvements in firms' access to energy.

5.3. Impact of energy infrastructure conditions

The structure of energy generation infrastructure can also influence the supply of energy and mitigate the impact of external auditing of accounts on firms' energy constraints. The Global Energy Transformation Report (International Renewable Energy Agence (IRENA), 2018) notes that the rapid transformation in the production and distribution of energy worldwide, driven by the rapid decline in renewable energy cost, improving energy efficiency, widespread electrification, and increasing use of smart technologies, has impacted considerable on the cost of energy use by firms and households. Taking these conjectures into consideration, we focus on energy infrastructure and distinguish between six sources of energy generation: non-oil fossil fuels, gas, hydropower, nuclear, oil-based fuels and renewable sources (e.g., wind, solar, geothermal and hydropower). We re-estimate the baseline equation. Table 10 presents the

Table 9
Impact of the accounting and auditing environment.

	All countries	High-income countries	Low-income countries	High population	Low population
AUDIT	−0.106***	−0.081**	−0.141***	−0.162***	−0.016
	(0.029)	(0.037)	(0.035)	(0.039)	(0.026)
OVERSGHTB	0.567***	1.049***	−1.741***	−1.141***	0.429***
	(0.114)	(0.183)	(0.096)	(0.090)	(0.138)
AUDITEXP	0.411**	−0.394***	−0.037	1.254***	−0.795***
	(0.177)	(0.035)	(0.123)	(0.207)	(0.146)
APPLIFRS	−0.689***	0.078	1.672***	0.538***	−0.710***
	(0.183)	(0.171)	(0.137)	(0.111)	(0.129)
AUDITQUAL	−0.930***	−0.533***	−1.142***	−1.312***	−0.915***
	(0.065)	(0.027)	(0.078)	(0.236)	(0.064)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.104	0.081	0.101	0.112	0.092
N	50,790	28,188	22,602	32,369	18,421

Notes: The table reports the results after controlling for the impact of the accounting and auditing conditions. The outcome variable is access to energy, ENERGY. The key independent variable is whether the firm has had its financial accounts externally audited, AUDIT. The pool sample period is 2006–2016. The whole sample is split between high- and low-income countries and between high- and low-population countries. Standard errors are clustered at the country level and are reported in parentheses. Control variables are the firm-specific characteristics, and whether an accounting oversight body exists (OVERSGHTB), the average professional experience (years) of external auditors (AUDITEXP), whether non-listed firms apply IFRS (APPLIFRS) and the one-year lagged value of the index of audit environment quality (AUDITQUAL). An ordered probit model is used. The marginal effects of the regressions are reported. The effects of the firm-specific characteristics and the country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

Table 10
Impact of the energy production infrastructure.

	All countries	High-income countries	Low-income countries	High population	Low population
AUDIT	−0.031*	−0.030*	−0.032	−0.082***	0.001
	(0.017)	(0.020)	(0.029)	(0.028)	(0.019)
S_COAL	0.052	0.309**	0.202	0.005	−0.010
	(0.053)	(0.125)	(0.577)	(0.098)	(0.038)
S_GAS	0.070*	0.316**	0.251***	−0.019	0.021
	(0.041)	(0.130)	(0.012)	(0.080)	(0.030)
S_HYDRO	0.083*	0.345**	0.176***	0.021	0.032
	(0.043)	(0.141)	(0.012)	(0.070)	(0.028)
S_NUCLR	0.051	0.318*	1.243***	−0.003	0.027
	(0.044)	(0.162)	(0.300)	(0.077)	(0.024)
S_OIL	0.074**	0.327**	0.203***	0.044	0.034
	(0.037)	(0.143)	(0.012)	(0.083)	(0.026)
S_RENEW	0.014	0.242*	0.089***	−0.219*	−0.010
	(0.029)	(0.130)	(0.026)	(0.117)	(0.029)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
pseudo R^2	0.082	0.068	0.098	0.086	0.074
N	60,993	40,495	20,498	29,642	31,351

Notes: The table reports the results after controlling for the impact of energy production infrastructure. The pool sample period is 2006–2016. The whole sample is split between high- and low-income countries and between high- and low-population countries. Standard errors are clustered at the country level and are reported in parentheses. The outcome variable is access to energy, ENERGY. The key independent variable is whether the firm has had its financial accounts externally audited, AUDIT. Control variables are the firm-specific characteristics, and the one-year lagged values of the percent of total electricity produced from coal (S_COAL), the percent of total electricity produced from natural gas (S_GAS), the percent of total electricity produced from hydroelectric sources (S_HYDRO), the percent of total electricity produced from nuclear sources (S_NUCLR), the percent of total electricity produced from oil (S_OIL) and the percent of total electricity produced from renewable sources (S_RENEW). An ordered probit model is used. The marginal effects of the regressions are reported. The effects of the firm-specific characteristics and the country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

results of the expanded baseline model after controlling for the impact of the percent of total electricity produced from coal (S_COAL), the percent of total electricity produced from natural gas (S_GAS), the percent of total electricity produced from hydroelectric sources (S_HYDRO), the percent of total electricity produced from nuclear sources (S_NUCLR), the percent of total electricity produced from oil (S_OIL) and the percent of total electricity produced from renewable sources (S_RENEW). The results show that the coefficient of AUDIT remains negative and significant in all models, except for low-income and low-population countries. The significance of the effect appears to be stronger in large and richer developing countries. Coal-based energy production has a broadly negligible effect on firms' access to energy. All other sources of energy generation surprisingly are associated with higher energy constraints of firms. A notable exception is the contribution of renewable resources to firms' energy access, which is positive in large and rich developing countries.

6. Conclusions

International pressures on developing countries to achieve the universal energy access 2030 goal are high. Further, developing countries must establish stricter monitoring mechanisms to closely monitor firms' financial information, thereby attracting energy investment. A key monitoring mechanism is the integrity of financial information included in the firms' financial accounts. We proxy the integrity of financial information by the extent to which the firm has had its financial accounts checked and audited by an external auditor the previous year. Then, we analyze the impact of financial information integrity on firms' access to energy in developing countries. We use data drawn from the World Bank's Enterprise Surveys that cover 132,903 non-financial firms from 138 developing countries, between 2006 and 2016. An important strength of the data is the coverage of small and medium enterprises and of private, non-listed firms. Our results show that the integrity of financial information is a robust predictor of firms' access to energy in all countries. On average, across all developing countries, the decision of firm to have its financial accounts externally audited is associated with a more significant likelihood of better access to energy. The effect is especially strong in large countries but it does not differ much between richer and poorer countries. Large countries have a wider range of on-grid and off-grid sources of energy generation and of auditing services providers. In contrast, small developing countries seem to lack the benefits of scale and expertise. The specific characteristics of firms are broadly important predictors of their energy constraints, highlighting the microeconomic dimension of the analysis. Some firm characteristics (e.g. size, sector, private ownership) are more robust predictors, whilst others (e.g. age, legal status, etc.) are less so. The baseline results hold when we split the sample in accordance with firm size, sector of activity, and geographical location. However, we also document differences. The integrity of information effect is considerably stronger in large firms relatively to small firms, in the firms operating in the manufacturing sector relative to those of the services sector, and in the firms located in the East Asia and the Pacific region that include some of the more technologically advanced and dynamic countries. We extended our analysis to include the impact of controlling impact of various national economic and non-economic factors, such as the macroeconomic, auditing and energy infrastructure environments. While the baseline results hold well, we also document a significant mitigation effect of the country-level controls. This shows that the levels of economic and financial development, monetary stability and economic openness, the conditions that form an efficient accounting and auditing environment and the technical structure of energy generation in a country play a role in mitigating the financial information integrity effect on firms' access to energy. It appears that energy policy in the developing world aiming at improving firms' access to energy must pay attention to the conditions that lead firms to embrace higher level and quality of external auditing and those that raise the level and quality supply of expert auditing services.

Credit author statement

Charilaos Mertzanis was responsible for the project's conceptualization, data curation, formal analysis, methodology and presentation. Samy Garas was responsible for the review of the literature. Ahmed Abdel-Maksoud was responsible for review & editing of the original draft.

Note to the reviewers

The data used for the paper was provided by the World Bank on a confidential basis. It cannot be shared or publicly uploaded. The reviewer may have access to the data subject to signing a confidentiality agreement with the corresponding author. The analysis used STATA software. The commands are uploaded on Mendeley (see link below): https://data.mendeley.com/datasets?query=mertzanis%20charilaos&page=0.

Appendix A. Definition of variables

Variable	Description and source
ENERGY	Ordinal variable that takes the value of 0 if the firm experiences access to energy to be no constraint for its business operation, 1 (minor constraint), 2 (moderate constraint), 3 (major constraint) and 4 (very severe constraint), from the World Bank's Enterprise Surveys
AUDIT	Binary variable that takes the value of 1 if the firm has had its financial accounts checked ad certified by an external auditor in the previous year and 0 otherwise, from the World Bank's Enterprise Surveys
FINCON	Binary variable that takes the value of 1 if the firm experiences financial constraints and 0 otherwise, from the World Bank's Enterprise Surveys.
CORRUPT	Binary variable that takes the value of 1 if the firm experiences corruption as an obstacle to its business operations and 0 otherwise, from the World Bank's Enterprise Surveys.
AGE	Logarithm of the number of years between the present year and the year of the firm's establishment, from the World Bank's Enterprise Surveys.
SIZE	Ordinal variable that takes the value of 1 if the firm is small (5–19 employees), 2 if it is medium (20–99 employees) and 3 if it is large (over 99 employees), from the World Bank's Enterprise Surveys
SECTOR	Binary variable that takes the value of 1 if the firm is in manufacturing and the value of 2 if the firm is in other sectors of activity, from the World Bank's Enterprise Surveys.
LEGAL	Binary variable equal to 1 if the firm is a limited-liability joint stock company and 0 otherwise, from the World Bank's Enterprise Surveys.
EXPORT	Binary variable equal to 1 if the firm exports directly more than half of its total sales, from the World Bank's Enterprise Surveys.
OWNP	The percentage of the firm owned by domestic private individuals, companies or organizations, from the World Bank's Enterprise Surveys.
OWNF	The percentage of the firm owned by foreign private individuals, companies or organizations, from the World Bank's Enterprise Surveys.
OWNG	The percentage of the firm owned by the state, from the WB Enterprise Surveys.
OUTAGE	The average duration of power outages in a typical month over the fiscal year experienced by the firm, from the World Bank Enterprise Surveys.
GENRT	The percent of electricity coming from generators owned or shared by the firm, from the World Bank Enterprise Surveys.
GDPCAP	Logarithm of the GDP per capita (current USD), from the World Development Indicators. It is generally considered a measure of a country's level of economic development.
CREDIT	Logarithm of domestic credit to the private sector (percent of GDP), from the World Development Indicators. It is generally considered a measure of a country's level of financial development.
INFL	Index of the consumer price level (2010=100, year average), from the World Development Indicators.
GLOBFIN	The degree of economic globalization of a country, ranging from 0 to 100, from the ETH Zurich (KOF index, annually updated). Higher values indicate more globalized financial flows.
ENERCONS	The annual level of electric power consumption (Kw) per capita, from the World Bank's World Development Indicators.
INTENSCO	The annual level of the CO_2 emissions intensity, from the World Bank's World Development Indicators.
APPLIFRS	Ordinal variable that focuses on a country's policy towards IFRS implementation for non-listed firms. It takes the value of 1 if IFRS is not permitted, 2 if IFRS is permitted, 3 if IFRS is required for some firms and 4 if IFRS is required for all firms. The variable is based on calculations from Deloitte IAS*Plus* database.
OVERSGHTB	Dummy variable that takes the value of 1 is there is an accounting and auditing oversight body in the country, and 0 otherwise), from the IFAQ's assessment of the regulatory and standard-setting framework.
AUDITEXP	Log value of the average number of years of auditor experience, from the IFAQ's assessment of the regulatory and standard-setting framework.
APPLIFRS	Ordinal variable that focuses on a country's policy towards IFRS implementation for non-listed firms. It takes the value of 1 if IFRS is not permitted, 2 if IFRS is permitted, 3 if IFRS is required for some firms and 4 if IFRS is required for all firms. The variable is based on the authors' calculation of information from the Deloitte's IASPlus database.
AUDITQUAL	Dummy variable that takes the value of 1 if there are at least 3 Big-4 offices in the country, and 0 otherwise, from the World Economic Forum's Global Competitiveness Report. It is generally considered a measure of audit quality.
S.COAL	Electricity production from coal sources (% of total), from the World Bank Development Indicators.
S.HYDRO	Electricity production from hydroelectric sources (% of total), from the World Bank Development Indicators.
S.GAS	Electricity production from natural gas sources (% of total), from the World Bank Development Indicators.
S.NUCLR	Electricity production from nuclear sources (% of total), from the World Bank Development Indicators.
S.OIL	Electricity production from oil sources (% of total), from the World Bank Development Indicators.
LABORSIZE	The number of total production workers in the firm, from the World Bank's Enterprise Surveys. The variable is used as an instrument in endogeneity analysis.

Appendix B. Sensitivity and endogeneity analysis

The analysis must account for a number of potential estimation problems. First, there is a possibility that the firms' energy constraints influence endogenously their decision to have their financial accounts externally audited, generating a problem of reverse causation. This problem might cause regressors to be correlated with the error term. However, we argue that endogeneity concerns arising from reverse causation do not apply in this study. It is rather unreasonable to expect a feedback effect moving from the individual firms' energy constraints to their decision to have their accounts audited. The two types of decisions are driven mainly by different considerations. Further, the large cross-section of firms and countries also limits the possibility of reverse causation. Moreover, we add firm-level characteristics as first-level controls and include dummies capturing fixed effects. Subject to these controls, the baseline results remain relatively robust and stable. However, in order to check further the robustness of our baseline results, additional sensitivity tests are applied below, focusing on alternative measurement and estimation methodologies.

The first set of sensitivity controls focuses on alternative measurement of key variables and on alternative sample structures. To save on space, only a summary of the results is presented in Table B1. *First*, we explore the sensitivity of results to a different measure of the outcome variables. We recode ENERGY as a binary variable that takes the value of 1 if the firm experiences any energy constraint and 0 otherwise. A binary response makes sense because, in their decision-making, firms may not practically use the full range of available responses. This binary measure may better reflect reality of firms across firm size, location and industry. Panel A of Table B1 reports a significant and negative coefficient of AUDIT in all models, thus broadly confirming the stability of the baseline results. The significance of the effect appears to be slightly stronger relative to the baseline model. This is especially the case for the firms in high-population countries, which have a larger range of auditing services. *Second,* we explore the sensitivity of results to a different sample structure. The sample size is expanded to include all exchange-listed firms. This increases the sample size by 6591 firms. Given that listed firms are subject to more stringent disclosure requirements, this sample extension should strengthen the impact of financial information integrity. Panel B of Table B1 reports the results. The coefficient of AUDIT remains significant and negative in all models. However, its significance appears to be somewhat weaker, except for high-income countries due to the presence of active exchanges in the latter countries.

Third, we explore the sensitivity of the results to a different sample by country size. Now the sample excludes all small countries with less than 500 firms in each. This decreases the sample size by 8297 firms. While there is an audit process to validate ES data, its quality might still suffer for some firms in very small countries. If poor data quality was systematically related to family ties it would confound the outcome. The restriction of the sample confines the analysis to large countries, in which auditing might benefit from wider choices and better resources. Panel C of Table B1 reports the results. Similarly, the coefficient of AUDIT remains significant and negative in almost all models thus confirming the stability of the baseline results. Again, the financial information integrity effect appears to be associated with lower energy constraints of firms. *Fourth*, we explore the sensitivity of the results to a different sample that includes roughly the same number of firms per country. The original sample includes countries with a large number of firms (i.e. India, Russia, Egypt) and countries with a small number of firms. In order to contain large country bias, we restrict the sample size to at most 500 firms per country for all 138 countries. This threshold avoids a drastic reduction in the sample size, which is nevertheless reduced to about one half. However, small and large countries are now roughly equally weighted. Panel D of Table B1 reports the results. The coefficient of AUDIT remains significant and negative for most models, except for high-income countries. In conjunction with the findings in Panel C above, this result appears to imply that the financial information effect on energy access is relatively stronger in low-income countries. *Fifth*, we explore the sensitivity of the results to a different set of firm-level controls. We now add two new variables that capture the extent to which firm's energy constraints are affected by technical conditions, such as the extent of electricity generation through the use of generators (GENERAT) and the duration of electric power outages (OUTAGE). The Appendix A describes the variables. Panel E of Table B1 reports the results. The coefficient of AUDIT remains significant and negative for most models, except for low-income countries, thus broadly confirming the validity of the baseline results. Overall, our sensitivity controls broadly confirm the baseline results and do not fundamentally affect their overall distribution according to country development. Notably, the higher the integrity of financial information, the lower the energy constraints of firms in developing countries.

The second set of sensitivity controls focus on the use of alternative estimation methodologies. We use three different methodologies for re-estimating Eq. (1): an OLS method and an instrumental variables (IV) method that uses separately the 2SLS and the GMM estimators. On the one hand, the OLS method has the disadvantage that its linear estimation may result in predicted values for the outcome variable below zero or above one. However, it has the advantage of avoiding the possible estimation bias from the incidental parameter problem inherent in nonlinear estimations (probit) with fixed effects, as well as of maintaining simplicity and comparability across studies (Angrist and Pischke, 2009, p. 197). On the other hand, when the explanatory variable is measured with error, this error is embedded in the residual. However, the observed explanatory variable also contains error, causing a correlation of the regression error term and the explanatory variable that generally results in estimation bias. The latter is especially severe when the variability of the error is large, which is of particular concern in our cross-country setting. We make an effort to correct for measurement error of our key regressor, AUDIT, using an instrumental variable approach (Greene, 2012). Specifically, we identify a second institutional variable that is strongly related to the (allegedly) mis-measured regressor, but with a measurement error that is uncorrelated to the measurement error in the key institutional regressor. This variable is the number of permanent, full-time production employees in the firm, LABORSIZE. The instrument correlates considerably with AUDIT (16.11%) and very little with ENERGY (0.46%). This external instrument is measured by methods and information sources, which have a closely related theoretical context with AUDIT, does not suffer from missing values, and produces relatively strong first-stage results, i.e. it is not a weak instrument. The firm's level of core employment affects the extent of compliance with regulatory mandates (Cooke, 1992). Except for very few countries, small companies are not required to have their accounts audited (Page, 1997). Nevertheless, large and complex corporations are mandated to audit their financial accounts to comply with stock market listing and satisfy the public interest (Cooke, 1992), and to mitigate the conflict of interests among firm managers, shareholders, and bondholders (Tauringana and Clarke, 2000). Accordingly, the size of leverage and employment as well as the extent of accounting-based debt covenants raise the probability of the firm having its financial accounts externally audited. Table B2 provides the results of the analysis using the three different estimation methods. The chosen instrument satisfies Stock and Yogo's (2005) rule of thumb that if the F-stat >10 the instruments are not weak. Further, given that we use a single external instrument, since the p-values of the Sargan and Hansen *J* tests are larger than 5%, the null hypothesis that the over identifying restrictions are jointly valid, is not rejected. This implies that the choice of the external instrument is broadly relevant. The results show that AUDIT remains significant and negative in all estimation methods. The magnitude of the financial information integrity effect is roughly similar between the OLS and the IV methods.

Any remaining source of endogeneity can arise from within-country effects. To the extent that AUDIT is not systematically correlated with within-country variables, the probit estimates are consistent and unbiased. In order to further insulate our results from the possibility of inconsistency and omitted variable bias, another instrumental variables approach is used that fits better our estimation framework. Given that our outcome variable is an ordinal one, we use a conditional mixed process maximum likelihood estimator with robust standard errors for the estimation of possible endogeneity of AUDIT (Roodman, 2011). The conditional process means that the model can vary by observation. An equation can be dropped for observations for which it is not relevant. The mixed process means that different equations can have different types of dependent variables (different response types). The maximum likelihood approach to estimating the separate equations as a system (mixed process), rather than as a two-step estimator, has clear benefits. It overcomes several potential problems of endogeneity and unobservable influences, but at the cost of estimation efficiency. The external instrument used is the number of permanent, full-time production employees in the firm, LABORSIZE. Table B3 reports the results of the unconstrained, the constrained and the mixed conditional process (only key effects are reported to save on space). Comparison among the different process estimates provides the basis for assessing endogeneity. The key point of reference is the significance of the Atanhrho12 correlation coefficient. The F and the Wald statistics are high, so the null hypothesis of relevant instruments is not rejected. The results show that the Atanhrho12 coefficient is insignificant and hence the null hypothesis of exogeneity of AUDIT cannot be rejected at the 5% level.

Table B1
Sensitivity analysis I – different variable measurement and sample structure.

Outcome variable: ENERGY	All countries	High-income countries	Low-income countries	High-population countries	Low population countries
Panel A. Different measure of the outcome variable (binary)					
AUDIT	-0.074^{***}	-0.051^{***}	-0.109^{***}	-0.140^{***}	-0.014
	(0.010)	(0.013)	(0.016)	(0.015)	(0.014)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes

(continued on next page)

Table B1 (*continued*)

Outcome variable: ENERGY	All countries	High-income countries	Low-income countries	High-population countries	Low population countries
Pseudo R^2	0.191	0.159	0.174	0.184	0.199
Wald Chi^2	21,022.387	10,612.488	7594.977	9840.421	11,381.594
Obs.	112,416	59,706	52,710	53,723	58,693
Panel B. Inclusion of publicly-listed firms					
AUDIT	−0.057***	−0.049***	−0.067***	−0.114***	−0.008
	(0.008)	(0.010)	(0.011)	(0.011)	(0.010)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.090	0.077	0.095	0.089	0.091
Wald Chi^2	31,222.236	13,956.740	14,967.135	15,089.032	16,066.444
Obs.	118,115	63,050	55,065	55,996	62,119
Panel C. Inclusion of countries with more than 500 firms only					
AUDIT	−0.059***	−0.055***	−0.064***	−0.115***	−0.004
	(0.008)	(0.011)	(0.012)	(0.012)	(0.011)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.090	0.078	0.094	0.090	0.091
Wald Chi^2	27,853.630	12,662.783	13,290.494	14,687.208	13,275.215
Obs.	105,317	56,435	48,882	53,723	51,594
Panel D. All countries are restricted to 500 firms each					
AUDIT	−0.032***	−0.001	−0.069***	−0.104***	−0.013
	(0.012)	(0.017)	(0.017)	(0.026)	(0.013)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.100	0.086	0.100	0.099	0.100
Wald Chi^2	13,666.022	5861.001	6848.639	3285.112	10,424.587
Obs.	48,038	24,433	23,605	10,500	37,538
Panel E. Inclusion of power generation variables					
AUDIT	−0.030***	−0.038***	−0.018	−0.068***	0.011
	(0.009)	(0.012)	(0.013)	(0.012)	(0.012)
OUTAGE	0.720***	0.641***	0.844***	0.783***	0.654***
	(0.009)	(0.011)	(0.014)	(0.012)	(0.013)
GENERAT	0.174***	0.121***	0.225***	0.213***	0.127***
	(0.009)	(0.013)	(0.012)	(0.012)	(0.012)
Firm-specific charact.	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.121	0.105	0.131	0.126	0.117
Wald Chi^2	31,762.543	14,759.966	16,042.385	17,150.408	14,788.327
Obs.	95,509	50,654	44,855	49,701	45,808

Notes: The table reports the results of the first round of sensitivity tests. In all models, heteroscedasticity-robust standard errors are reported in parentheses. In all models, the independent variable is the extent to which firms have their accounts externally audited, AUDIT, and control variables include the firm-specific characteristics. In all models, the pool sample period is 2006–2016 and an ordered probit estimation methodology is used. In all models, the effects of firm-specific characteristics and the country-year effects are not reported for saving on space. In Panel A, the outcome variable, ENERGY, is recoded as a binary variable (1 = energy constraint, 0 = no constraint). In Panel B, the sample size is expanded to include publicly listed firms. The outcome variable is the ordinal variable ENERGY. In Panel C, the sample size is restricted by excluding small countries with less than 500 firms. The outcome variable is the ordinal variable ENERGY. In Panel D, the sample size is restricted to having all countries with at most 500 firms each. The outcome variable is the ordinal variable ENERGY. In Panel E, two new variables are added that capture the firm's technical conditions of energy generation and transmission, OUTAGE and GENERAT. The outcome variable is the ordinal variable ENERGY. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$, $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

Table B2
Sensitivity analysis II – alternative estimation methods.

	OLS	IV-2SLS	IV-GMM
AUDIT	−0.066***	−0.071***	−0.070***
	(0.009)	(0.010)	(0.011)
FINCON	0.423***	0.424***	0.423***
	(0.009)	(0.009)	(0.009)
CORRUPT	0.342***	0.341***	0.341***
	(0.010)	(0.010)	(0.010)
AGE	0.081	−0.032	−0.032
	(0.280)	(0.288)	(0.294)
SIZE	0.033***	0.035***	0.035***
	(0.006)	(0.006)	(0.006)
SECTOR	−0.268***	−0.270***	−0.270***
	(0.009)	(0.009)	(0.009)
LEGAL	0.001	−0.002	−0.002
	(0.011)	(0.012)	(0.012)
EXPORT	−0.004	−0.006	−0.006
	(0.016)	(0.016)	(0.016)
OWNP	0.001**	0.001	0.001
	(0.001)	(0.001)	(0.001)
OWNF	0.001**	0.001	0.001

Table B2 (*continued*)

	OLS	IV-2SLS	IV-GMM
	(0.001)	(0.001)	(0.001)
OWNG	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)
Year effects	Yes	Yes	Yes
Country effects	Yes	Yes	Yes
Adj. R^2	0.246	0.244	0.244
F-stat	224.937	137.392	202.972
Sargan (p-value)		1.284 (0.257)	
Hansen_*J* (p-value)			0.460 (0.498)
N	116,019	105,382	105,382

Notes. The table reports the results from using different estimation methods. Heteroscedasticity-robust standard errors are presented in parentheses. In all models, the outcome variable is ENERGY. The key independent variable is AUDIT. Control variables include the firm-specific characteristics. The pool sample period is 2006–2016. The marginal effects of the regressions are reported. The column OLS presents the results of fitting an ordinary least squares estimation. The column IV-2SLS presents the results of a 2SLS instrumental variables approach in which the number of external instruments exceeds that of potentially endogenous regressors. The column IV-GMM presents the results of an instrumental variables approach that uses the system GMM estimator. The external instrument used is the number of full-time production workers in the firm, LABORSIZE. The test for the instrument strength is the F statistic v-a-v the Stock and Yogo (2005) critical values. The test for overidentifying restrictions and the relevance of all instruments for the IV-2SLS method is the Sargan statistic, whilst for the IV-GMM method is the Hansen *J* statistic. Country-year effects are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

Table B3
Endogeneity analysis – further testing.

PROCESS	Unconstrained	Constrained	Mixed
OUTCOME VARIABLE	AUDIT	ENERGY	AUDIT
LABORSIZE	−0.001***		−0.001**
	(0.001)		(0.001)
ATANHRHO_12			−0.0012
			(0.003)
Firm-specific charact.	Yes	Yes	Yes
Year effects	Yes	Yes	Yes
Country effects	Yes	Yes	Yes
Adj. R^2	0.133	0.028	
F stat	1898.1	94.34	
Wald Chi^2			22,326.2
N	109,543	45,232	99,367

Notes: The table reports the results of the endogeneity analysis of the independent variable, AUDIT. Heteroscedasticity-robust standard errors are presented in parentheses. The endogeneity analysis uses an ordered probit model and a conditional mixed process maximum likelihood estimator, executed by the *cmp* command in Stata (Roodman, 2011). The external instrument is the number of full-time production workers in the firm, LABORSIZE. For each outcome variable, the columns show the results of the unconstrained, constrained and mixed regressions, respectively. The point of interest is the third column (mixed process), which shows the maximum likelihood estimate (ATANHRHO_12 coefficient) of the correlation of the error terms of the constrained and unconstrained models and compares their likelihoods. Year effects and coefficients of firm-specific characteristics are not reported. The symbols *, **, *** correspond to $p < 0.1$, $p < 0.05$ and $p < 0.01$, respectively. The Appendix A provides definitions of the variables.

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