Energy Economics 130 (2024) 107309

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneeco

Firm productivity in the Energy-electricity sector over the last two decades with crisis: The role of cross-listing

Tam Hoang-Nhat Dang [a], Faruk Balli [a,b,*], Hatice Ozer Balli [a], Hannah Nguyen [a]

[a] School of Economics and Finance, Massey University, East Precinct, Albany Expressway, Albany, Auckland 0632, New Zealand
[b] Higher School of Economics and BusinessAl-Farabi Kazakh National University, Almaty, Kazakhstan

ARTICLE INFO

JEL codes:
G15
G32
G34

Keywords:
Firm productivity
Total factor productivity
Cross-listing
Energy sector
Capital expenditures

ABSTRACT

Novel to the literature, this study examines how cross-listing impacts firms' productivity in Energy sector. Annual data of firm cross-listing over the last two decades with crisis (2002-2022) is employed for our analyses. We find evidence of significant drop in productivity after Energy firms (including electricity firms) cross-list in the US market. Meanwhile, we do not find strong evidence of significant decreases in firm productivity from other sectors in our sample. We note one possible explanation for this finding is that after cross-listing, Energy firms appear to utilize their increased capital to heavily invest in infrastructure, equipment, and plants for expansion, which might eventually damage their productivity. To seek for more thorough explanations for such decreases in Energy firms' productivity after cross-listing, we identify the determinants of firm productivity in Energy sector. Our results provide strong evidence that the increases in capital expenditures after Energy firms cross-list appear to be associated with the decreases in firm productivity. Notably, we note that negative impacts of capital expenditures (after cross-listing) and state ownership on firm productivity become much stronger and more statistically significant in developed countries than in emerging countries. Last, corporate governance and firm liquidity are found to be two determinants that help improve firm productivity in both electricity firms and other energy firms.

1. Introduction

Investment barriers across financial markets have been dramatically reduced due to cross-border capital market liberalization (Dodd, 2013), which allow investors to gain access to various financial assets worldwide (Balli et al., 2022). However, there still exist some international capital flow obstacles which have been unresolved, including trading costs, different investor protection, and different restrictions relating to foreign ownership among different capital markets. From the perspective of several corporate managers, such investment barriers could be overcome by cross-listing shares (Balli et al., 2022; Reiter, 2021).

Cross-listing is considered the situation in which the stock of a firm is listed on one foreign stock exchange (Karolyi, 2006; Shi et al., 2012). A significant body of literature has investigated motivations for cross-listing of firms. The extant literature documents two main focuses on the benefits of cross-listing (Peng and Su, 2014). *First*, firms can gain access to great source of foreign capital with a lower cost of financing as firm shares become available to a greater group of international investors (Hail and Leuz, 2009). In more detail, as cross-listing allows firm shares to be accessible to global investors, it will enhance stock investibility and improve risk sharing, leading to reduced cost of capital. *Second*, in line with the "bonding hypothesis", cross-listing on a foreign stock exchange with more stringent legal and disclosure requirements than those in the home stock exchange appears to lead to improved corporate governance practices (Coffee, 1999a; Stulz, 1999).

Cross-listing decision could be highly strategic regarding the growth of firms (Peng and Su, 2014). According to business strategy theory, a decision of cross-listing appears to be an integrated part of the global business strategies of a firm (King and Mittoo, 2007; Pagano et al., 2002). Firms might choose to cross-list in foreign stock exchanges to access overseas capital markets to fund their global investment projects, to support their mergers and acquisitions (M&A) activities in overseas markets as well as to retain their competitive position against other peers in the industry (Dodd, 2013; Mittoo, 2003; Pagano et al., 2002).

Previous studies indicate that firms cross-listing in the US markets appear to access more extensive, efficient, and liquid market compared

* Corresponding author.
E-mail addresses: H.N.T.Dang@massey.ac.nz (T.H.-N. Dang), F.Balli@massey.ac.nz (F. Balli), H.OzerBalli@massey.ac.nz (H.O. Balli), H.Nguyen2@massey.ac.nz (H. Nguyen).

https://doi.org/10.1016/j.eneco.2024.107309
Received 31 May 2023; Received in revised form 26 December 2023; Accepted 7 January 2024
Available online 10 January 2024

to the home market (Balli et al., 2022; Lambrecht and Myers, 2012). Additionally, recent studies show evidence that easy access to capital through financial liberalization helps foster investment and enhance resource allocation (Heil, 2019; Lambrecht and Myers, 2012). Furthermore, as demonstrated by Heil (2019), financial liberalization, encompassing the relaxation of foreign capital controls and equity market opening, is linked to improved productivity. As such, our hypothesis posits that the more affordable capital acquired by companies through cross-listing is likely to enhance their access to foreign capital and potentially boost firms' overall productivity.

Firm productivity is regarded as the improved efficiency in the real economic performance of a firm, which is measured by the residual production output beyond the input costs' contribution. The total factor productivity has been considered an essential component of firm's economic growth (Baier et al., 2006; Dowrick and Nguyen, 1989; Thompson and Rushing, 1999; Tian and Twite, 2011). Existing literature indicates that there are different channels through which foreign ownership might exert significant effects on firm productivity (Xu et al., 2022). One of those channels is financing support. Beck et al. (2005a) suggest that financial obstacles appear associated with lower firm performance and productivity. Meanwhile, several empirical studies indicate that foreign ownership is linked to reduced financial obstacles (Dong and Men, 2014; Knack and Xu, 2017). Through the financial support from firm's foreign parents, firms with overseas ownership is likely to relax their financial constraints and achieve greater productivity (Xu et al., 2022). Although the nexus between firm productivity and foreign ownership has been investigated, we note that the relationship between cross-listing and firm productivity appears to be largely ignored.

In recent years, energy sector is reported to drive economies and sustain societies worldwide (UNEP, 2023). According to The World Bank (2023a), energy is considered the heart of development as it enables innovations, investments as well as new industries which might lead to job opportunities, shared prosperity, and inclusive growth for economies across the globe. Previous studies show evidence that energy sector is one of significant determinants of GDP growth for emerging economies mostly (Stern, 1993, 2000). Indeed, private sectors highly prioritize Energy sector since the demand for energy services is increasing in not only developed but also developing economies as well as this sector has significantly social and environmental impacts (Biagini and Sagar, 2004). Over the last two decades, the world has experienced several energy-related crises, including the 2000s energy crisis (2003–2008), the great oil crash of 2014, the stunning drop in oil prices in 2016 and the 2021–2023 global energy crisis following the Covid-19 pandemic in 2021 and the Russian invasion of Ukraine in 2022. Such crises appear to cause significant impacts on both macroeconomic and a firm level. Given that energy is a highly capital intensive sector (Raikar and Adamson, 2020), and is considered as the main growth determinant for some emerging economies, the productivity in this sector is directly related the economic welfare of the world. This study aims to investigate how cross-listing of energy companies impacts their productivity under the age of energy crises. Additionally, we explore the determinants of Energy sector's productivity at firm level.

In that respect, our study contributes to the literature in the following aspects. *First*, to the best of our knowledge, this is the first paper to investigate how cross-listing into the US markets of Energy firms affects their productivity. Specifically, we consider that after cross-listing, firms might have easy access to foreign capital with lower costs. This is even more meaningful for emerging markets where the capital is relatively scarce (Bruhn and Zia, 2013; Veronica et al., 2020) and cost of capital is relatively higher (IEA and ICL, 2023). Eventually, improved access to foreign capital is expected to enable firms to become more competitive (Dodd, 2013; Mittoo, 2003), and thus firms appear to gain higher productivity in general. As such, our study aims to examine how firm productivity in Energy sector changes after cross-listing and find reasonable explanations for those changes. *Second*, we also provide in-depth analysis on firm productivity, including (*i*) estimating and comparing firm productivity between different stages of cross-listing (before cross-listing; Stage (1) - the first five years after cross-listing; and Stage (2) - the remaining years following Stage (1)); (*ii*) comparing firm productivity between Energy sector and other sectors in the sample; and (iii) separating the whole sample into Developed and Emerging countries to see the differences in firm productivity between those two groups of countries. *Third more importantly,* to understand which factors significantly explain firm productivity in the presence of cross-listing, we identify the determinants of productivity in Energy sector at firm level. We simply test if the productivity increased after the cross listing, and if it is directly related to capital expenditure. Interestingly, the decrease in productivity for energy firms are directly related with their high volume of capital expenditure, in the early stages. We also perform several robustness tests to ensure the reliability of our baseline results.

Findings from our study show that firms in Energy sector (including electricity firms) experience significant drop in productivity after they cross-list in the US markets, whereas we do not find strong evidence of significant decreases in firm productivity from other sectors in our sample. We also observe that capital expenditures and fixed assets of both electricity firms and other Energy firms witness significant increases after cross-listing. Accordingly, Energy firms might utilize their increased capital (obtained through cross-listing process) to heavily invest in infrastructure, equipment, and plants for expansion, which might eventually damage their productivity. By identifying the determinants of firm productivity in Energy sector, we find strong evidence that the increases in capital expenditures after Energy firms cross-list appear to be associated with the decreases in firm productivity. Especially, the negative effects of factors (i.e., *capital expenditures after cross-listing* and *state ownership*) on firm productivity are found to be much stronger and more statistically significant in developed economies than in emerging economies. Last, corporate governance and firm liquidity are two factors that help enhance firm productivity in both electricity firms and other firms from Energy sector.

The rest of our study is structured as follows. Section 2 presents our literature review while Section 3 introduces our methodology and data. In Section 4, we present and discuss our empirical results. Last, Section 5 shows our conclusions and proposed implications.

2. Literature review

The process of globalization in financial markets has resulted in a significant increase in the number of non-U.S. firms opting to cross-list their shares on U.S. exchanges (Eun and Sabherwal, 2003; Karolyi, 2006). These companies not only represented those from developed economies but also included numerous firms from emerging economies that were opening their stock markets to foreign investors for the first time. The growing popularity of cross-listings has sparked considerable academic interest, leading to numerous studies focused on understanding the motivations behind firms pursuing cross-listing. Based on conventional wisdom, scholars have primarily identified three key motivations, including (i) share price reactions; (ii) liquidity, multi market trading, price discovery, and (iii) changing market risk exposures and the cost of capital.

Regarding the first justification for cross-listing, empirical studies have predominantly focused on the share price reactions surrounding a firm's listing decision. Several studies have extensively examined this aspect, such as Pascual et al. (2006)' study for Spanish firms cross listed in NYSE, Frijns et al. (2010)' study for four Australian stocks cross-listed in New Zealand and five New Zealand stocks cross-listed in Australia. In the study conducted by Eun and Sabherwal (2003), the authors specifically investigate the contribution of U.S. stock exchanges to the price discovery process for non-U.S. stocks that have been cross-listed in the United States. The findings reveal that the U.S. exchange significantly contributes to the price discovery mechanism for these stocks.

Table 1
List of variables and their data sources.

Variable	Symbol	Proxied by	Unit	Data sources
A. Variables to estimate total factor productivity (TFP)				
Firm's output	*Output*	Operating income	US dollar	Refinitiv Eikon
Labor input	*Labor*	Number of employees	Employee	
Capital input	*Capital*	Net fixed assets	US dollar	
Intermediate input	*Intermediate*	Total costs exclude depreciation and amortization	US dollar	
B. Explanatory variables				
Capital expenditures	*Capex*	Firm's capital expenditures	US dollar	Refinitiv Eikon
Corporate governance	*Governance*	Governance pillar score	Score	
State ownership	*State_own*	Percentage of state ownership of capital	Ratio	
Liquidity	*Liquidity*	(Current assets - Current liabilities) / Total assets	Ratio	

Furthermore, various studies indicate that cross-listing on overseas exchanges can lead to improved liquidity for firms, which is often considered a primary motivation for corporate managers (Bris et al., 2007; Dodd, 2013). These enhancements are evident in several aspects, including lower bid-ask spreads, increased trading volumes, and higher trading values. Domowitz et al. (1998), for example, reported a higher trading volume, and a decrease in domestic bid-ask spreads for US cross-listed firms from Mexico. Bris et al. (2007) revealed an economically and statistically significant increase in the liquidity of domestic stock after the listing in the U.S. Another significant benefit of cross-listing is the potential for changing market risk exposures and the cost of capital. Cross-listings are often perceived positively because they allow management to circumvent regulatory restrictions, reduce costs, and overcome information barriers that typically impede cross-border equity investment (Karolyi, 2006). Study by Hail and Leuz (2009) showed that companies with cross-listings on U.S. exchanges observe a reduction in their cost of capital ranging from 70 to 120 basis points.

Several additional studies highlight various benefits that cross-listed firms can enjoy. These include an enhancement in the information environment for non-U.S. stocks (Fernandes and Ferreira, 2008), greater analyst coverage and increased forecast accuracy (Lang et al., 2003), and governance improvements (Karolyi, 2006). According to the findings of Edison and Warnock (2008), emerging equity markets often face higher transaction costs, increased risk of failed trades, and potential challenges related to financial information due to diverse accounting practices, disclosure requirements, and enforcement. By deciding to pursue cross-listing on a U.S. exchange, these costs, both direct and informational, can be eased. This strategic move allows the cross-listed firm to benefit from the robust information environment and investor protection regulations associated with the United States.

Productivity is widely recognized as the most significant characteristic of a firm and serves as a versatile measure of its performance. Extensive research has been conducted to identify the factors that contribute to improvements in productivity at the firm level. In a comprehensive survey conducted by Syverson (2011), it is suggested that the existing literature has identified various internal and external drivers that account for differences in productivity among firms. The internal drivers encompass factors such as managerial talent, the quality of capital and labor inputs, research and development, information technology, learning by doing, firm structure decisions, and product innovation. The external drivers of productivity include productivity spillovers, competition within the market, industry deregulation, the flexibility of input markets, and trade competition.

Emerging literature suggests that foreign ownership can serve as another driver of firm productivity. In a recent study by Xu et al. (2022), which utilized the World Bank Enterprise Survey (WBES) dataset comprising over 120,000 firms from 139 countries, the impact of foreign ownership on firm productivity in private firms was examined. The study found strong evidence of positive relationship between foreign ownership and firm productivity. Previous research has also explored two potential channels through which foreign ownership influences productivity: innovation and finance. Foreign ownership is associated with increased innovation activities and reduced financial constraints within host firms and both innovation and improved access to finance are known to contribute to higher firm performance and productivity (Boubakri et al., 2013; Jin et al., 2019; Luong et al., 2017). For instance, several papers have highlighted the link between foreign ownership and reduced financial constraints (Beck et al., 2006). Financing obstacles, in turns, have been identified as factors that hinder firm performance and productivity (Beck et al., 2005b). Therefore, firms with foreign ownership may benefit from the financial support provided by their foreign parents, leading to higher levels of productivity. In addition, Xu et al. (2022) propose that foreign ownership can enhance productivity through the utilization of telecommunication facilities and the management of labor costs. In fact, firms with foreign ownership often rely more extensively on communication technology compared to their purely domestic counterparts. Given that the adoption of telecommunication applications has been found to have a positive impact on firm productivity (Arnold et al., 2008), it is likely that firms with foreign ownership achieve higher productivity levels through their broader usage of telecommunication resources.

Despite the extensive body of research exploring the impact of cross-listing on various aspects of firm performance and studying the effects of foreign ownership on firm productivity, the relationship between cross-listing and firm productivity has received relatively limited attention. It is important to note that while both cross-listing and foreign ownership enable companies to expand their reach beyond their domestic markets, cross-listing and foreign ownership are distinct concepts with different implications. Cross-listing entails a deliberate strategic decision by a company to expand its market presence by listing its shares on a foreign exchange. This strategic move allows the company to attract a larger pool of investors and enhance its visibility in international markets. In contrast, foreign ownership refers to the composition of a company's ownership structure, indicating the participation of foreign investors who hold shares in the company. It signifies the presence of international investors among the company's shareholders and does not necessarily involve cross-listing.

Generally, empirical studies highlighted that cross-listing presents a significant advantage by potentially reshaping market risk exposures and reducing the cost of capital. Simultaneously, studies have consistently shown that the alleviation of financial constraints, facilitated by the financial support extended by foreign investors, can act as a vehicle for enhancing firm productivity. Considering these findings, our hypothesis suggests that the more cost-effective capital acquired by companies through cross-listing has the potential to stimulate their overall productivity.

This research aims to expand the existing body of scholarly knowledge concerning the nexus of firm productivity and cross-listing, with a specific focus on their interplay within the energy sector cross-listed in the US market. Our emphasis on the energy sector is based on a series of energy-related crises that have unfolded over the past two decades. These crises encompassed the 2000s energy crisis (2003–2008), the oil

Table 2
Summary statistics of variables.

A. Descriptive statistics

Variable name	Observations	Mean	Median	SD	Min	Max
Output	911	21.122	20.374	3.065	12.991	30.795
Capital	911	23.025	22.268	3.143	15.006	32.240
Labor	911	8.611	8.517	1.947	2.197	13.223
Intermediate	911	22.974	22.552	3.097	15.118	31.388
TFP-WRDG	911	2.707	2.762	1.077	−2.276	5.562
TFP-LP (2003)	911	0.846	0.928	1.008	−3.926	3.084
TFP-OP (1996)	911	2.365	2.431	1.058	−2.620	5.230
TFP-Translog	911	2.724	2.666	1.240	−2.080	6.311
Capex	911	14.516	19.886	10.52	0.000	29.053
Governance	911	0.343	0.325	0.315	0.000	0.986
State_own	911	0.188	0.000	0.256	0.000	0.727
Liquidity	911	0.086	0.091	0.142	−1.103	0.525
Cross_listing	911	0.673	1.000	0.469	0.000	1.000

B. Correlation matrix

	TFP-WRDG	*capex*	*governance*	*state_own*	*liquidity*
TFP-WRDG	1.000				
Capex	0.141	1.000			
Governance	0.078	0.413	1.000		
State_own	0.077	0.464	0.583	1.000	
Liquidity	0.291	0.012	−0.060	−0.013	1.000

Note: *Output* - firm's output; *Capital* - capital input; *Labor* - labor input; *Intermediate* - intermediate input; *TFP-WRDG* - firm productivity using Wooldridge (2009) method; *TFP-LP (2003)* - firm productivity using Levinsohn and Petrin (2003) method; *TFP-OP (1996)* - firm productivity using Olley and Pakes (1996) method; *TFP-Translog* - firm productivity using translog method; *Capex* - firm's capital expenditures; *Governance* - corporate governance; *State_own* - state ownership of capital; *Liquidity* - firm's liquidity; *Cross_listing* - a dummy variable (= 1 for the period after cross-listing and = 0 otherwise).

crash of 2014, the substantial decline in oil prices in 2016, and the global energy crisis spanning from 2021 to 2023. This more recent crisis of the Covid-19 pandemic in 2021 and the Russian invasion of Ukraine in 2022 were also included. These crises have affected not only how the world's economy works but also how individual companies operate. Indeed, Ahir et al. (2022) argue that numerous remarkable events occurring in recent years, including the global financial crisis and the Covid-19 crisis, appear to raise concerns regarding increasing economic uncertainties. Especially, Dang et al. (2023) find that the energy-related uncertainties significantly increased during the recent crises, such as global financial crisis (2008), the debt crisis in Europe (2010−2011), the Covid-19 crisis (2020−2021), and the Russia's invasion of Ukraine (2022). Such remarkable events appear to lead to negative effects on both the global economy and the energy markets (Dang et al., 2023; Farid et al., 2023; Naeem et al., 2023; Naeem et al., 2022). Previous empirical studies also show evidence of substantial contagion effects across energy markets over the periods of crisis (Naeem et al., 2021; Naeem et al., 2020; Rehman et al., 2023; Umar et al., 2022). Furthermore, owing to the inherent capital-intensive nature of the energy sector and its key role as a primary ingredient for growth in economies, its productivity has significant implications for the overall global economy. Consequently, this study seeks to explore the intricate relationship between cross-listing and the productivity of energy companies, within the context of the energy crises.

Through a comprehensive analysis, various aspects of this relationship are explored. Firstly, we investigate how cross-listing influences productivity in different market contexts by comparing firms in emerging markets to those in developed markets. This analysis allows us to gain insights into the varying impact of cross-listing on productivity across different market environments. Furthermore, we extend our analysis beyond the energy sector by comparing the productivity of energy sector firms with firms from other sectors that have also undergone cross-listing. This comparative approach suggests whether the impact of cross-listing on productivity is unique to the energy sector or if similar patterns exist across different industries. In addition, we examine the effects of cross-listing on firm productivity across different phases after the cross-listing process. Specifically, we analyze the first five years following cross-listing and the subsequent years to identify potential variations in the impact of cross-listing on firm productivity over time. Lastly, our study aims to identify the key factors that significantly contribute to variations in productivity among cross-listed energy sector firms in the presence of cross-listing. By uncovering these factors, we can better understand the underlying mechanisms that drive productivity outcomes in this specific context.

3. Methodology and data

3.1. Methodology

3.1.1. Estimating firm productivity

In this study, we estimate the total factor productivity (TFP) at firm level, a proxy for firm productivity. We based on an assumption that the output of firm i is identified through a Cobb-Douglas production function as in Eq. (1) (Fons-Rosen et al., 2021).

$$Y_{it} = TFP_{it} L_{it}^{\beta_l} K_{it}^{\beta_k} \quad (1)$$

where Y_{it} is the firm value added or firm output. TFP_{it} is the total factor productivity. L_{it} and K_{it} stand for labor input and capital input, respectively. β_l represents the labor output elasticity while β_k is the capital output elasticity.

The firm-level total factor productivity is estimated as in Eq. (2).

$$log(TFP_{it}) = log(Y_{it}) - \widehat{\beta}_l log(L_{it}) - \widehat{\beta}_k log(K_{it}) \quad (2)$$

where $\widehat{\beta}_l$ and $\widehat{\beta}_k$ are estimated using the generalized method of moments (GMM) estimators suggested by Wooldridge (2009) for the baseline results. The extant literature shows several approaches to estimate production functions for firm productivity (see Ackerberg et al. (2015)). In this study, we follow the method proposed by Wooldridge (2009) with one-step GMM estimator for our baseline findings. Additionally, for robustness checks, we also employ the methods of Levinsohn and Petrin (2003) and Olley and Pakes (1996) with Ackerberg et al. (2015) (ACF) correction.

Referring to related studies (Ackerberg et al., 2015; Li et al., 2021; Ren et al., 2022), we adopt following variables (as presented in

Table 3
Firm productivity among sectors: Before and after cross-listing (Full sample).

	Comparison	Difference in means	Propensity-score matching	Number of observations
Energy	After vs Before	0.011	−0.406***	911
	Stage (1) vs Before	0.098	−0.188**	535
	Stage (2) vs Before	−0.044	−0.543***	674
Electricity firms	After vs Before	−0.182**	−0.253***	385
	Stage (1) vs Before	−0.185**	−0.246**	229
	Stage (2) vs Before	−0.180**	−0.163**	291
Other sectors				
Basic Materials	After vs Before	0.042	0.008	1515
	Stage (1) vs Before	0.088*	0.060	955
	Stage (2) vs Before	0.011	−0.025	1133
Consumer Discretionary	After vs Before	0.119***	0.191***	2774
	Stage (1) vs Before	0.186***	0.246***	1831
	Stage (2) vs Before	0.064*	0.148**	1996
Health Care	After vs Before	0.351***	0.229***	1041
	Stage (1) vs Before	0.305***	0.305***	653
	Stage (2) vs Before	0.382***	0.258***	781
Industrials	After vs Before	0.040	−0.002	3569
	Stage (1) vs Before	0.097***	0.127***	2345
	Stage (2) vs Before	−0.003	−0.068	2647
Real Estate	After vs Before	0.395***	0.256***	663
	Stage (1) vs Before	0.379***	0.278***	448
	Stage (2) vs Before	0.407***	0.223***	492
Technology	After vs Before	0.120*	0.057	827
	Stage (1) vs Before	0.078	0.061	510
	Stage (2) vs Before	0.146*	−0.045	633
Telecommunications	After vs Before	0.027	0.140	384
	Stage (1) vs Before	0.264**	0.154	202
	Stage (2) vs Before	−0.102	−0.055	285
Utilities	After vs Before	−0.061	−0.050	779
	Stage (1) vs Before	−0.0001	0.020	461
	Stage (2) vs Before	−0.098*	−0.143**	589

Notes: ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. Firm productivity is estimated employing the Wooldridge (2009)'s approach. Due to space limit, the standard errors are not presented. "Before" stands for Before cross-listing. "After" is After cross-listing. Stage (1) is the first five years after cross-listing. Stage (2) is the remaining years following Stage (1). A statistically significant negative (positive) value indicates a significant decrease (increase) in the latter period compared to the former period. Column "Difference in means" represents the mean difference between before and after cross listing productivity. See the full table at Appendix Table A1.

Table 1A) to estimate firm productivity (TFP) following aforementioned approaches.

3.1.2. Estimating the determinants of firm productivity

To identify the determinants of firm productivity in Energy sector, we propose the regression model as in Eq. (3).

$$TFP_{i,c,t} = \alpha_c + \alpha_t + \beta_1 Capex_{i,c,t} + \beta_2 Cross\_listing + \beta_3 Capex_{i,c,t} * Cross\_listing + X_{i,c,t}\gamma + \varepsilon_{i,c,t} \quad (3)$$

where *i, c, t* stand for firm, country, and year, respectively. *TFP* is the total factor productivity, estimated using Wooldridge (2009) with one-step GMM estimator. α_c and α_t captures the country-fixed effects and year-fixed effects, respectively. *Capex* stands for firm's capital expenditures. *Cross_listing* is a dummy variable (*Cross_listing* = 1 for the period after cross-listing and = 0 otherwise). *X* represents the matrix of other firm-level variables, including (i) *Governance*, corporate governance, measured by the governance pillar score; (ii) *State_own*, the state ownership of capital; and (iii) *Liquidity*, the ratio of (current assets - current liabilities) to total assets (see Table 1B). We based on previous studies on firm productivity (Ding et al., 2016; Tian and Twite, 2011) to employ those firm-level variables in our regression models.

Various model specifications are employed to estimate the determinants of firm productivity, including (1) random effects model; (2) country-fixed effects; (3) year-fixed effects; and (4) both country-fixed effects and year-fixed effects, which is also the regression model in Eq. (3). In each model from (1) to (4), we present the regression results for the non-demeaned interaction term (i.e., *Capex*Cross_listing*) and the demeaned interaction term (i.e., *Demeaned_capex*Cross_listing*). The demeaned interaction term is proposed by Balli and Sørensen (2013) to minimize the risk in which the estimated interaction terms might capture the data's other features spuriously. Accordingly, the authors suggest the panel regressions should be estimated as is Eq. (4).[1]

$$Y_{it} = \mu_i + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 (X_{1it} - \overline{X}_{1i.})(X_{2it} - \overline{X}_{2i.}) + \varepsilon_{it} \quad (4)$$

where X_{1it} and X_{2it} stand for the explanatory variables for unit *i* at time *t*. $\overline{X}_{1i.}$ and $\overline{X}_{2i.}$ represent the mean of X_{1it} and X_{2it} over time for cross-sectional unit i, respectively.

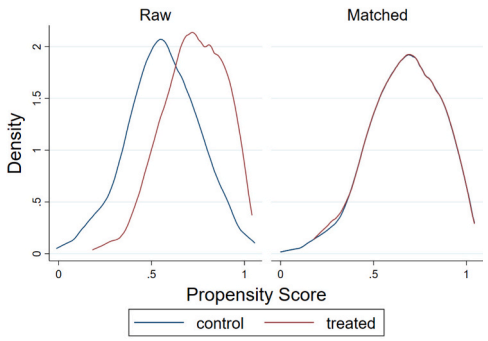
Additionally, robust standard errors are adopted in all of our regression models (see the empirical results in Section 4.2). Such robust standard errors are considered to be asymptotically equivalent to the ones proposed in Arellano (1987)'s study, which appear robust to both within-panel (serial) correlation and cross-sectional heteroskedasticity.

3.2. Data

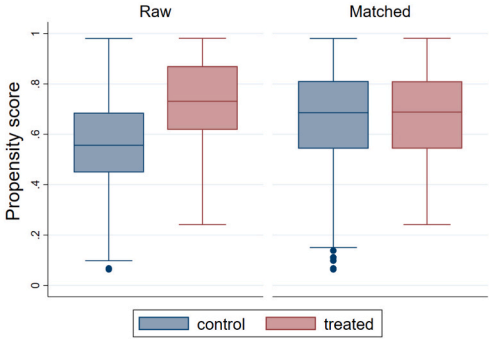
Based on the consolidated data from Citibank and Bank of New York Mellon depository receipts websites, we obtain list of firms which cross-list to the US stock markets from 2002 to 2022. Annual data of variables for estimating the total factor productivity (TFP) and regression models are all collected from Refinitiv Eikon. Our final sample consists of 911 firm-year observations on 59 cross-listed firms from Energy sector. Regarding electricity firms, we have a total number of 22 electricity firms with 385 firm-year observations.

Table 2 reports the summary statistics of all variables employed in our study. We note that our mean of total factor productivity (TFP) (as

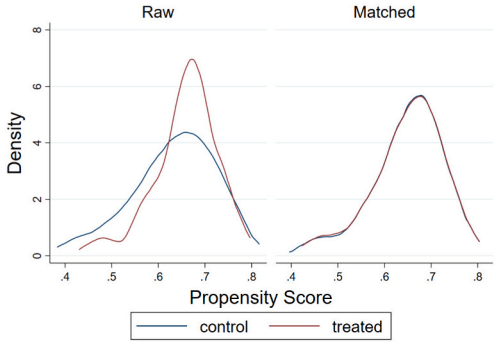
[1] This is done for one interaction variable example, to illustrate the model in a simple manner.



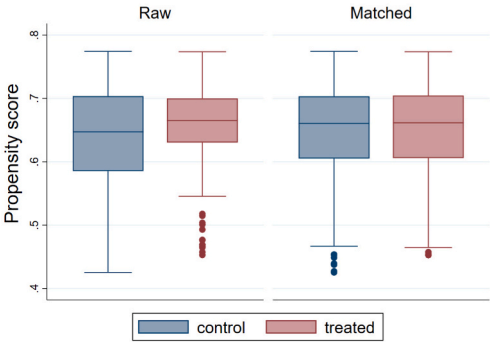
a1. Kernel density plots (Energy sector)



a2. Box plots (Energy sector)



b1. Kernel density plots (Electricity firms)



b2. Box plots (Electricity firms)

Fig. 1. Plots to check for covariate balance after estimations of propensity-score matching (firm productivity before versus after cross-listing).

shown in Table 2A) is nearly equal to the mean TFP from previous studies on firm productivity (Figal Garone et al., 2020; Fiorini et al., 2021; Nakatani, 2023; Tian and Twite, 2011). Such similarity confirms the reliability of our estimations of firm productivity. The correlation matrix in Table 2B indicates that all cross correlations are less than 80% (in absolute value), which show that there is little evidence of multi-collinearity in our models. Additionally, we also perform the panel unit root tests for our employed variables. The augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests confirm the stationarity of all variables employed in our study.

4. Empirical results

4.1. Firm productivity in energy sector and cross-listing

In this section, we first estimate the total factor productivity (TFP) employing Wooldridge (2009)'s approach with one-step GMM estimator for our baseline results.

Table 3 presents our estimated firm productivity in Energy sector for the whole sample. For comparison purposes, we also include firm productivity estimated for other selected sectors in our sample. We split the period after cross-listing into two different stages: Stage (1) is the first five years after cross-listing, and Stage (2) is the remaining years following Stage (1). Subsequently, we present different comparisons of firm productivity, including (*i*) After cross-listing versus Before cross-listing; (*ii*) Stage (1) versus Before cross-listing, and (*iii*) Stage (2) versus Before cross-listing.

We use the t-test for difference in mean to identify the difference in firm productivity between the groups (i.e., periods after cross-listing versus before cross-listing). Additionally, we adopt the propensity-score matching (PSM) method which was proposed by Rosenbaum and Rubin (1983). This approach is a quasi-experimental method that helps create a control group through matching each treated unit with each non-treated one which has similar properties. By employing those matches, we could examine the effect of an intervention (such as cross-listing decision) (The World Bank, 2023b). For each table in this sub-section, a statistically significant negative (positive) value indicates a significant decrease (increase) in the latter period compared to the former period (for example, "After cross-listing" compared to "Before cross-listing").

Looking at Table 3, we find evidence that a majority of sectors witness increases in firm productivity after cross-listing (i.e., Stage (1) and/or Stage (2) compared to Before cross-listing), indicated by the statistically significant positive values from Table 3.

Remarkably, as can be seen in Table 3, regarding Energy sector, the propensity-score matching shows statistically significant negative coefficients, which indicate significant decreases in productivity after energy firms cross-list in the US. Similarly, we also find strong evidence (from both the *t*-test and propensity-score matching) that electricity firms witness decreased productivity after they cross-list. These findings are contrary to our hypothesis that firm productivity will be improved after cross-listing process because we consider that after cross-listing, firms might have easy access to foreign capital with lower costs, which in turn enables firms to become more competitive (Dodd, 2013; Mittoo, 2003), and hence firms might gain higher productivity in general.

We also conduct additional diagnostics to ensure that the propensity-score matching performs properly. Generally, if the matching approach is well specified, the covariates should be balanced. The kernel density plots and box plots in Fig. 1 might help assess whether the propensity-score matching balance the covariates over treatment levels. As can be seen from Fig. 1.a1 & 1.b1, the kernel density plots for the matched sample appear mostly indistinguishable between the control group (blue line) and the treated group (red line), meaning that the covariates appear to be balanced by matching on the estimated propensity score. With respect to Fig. 1.a2 & 1.b2, we can see that the box plots in case of

Table 4
Firm's capital expenditures and fixed assets in Energy sector: Before and after cross-listing (Emerging versus Developed countries).

		Energy sector						Electricity firms					
		Emerging countries			Developed countries			Emerging countries			Developed countries		
		Difference in means	Propensity-score matching	N	Difference in means	Propensity-score matching	N	Difference in means	Propensity-score matching	N	Difference in means	Propensity-score matching	N
Capital expenditures	After vs Before	10.224*** (1.167)	10.201*** (1.392)	389	10.767*** (0.772)	10.245*** (0.980)	522	7.970*** (2.383)	5.281** (2.120)	126	14.162*** (0.976)	15.178*** (1.492)	259
	Stage (1) vs Before	8.212*** (1.542)	9.980*** (1.584)	205	9.589*** (1.036)	9.713*** (1.110)	330	12.095*** (2.685)	10.310*** (2.291)	59	13.820*** (1.427)	14.750*** (1.283)	170
	Stage (2) vs Before	11.284*** (1.212)	10.783*** (1.454)	292	11.625*** (0.872)	11.332*** (0.986)	382	6.062*** (2.492)	3.666 (2.469)	95	14.405*** (1.252)	15.177*** (1.536)	196
Fixed assets	After vs Before	1.583*** (0.380)	0.743** (0.330)	389	1.740*** (0.227)	1.559*** (0.290)	522	−0.0084 (0.298)	0.263 (0.198)	126	1.107*** (0.418)	1.491*** (0.406)	259
	Stage (1) vs Before	0.853** (0.487)	−0.316 (0.460)	205	1.224*** (0.276)	1.112*** (0.383)	330	0.585* (0.439)	0.634* (0.325)	59	0.398 (0.555)	0.586 (0.558)	170
	Stage (2) vs Before	1.968*** (0.405)	1.465*** (0.347)	292	2.116*** (0.258)	2.158*** (0.315)	382	−0.283 (0.243)	0.0004 (0.180)	95	1.609*** (0.480)	2.176*** (0.448)	196

Notes: Standard errors are in parentheses. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. "Before" stands for Before cross-listing. "After" is After cross-listing. Stage (1) is the first five years after cross-listing. Stage (2) is the remaining years following Stage (1). A statistically significant negative (positive) value indicates a significant decrease (increase) in the latter period compared to the former period. N stands for the number of observations. Column "Difference in means" represents the mean difference between before and after cross listing.

the matched sample tend to be very similar. We note that the 25th percentiles, the medians, and the 75th percentiles seem to be the same (for the matched sample), even though some differences are found in the lower adjacent values, the tails, and the outliers. As such, the box plots also indicate that the matching method balances the estimated propensity scores. In summary, the diagnostic plots confirm the reliability of the results estimated by the propensity-score matching.

This interesting finding leads us to separate our sectoral sub-samples into developed and emerging countries for further analysis (see Appendix Table A2). Similar to above findings for the full sample, we note that in several sectors from both developed and emerging countries, productivity at firm level appears improved after cross-listing decisions. Again, we document that Energy is the only sector in which firm productivity become lower after cross-listing in both emerging and developed countries. As such, we will identify the determinants of firm productivity in Energy sector to see which factors cause the decreases in productivity of energy firms after they cross-list to the US financial markets (see Section 4.2).

4.2. *Determinants of firm productivity in energy sector*

We consider one possible explanation for the declined productivity in Energy sector is that after cross-listing in the US, both electricity firms and other firms from Energy sector tend to use their increased capital to heavily invest in infrastructure, equipment, and plants for expansion. Indeed, the US deregulation and restructuring in Energy sector are found to lead to energy firms' excessive investments (Constellation, 2023; Hill, 2021) in the early years of the deregulation. Such investments might in turn hinder improvements in their productivity. Energy firms cross listed in US markets might have the same amount of investment after they cross list and obtain the funds. In order to check for this assumption, we then perform the tests to see whether firm's capital expenditures and fixed assets increase after firms cross-list.

As can be seen from Table 4, our *t*-test and propensity-score matching show statistically significant positive values in both emerging and developed economies, meaning that capital expenditures and fixed assets of both electricity firms and other Energy firms have significant increases after cross-listing. We also use the kernel density plots to check for the covariate balance after performing the propensity-score matching (see Appendix Figs. A1 & A2), which show that the matching method balances the estimated propensity scores. It implies that our results estimated by the propensity-score matching appear reliable. Our findings also confirm the aforementioned assumption that energy companies do have greater ability to raise more external lower-cost funding after they cross-list to the US financial markets and hence, invest more in equipment and infrastructure, which are shown by the increases in their fixed assets after cross-listing process. Besides, our findings are consistent with Lins et al. (2005), Pagano et al. (2002) and Reese and Weisbach (2002) who find that cross-listed firms appear to have a better ability to access external financing at a lower cost. Indeed, extant literature has provided several explanations for why cross-listing might help firms raise lower-cost capital. First, theory suggests that cross-listing could help lower costs regarding market segmentation effectively, which in turn might reduce the cost of external financing (Khurana et al., 2008). Second, according to the investor recognition hypothesis of Merton (1987), if a firm's stock improves its investor base through increasing visibility (i.e., cross-listing), firm's cost of capital should be eventually reduced and firm's market value should increase. Another reason that cross-listed firms might obtain lower-cost external capital lies in the arguments of Coffee (1999b) and Stulz (1999), who suggest that cross-listing will lead to a lower-cost external funding by serving to mitigate the risk arising from wealth expropriation. For instance, if a firm cross-lists in the US market, investors appear to receive better protection from the US institutions than those in the home country of that cross-listed firm (Khurana et al., 2008).

Next, we analyze the determinants of Energy sector's firm

Table 5
Determinants of firm productivity in Energy sector (full sample).

	(1)		(2)		(3)		(4)	
	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned
Capex	0.013**	0.017***	0.014***	0.012**	0.015**	0.004	0.021***	0.014**
	(0.005)	(0.006)	(0.005)	(0.005)	(0.007)	(0.007)	(0.006)	(0.007)
Cross_listing	0.144	−0.204**	0.076	−0.277***	0.541***	0.306***	0.371***	0.017
	(0.158)	(0.099)	(0.135)	(0.095)	(0.133)	(0.116)	(0.126)	(0.111)
*Capex*Cross_listing*	−0.024***	−0.033***	−0.028***	−0.035***	−0.016*	−0.015*	−0.023***	−0.026***
	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)	(0.009)	(0.008)	(0.008)
Governance	0.294*	0.295*	1.244***	1.255***	0.638***	0.661***	1.287***	1.291***
	(0.175)	(0.174)	(0.154)	(0.152)	(0.142)	(0.142)	(0.149)	(0.150)
State_own	−0.644***	−0.665***	−1.044***	−1.034***	−0.440**	−0.460**	−0.578***	−0.601***
	(0.191)	(0.191)	(0.159)	(0.159)	(0.189)	(0.193)	(0.177)	(0.180)
Liquidity	0.671	0.575	1.003***	0.948**	0.732**	0.716**	0.873**	0.840**
	(0.522)	(0.537)	(0.375)	(0.386)	(0.340)	(0.340)	(0.376)	(0.378)
Random effects	Yes	Yes	No	No	No	No	No	No
Country fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	911	911	911	911	911	911	911	911
Adjusted R^2	0.060	0.067	0.258	0.264	0.086	0.085	0.290	0.289

Notes: Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. Non-demeaned stands for the regression model with non-demeaned interaction term (i.e., capex*cross_listing). Demeaned stands for the regression model with the demeaned interaction term (i.e., demeaned_capex*cross_listing) which is proposed by Balli and Sørensen (2013).

Table 6
Determinants of firm productivity in Energy sector (Emerging countries versus Developed countries).

	(1)		(2)		(3)		(4)	
	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned
A. Emerging countries								
Capex	0.015*	0.018**	0.022***	0.011	0.017*	0.004	0.038***	0.018*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.011)	(0.010)	(0.011)
Cross_listing	0.117	−0.227	−0.053	−0.312**	0.362**	0.452**	0.427**	0.213
	(0.247)	(0.173)	(0.195)	(0.154)	(0.182)	(0.198)	(0.173)	(0.194)
*Capex*Cross_listing*	−0.023**	−0.030***	−0.027**	−0.031***	0.011	0.012	−0.013	−0.013
	(0.011)	(0.010)	(0.011)	(0.011)	(0.011)	(0.014)	(0.011)	(0.013)
Governance	0.085	0.097	1.348***	1.420***	0.852***	1.014***	1.387***	1.502***
	(0.251)	(0.248)	(0.230)	(0.226)	(0.246)	(0.240)	(0.218)	(0.222)
State_own	−0.120	−0.167	−0.881***	−0.903***	0.120	0.136	−0.244	−0.351
	(0.272)	(0.280)	(0.238)	(0.240)	(0.295)	(0.308)	(0.258)	(0.269)
Liquidity	1.968***	1.878***	2.266***	2.304***	1.622***	1.662***	1.830***	1.923***
	(0.594)	(0.604)	(0.395)	(0.400)	(0.437)	(0.441)	(0.402)	(0.404)
B. Developed countries								
Capex	0.010	0.015*	0.009	0.015**	−0.000	0.002	−0.001	0.004
	(0.006)	(0.008)	(0.006)	(0.007)	(0.008)	(0.009)	(0.008)	(0.009)
Cross_listing	0.243	−0.160	0.400**	−0.136	0.593***	0.067	0.344*	−0.099
	(0.189)	(0.126)	(0.175)	(0.118)	(0.173)	(0.148)	(0.200)	(0.148)
*Capex*Cross_listing*	−0.028***	−0.036***	−0.037***	−0.047***	−0.034***	−0.043***	−0.029***	−0.039***
	(0.009)	(0.011)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
Governance	0.339	0.330	0.924***	0.912***	0.403**	0.445***	0.893***	0.874***
	(0.227)	(0.229)	(0.198)	(0.195)	(0.160)	(0.159)	(0.205)	(0.203)
State_own	−0.839***	−0.849***	−1.123***	−1.168***	−0.884***	−1.000***	−0.988***	−1.091***
	(0.231)	(0.230)	(0.191)	(0.194)	(0.234)	(0.241)	(0.230)	(0.230)
Liquidity	−0.490	−0.580	−0.469	−0.631*	−0.465	−0.568	−0.477	−0.638*
	(0.568)	(0.603)	(0.350)	(0.378)	(0.323)	(0.356)	(0.351)	(0.385)
Random effects	Yes	Yes	No	No	No	No	No	No
Country fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	Yes	Yes	Yes	Yes

Notes: Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. Non-demeaned stands for the regression model with non-demeaned interaction term (i.e., capex*cross_listing). Demeaned stands for the regression model with the demeaned interaction term (i.e., demeaned_capex*cross_listing) which is proposed by Balli and Sørensen (2013). See the full tables at Appendix Tables B1 & B2.

productivity to seek for more thorough explanations for the decreased firm productivity in Energy sector after cross-listing. For that purpose, we employ the regression model (3) as presented in Section 3.1.2. The regression models are performed for the full sample (Table 5) and for the two sub-samples, including emerging countries and developed countries (Table 6). We estimate our regression models using different specifications, including (1) random effects model; (2) country-fixed effects; (3) year-fixed effects; and (4) both country-fixed effects and year-fixed effects, which is also the regression model in Eq. (3). In each model from (1) to (4), we present the regression results for the non-demeaned interaction term (i.e., *Capex*Cross_listing*) and the demeaned interaction term (i.e., *Demeaned_capex*Cross_listing*) which is

Table 7
Determinants of firm productivity of electricity firms.

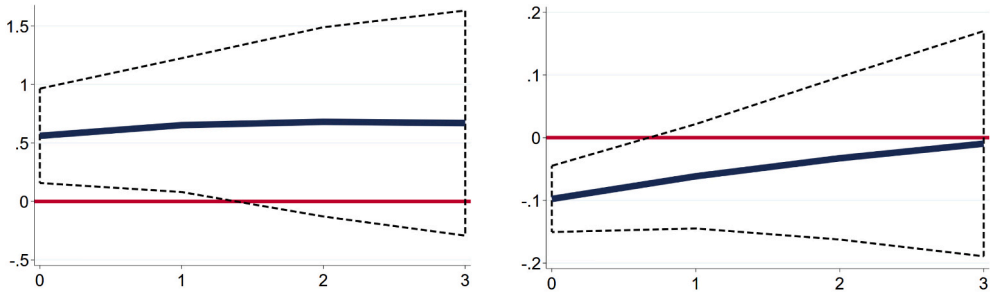
	Full sample		Emerging countries		Developed countries	
	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned
Capex	0.001	−0.002	0.004	0.002	0.004	−0.001
	(0.007)	(0.006)	(0.012)	(0.013)	(0.013)	(0.012)
Cross_listing	−0.497***	−0.391***	−0.279	−0.264	−0.486	−0.303
	(0.190)	(0.148)	(0.175)	(0.229)	(0.652)	(0.249)
*Capex*Cross_listing*	0.008	0.018	0.002	0.009	0.011	0.015
	(0.009)	(0.013)	(0.012)	(0.016)	(0.029)	(0.036)
Governance	0.645***	0.649***	0.834*	0.787*	0.686**	0.669**
	(0.216)	(0.215)	(0.475)	(0.470)	(0.267)	(0.268)
State_own	0.003	0.036	−0.372	−0.296	0.143	0.166
	(0.203)	(0.199)	(0.368)	(0.374)	(0.270)	(0.265)
Liquidity	1.059**	1.046**	0.898	0.903	1.227**	1.251**
	(0.457)	(0.451)	(1.008)	(1.008)	(0.583)	(0.594)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	385	385	125	125	259	259
Adjusted R^2	0.321	0.325	0.388	0.391	0.289	0.288

Notes: Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. Non-demeaned stands for the regression model with non-demeaned interaction term (i.e., capex*cross_listing). Demeaned stands for the regression model with the demeaned interaction term (i.e., demeaned_capex*cross_listing) which is proposed by Balli and Sørensen (2013).

Table 8
Robustness test: Determinants of firm productivity (using alternative approaches).

	Energy sector				Electricity firms			
	Two-step system GMM estimation		Linear mixed model		Two-step system GMM estimation		Linear mixed model	
	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned
Capex	0.029***	0.034***	0.013**	0.017***	−0.006	−0.004	−0.005	−0.006
	(0.010)	(0.010)	(0.005)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
Cross_listing	0.702*	−0.302	0.176	−0.192*	−0.798	−0.690***	−0.522*	−0.485***
	(0.382)	(0.193)	(0.156)	(0.099)	(0.501)	(0.239)	(0.305)	(0.174)
Capex Cross_listing*	−0.052***	−0.061***	−0.025***	−0.033***	0.011	0.013	0.003	0.011
	(0.017)	(0.012)	(0.007)	(0.008)	(0.017)	(0.017)	(0.010)	(0.011)
Governance	−0.102	0.064	0.297*	0.298*	0.720***	0.719***	0.591***	0.596***
	(0.319)	(0.331)	(0.173)	(0.172)	(0.241)	(0.251)	(0.219)	(0.221)
State_own	−0.920**	−0.622*	−0.653***	−0.674***	0.262	0.336	0.108	0.118
	(0.426)	(0.366)	(0.190)	(0.191)	(0.324)	(0.302)	(0.253)	(0.256)
Liquidity	0.683	0.802	0.693	0.598	1.430	1.542	1.235***	1.236***
	(1.000)	(0.845)	(0.517)	(0.533)	(0.968)	(1.051)	(0.440)	(0.432)
Observations	852	852	911	911	363	363	385	385
Hansen test of overidentifying restrictions								
Statistic	53.69	52.29	–	–	17.74	17.67	–	–
p-value	1.000	1.000			1.000	1.000		

Notes: Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. Non-demeaned stands for the regression model with non-demeaned interaction term (i.e., *Capex*Cross_listing*). Demeaned stands for the regression model with the demeaned interaction term (i.e., *Demeaned_capex*Cross_listing*) which is proposed by Balli and Sørensen (2013).



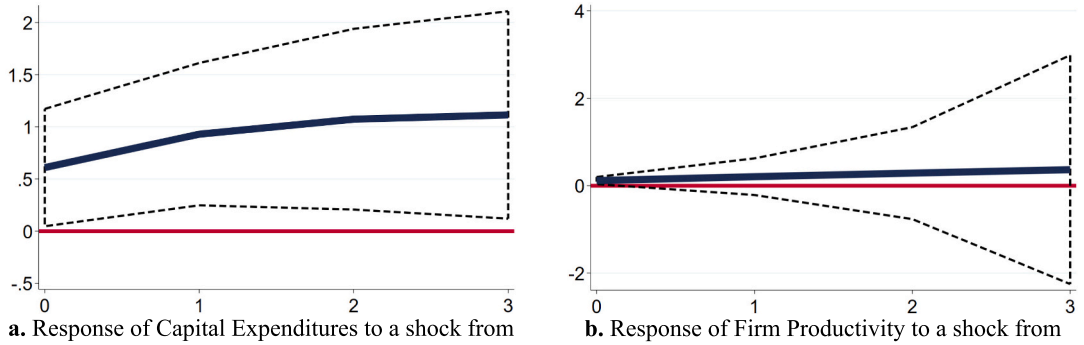
a. Response of Capital Expenditures to a shock from Cross-listing

b. Response of Firm Productivity to a shock from Capital Expenditures

Fig. 2. Impulse response analysis for Energy sector.
Notes: The analysis is based on the 95% confidence interval.

proposed by Balli and Sørensen (2013). Furthermore, in all regression models, the robust standard errors are adopted, which are robust to within-panel (serial) correlation and cross-sectional heteroskedasticity, as equivalent to Arellano (1987)'s robust standard errors.

Looking at model specification (1) in Table 5, we note that the coefficients of our key variable (*Capex* Cross_listing*) are −0.024 (in case of



a. Response of Capital Expenditures to a shock from Cross-listing

b. Response of Firm Productivity to a shock from Capital Expenditures

Fig. 3. Impulse response analysis for electricity firms.
Notes: The analysis is based on the 95% confidence interval.

Table 9
Robustness test: Firm productivity before and after cross-listing (using alternative productivity measures).

	Levinsohn and Petrin (2003)		Olley and Pakes (1996)		**Translog production function**	
	Difference in means	Propensity-score matching	Difference in means	Propensity-score matching	Difference in means	Propensity-score matching
A. Energy sector						
After vs Before	−0.103* (0.071)	−0.422*** (0.076)	−0.117* (0.075)	−0.414*** (0.073)	0.062 (0.088)	−0.390*** (0.089)
Stage (1) vs Before	0.030 (0.083)	−0.212** (0.087)	0.013 (0.089)	−0.239*** (0.088)	0.128 (0.101)	−0.103 (0.100)
Stage (2) vs Before	−0.186*** (0.076)	−0.568*** (0.099)	−0.199*** (0.080)	−0.592*** (0.097)	0.021 (0.094)	−0.459*** (0.102)
B. Electricity firms						
After vs Before	−0.238*** (0.086)	−0.272*** (0.068)	−0.160** (0.084)	−0.249*** (0.070)	−0.238*** (0.093)	−0.250*** (0.070)
Stage (1) vs Before	−0.223** (0.109)	−0.257** (0.108)	−0.189** (0.108)	−0.208** (0.106)	−0.184* (0.124)	−0.271** (0.117)
Stage (2) vs Before	−0.247*** (0.082)	−0.181*** (0.063)	−0.142** (0.083)	−0.187*** (0.069)	−0.271*** (0.090)	−0.142* (0.076)

Notes: Standard errors are in parentheses. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. "Before" stands for Before cross-listing. "After" is After cross-listing. Stage (1) is the first five years after cross-listing. Stage (2) is the remaining years following Stage (1). A statistically significant negative (positive) value indicates a significant decrease (increase) in the latter period compared to the former period Column "Difference in means" represents the mean difference between before and after cross listing productivity.

non-demeaned interaction term) and − 0.033 (in case of demeaned interaction term). Those coefficients are statistically significant and negative at 1% level, indicating strong evidence that an increase in firm's capital expenditures after cross-listing appears to reduce firm productivity. This is in line with our above proposition that heavy investments in the infrastructure in the Energy sector (thanks to cross-listing) might lead to the decreases in firm productivity in short term. We also find similar results across the remaining model specifications (2 to 4) in case of the full sample (Table 5) as well as the emerging and developed countries (Table 6). This finding mostly explains why productivity of energy firms becomes lower after they cross-list as found in Section 4.1. According to the agency theory (Jensen, 1986; Jensen and Meckling, 1976), when there are extra free cashflows, firm managers tend to use such excessive cash to invest in new projects, even though the net present values of those projects are forecast to be negative. Consequently, firm value appears to be deteriorated by the over-investment of free extra cashflows. In addition, it is found that firms that have excessive investments tend to witness lower future stock returns (Fairfield et al., 2003; Titman et al., 2004). Although the cashflow itself appears to exert a positive impact on firm growth, free cashflow might adversely affect firm growth (Brush et al., 2000). Eventually, extra free cashflows tend to damage firm value (Park and Jang, 2013). Given the negative impacts of excessive capital on firm's value and growth, although cross-listing might help improve energy firm's ability to raise additional external funding for investments, such extra capital tends to deteriorate firm productivity in short term. This interesting finding is contrary to our hypothesis that the more cost-effective capital acquired by companies through cross-listing has the potential to stimulate their overall productivity.

Additionally, we note that the state ownership of capital (*State_own*) has significant negative effects on firm productivity in Energy sector for the whole sample (Table 5). When decomposing the full sample into emerging and developed economies (Table 6), we note that the negative impacts of factors (i.e., *Capex*Cross_listing* and *State_own*) are found to be much stronger and more statistically significant in developed economies than in emerging economies. Furthermore, we also find evidence that corporate governance (*Governance*) (in case of the full sample - Table 5) and firm's liquidity (*Liquidity*) (in case of the full sample - Table 5 as well as emerging countries - Table 6A) might help improve firm productivity in Energy sector. These results are consistent with findings from previous studies (Ding et al., 2016; Tian and Twite, 2011).

Regarding electricity firms, as can be seen from Table 7, we do not

Table 10
Robustness test: Determinants of firm productivity (using alternative productivity measures).

A. Energy sector	Baseline model			Two-step system GMM estimation			Linear mixed model		
	LP (2003)	OP (1996)	Translog	LP (2003)	OP (1996)	Translog	LP (2003)	OP (1996)	Translog
Capex	0.014**	0.013*	0.028***	0.027***	0.034***	0.029***	0.011**	0.011*	0.015***
	(0.006)	(0.007)	(0.007)	(0.010)	(0.013)	(0.011)	(0.005)	(0.006)	(0.005)
Cross_listing	0.292**	0.211*	0.527***	0.777**	0.203	0.490	0.138	0.076	0.265*
	(0.121)	(0.121)	(0.148)	(0.379)	(0.303)	(0.423)	(0.161)	(0.163)	(0.161)
*Capex*Cross_listing*	−0.021***	−0.014*	−0.035***	−0.055***	−0.040***	−0.048***	−0.025***	−0.023***	−0.027***
	(0.007)	(0.008)	(0.008)	(0.017)	(0.010)	(0.016)	(0.008)	(0.008)	(0.008)
Governance	1.072***	1.015***	1.457***	−0.182	−0.190	−0.065	0.244	0.303*	0.224
	(0.144)	(0.150)	(0.164)	(0.301)	(0.398)	(0.380)	(0.171)	(0.181)	(0.173)
State_own	−0.484***	−0.282	−0.904***	−1.092**	−0.616	−0.461	−0.672***	−0.607***	−0.664***
	(0.172)	(0.174)	(0.203)	(0.487)	(0.415)	(0.479)	(0.191)	(0.196)	(0.212)
Liquidity	0.853**	1.540***	0.106	0.465	0.681	0.577	0.750	1.060*	0.325
	(0.370)	(0.424)	(0.350)	(0.955)	(1.088)	(0.830)	(0.520)	(0.563)	(0.483)
Observations	911	911	911	852	852	852	911	911	911
B. Electricity firms	Baseline model			Two-step system GMM estimation			Linear mixed model		
	LP (2003)	OP (1996)	Translog	LP (2003)	OP (1996)	Translog	LP (2003)	OP (1996)	Translog
Capex	0.000	−0.001	0.003	−0.005	−0.006	−0.002	−0.005	−0.004	−0.005
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.009)	(0.005)	(0.005)	(0.006)
Cross_listing	−0.489***	−0.578***	−0.400**	−1.036**	−0.810	−0.817	−0.487	−0.504*	−0.559*
	(0.189)	(0.194)	(0.196)	(0.496)	(0.494)	(0.529)	(0.297)	(0.294)	(0.334)
*Capex*Cross_listing*	0.009	0.007	0.009	0.017	0.012	0.002	0.001	0.002	0.005
	(0.009)	(0.009)	(0.010)	(0.017)	(0.016)	(0.018)	(0.010)	(0.009)	(0.011)
Governance	0.650***	0.610***	0.638***	0.631***	0.711***	0.705**	0.542**	0.548**	0.643**
	(0.214)	(0.206)	(0.240)	(0.243)	(0.253)	(0.305)	(0.227)	(0.215)	(0.256)
State_own	0.023	0.061	−0.102	0.242	0.198	0.378	0.077	0.207	−0.031
	(0.203)	(0.195)	(0.225)	(0.344)	(0.348)	(0.355)	(0.252)	(0.247)	(0.270)
Liquidity	1.319***	1.444***	0.469	1.593*	1.499*	1.652	1.450***	1.381***	1.061**
	(0.465)	(0.467)	(0.467)	(0.883)	(0.800)	(1.314)	(0.430)	(0.461)	(0.422)
Observations	385	385	385	363	363	363	385	385	385

Notes: Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. LP (2003) stands for Levinsohn and Petrin (2003). OP (1996) stands for Olley and Pakes (1996). Translog stands for Translog production function. Baseline model is the regression model (3) presented in Section 3.1.2.

Table 11
Robustness test: Determinants of firm productivity (using alternative measure of capital expenditure).

	Energy sector			Electricity firms		
	Baseline model	Two-step system GMM	Linear mixed model	Baseline model	Two-step system GMM	Linear mixed model
Capex_labor	0.027***	0.044**	0.019**	−0.001	−0.014	−0.009
	(0.010)	(0.018)	(0.008)	(0.011)	(0.012)	(0.008)
Cross_listing	0.385***	0.350	0.175	−0.462**	−0.464	−0.448
	(0.126)	(0.323)	(0.154)	(0.189)	(0.743)	(0.289)
Capex_labor Cross_listing*	−0.039***	−0.060**	−0.040***	0.010	−0.010	0.001
	(0.012)	(0.026)	(0.012)	(0.015)	(0.047)	(0.015)
Governance	1.296***	0.053	0.308*	0.645***	0.659***	0.594***
	(0.149)	(0.331)	(0.170)	(0.213)	(0.226)	(0.213)
State_own	−0.581***	−0.973**	−0.668***	−0.002	0.555	0.110
	(0.177)	(0.489)	(0.191)	(0.205)	(0.472)	(0.251)
Liquidity	0.891**	0.291	0.709	1.072**	2.958	1.258***
	(0.369)	(1.106)	(0.518)	(0.463)	(2.222)	(0.434)
Observations	911	852	911	385	363	385

Notes: We use *Capex_labor* (capital expenditures/number of employees) as the variable of interest instead of *Capex* (firm's capital expenditures). Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively.

find statistically significant impacts of the capital expenditures after cross-listing (*Capex* Cross_listing*) on firm productivity. However, we note that there are some significant negative effects of cross-listing itself (*Cross_listing*) on electricity firm's productivity in case of the full sample. Similar to the findings from Energy sector (Tables 5 & 6), we also find evidence that corporate governance and firm liquidity are two factors that help enhance firm productivity, which are in line with Tian and Twite (2011) and Ding et al. (2016).

4.3. Robustness tests

4.3.1. Robustness tests using different approaches

In this section, we perform different approaches to test for the robustness of our baseline results. First, we employ the two-step system generalized methods of moments (GMM) estimation and linear mixed model to re-estimate the determinants of Energy firm productivity. Theoretically, the system GMM estimation will be suggested in case of panel data estimations that encounter endogeneity issues (Nickell, 1981). In this study, we employ the two-step system GMM estimators of Arellano and Bover (1995) and Blundell and Bond (1998) as a robustness

check as this estimation appears quite efficient to help mitigate the bias regarding fixed effects in short panels and solve the endogeneity problem (Canh et al., 2020). Furthermore, we use the finite-sample correction for the variance of two-step GMM estimators proposed by Windmeijer (2005) for more accurate inference. Regarding the linear mixed-effects model (or linear mixed model), it is considered an extension version of a simple linear model, allowing not only fixed effects but also random effects. In other words, a linear mixed model includes some factors that are random and other factors that are fixed (Duchateau and Janssen, 1997; Verbeke and Molenberghs, 2000). Oberg and Mahoney (2007) argue that linear mixed models appear to be a versatile tool for addressing research objectives efficiently. Under this framework, within-subject correlation could be modelled and the estimation process could be weighted to allow subjects with more information and information with less variability to give more to our analyses (Oberg and Mahoney, 2007).

As can be seen from Table 8, our robustness tests confirm the significant negative effects of capital expenditures (after cross-listing) (*Capex* Cross_listing*) and state ownership (*State_own*) on firm-level productivity in Energy sector. Also, Table 8 confirms the baseline findings (as found in Section 4.2) that corporate governance (*Governance*) positively affects firm productivity in both electricity firms and other firms in Energy sector.

Apart from the panel data analysis, we adopt the panel Impulse Response function (IRF) after a panel Vector Autoregression model (PVAR) as another robust test. In term of Energy sector, Fig. 2 provides the evidence that cross-listing significantly increases firm's capital expenditures (Fig. 2a) and that a shock from capital expenditures has a significant negative impact on firm productivity (Fig. 2b).

With respect to electricity firms, as can be seen from Fig. 3a, the impulse response analysis confirms that cross-listing does have positive effects on firm capital expenditures. Additionally, similar to our baseline findings, Fig. 3b indicates that capital expenditure is not a channel to affect productivity of electricity firms.

4.3.2. Robustness tests using alternative measures of firm productivity and capital expenditure

In this section, we employ alternative measures of firm productivity, which are estimated using the methods of (i) Levinsohn and Petrin (2003) with ACF (Ackerberg et al., 2015) correction; (ii) Olley and Pakes (1996) with ACF correction; and (iii) the Translog production function. We conduct the *t*-test and Propensity-score matching (Table 9) as well as the regression models using aforementioned alternative estimations of productivity (Table 10). Furthermore, we also use the ratio of capital expenditures/number of employees (*Capex_labor*) as the variable of interest, instead of firm's capital expenditures (*Capex*) to estimate the determinants of firm productivity (Table 11). As can be seen, the estimation results from Tables 9, 10 & 11 confirm the robustness of our baseline findings in Section 4.1 & 4.2.

5. Conclusions and implications

This paper investigates the impact of cross-listing on firm productivity within the energy-electricity sector, focusing on changes that occur before and after cross-listing in the US financial markets. We employ annual data spanning from 2002 to 2022 for our analysis. This extended study period enables us to cover a sequence of energy-related crises that have occurred over the last two decades.

Our findings provide valuable insights into the relationship between cross-listing and firm productivity across different sectors, with particular attention to the energy sector. While most sectors experience increased productivity post-cross-listing, the energy sector (including electricity firms) stands out as an exception. Contrary to our initial expectations, energy firms witness statistically significant decreases in productivity following cross-listing in the US market. We explore the possibility that energy firms, after cross-listing, allocate a significant portion of their resources towards investments in infrastructure, equipment, and expansion, which temporarily hinder improvements in productivity. Indeed, the results are contrary to our initial hypothesis that energy companies gain access to more substantial capital upon US cross-listing, subsequently investing in equipment and infrastructure, leading to improved productivity. Furthermore, looking into additional determinants of firm productivity, the analysis demonstrates that state ownership has a negative impact on energy sector firms' productivity, with this effect being more pronounced in developed economies. Additionally, in line with previous research, we found evidence that corporate governance and liquidity might play a role in enhancing firm productivity within the energy sector (including electricity firms).

These findings provide valuable guidance for policymakers and firm managers seeking to enhance the productivity of energy firms following cross-listing. For energy companies contemplating cross-listing on US financial markets, the observed decrease in productivity, attributed to substantial investments in infrastructure and expansion, underscores the necessity of prudent capital allocation strategies post-cross-listing to effectively mitigate declines in productivity. Additionally, the significance of state ownership as a determinant of firm productivity within the energy sector, particularly in developed economies, implies that government-owned energy companies should devote a higher level of attention and develop strategic plans, as they may encounter challenges in maintaining productivity levels following cross-listing. From a policymaker's perspective, the fact that cross-listing generally enhances productivity in most sectors while the energy sector experiences a decrease implies the importance of taking sector-specific considerations into account. Regulatory bodies should engage in conversation with industry stakeholders to develop frameworks that strike a balance between facilitating capital access and ensuring that firms allocate their resources strategically post-cross-listing. Policymakers should also consider strengthening corporate governance requirements for cross-listed energy and electricity companies and enhancing liquidity in their financial markets, as these measures might support firm productivity.

In future work, considering that our study primarily examines the energy sector in the context of cross-listing on US financial markets, expanding the scope to include cross-listings in other international markets could offer a more comprehensive understanding of how diverse market environments impact firm productivity.

CRediT authorship contribution statement

Tam Hoang-Nhat Dang: Writing – original draft, Software, Data curation, Conceptualization. **Faruk Balli:** Writing – review & editing, Writing – original draft, Supervision, Software, Methodology. **Hatice Ozer Balli:** Supervision, Software, Methodology. **Hannah Nguyen:** Writing – original draft, Visualization, Supervision, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Appendix

Table A1
Firm productivity among sectors: Before versus after cross-listing (Full sample).

		Difference in means	Propensity-score matching
Energy	After vs Before	0.010895	−0.4064392***
		(0.0761131)	(0.0758463)
	Stage (1) vs Before	0.0984389	−0.1880439**
		(0.0882756)	(0.0879302)
	Stage (2) vs Before	−0.0442856	−0.5425881***
		(0.081735)	(0.0954874)
Electricity firms	After vs Before	−0.1821467**	−0.2529812***
		(0.0844298)	(0.0679652)
	Stage (1) vs Before	−0.1852653**	−0.245853**
		(0.1107935)	(0.106433)
	Stage (2) vs Before	−0.1802675**	−0.1634148**
		(0.0825303)	(0.0678662)
Basic Materials	After vs Before	0.0423539	0.007656
		(0.050014)	(0.0628562)
	Stage (1) vs Before	0.0876197*	0.0601853
		(0.0602024)	(0.0716762)
	Stage (2) vs Before	0.0114762	−0.0251565
		(0.0566252)	(0.068006)
Consumer Discretionary	After vs Before	0.1193075***	0.1908548***
		(0.038194)	(0.0419345)
	Stage (1) vs Before	0.1860137***	0.246278***
		(0.0449472)	(0.0466556)
	Stage (2) vs Before	0.064273*	0.1481287**
		(0.0444602)	(0.0643162)
Health Care	After vs Before	0.3512836***	0.2291778***
		(0.0553858)	(0.0747371)
	Stage (1) vs Before	0.3052103***	0.3046211***
		(0.0716828)	(0.0729949)
	Stage (2) vs Before	0.3821575***	0.257841***
		(0.0617945)	(0.0778183)
Industrials	After vs Before	0.0396343	−0.0019353
		(0.031538)	(0.0363255)
	Stage (1) vs Before	0.0966241***	0.1267377***
		(0.0371773)	(0.0435315)
	Stage (2) vs Before	−0.0032942	−0.0675415
		(0.0356825)	(0.0445813)
Real Estate	After vs Before	0.3947137***	0.2559829***
		(0.0637187)	(0.0842821)
	Stage (1) vs Before	0.3790046***	0.2777799***
		(0.080901)	(0.0847433)
	Stage (2) vs Before	0.4072079***	0.2231771***
		(0.0722366)	(0.0792088)
Technology	After vs Before	0.1199777*	0.0565763
		(0.0843914)	(0.1426772)
	Stage (1) vs Before	0.0778393	0.0613968
		(0.1100347)	(0.1746948)
	Stage (2) vs Before	0.1457659*	−0.0448521
		(0.0937214)	(0.2046685)
Telecommunications	After vs Before	0.0270223	0.1400766
		(0.1304489)	(0.1169964)
	Stage (1) vs Before	0.2641977**	0.1539351
		(0.1180282)	(0.1805214)
	Stage (2) vs Before	−0.1019908	−0.05525
		(0.1530683)	(0.174572)
Utilities	After vs Before	−0.0614627	−0.0495664
		(0.0573179)	(0.0570373)
	Stage (1) vs Before	−0.0001344	0.0195149
		(0.0733028)	(0.0966213)
	Stage (2) vs Before	−0.0981053*	−0.1425277**
		(0.0599107)	(0.0594237)

Notes: Standard errors are in parentheses. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. "Before" stands for Before cross-listing. "After" is After cross-listing. Stage (1) is the first five years after cross-listing. Stage (2) is the remaining years following Stage (1). A statistically significant negative (positive) value indicates a significant decrease (increase) in the latter period compared to the former period. Column "Difference in means" represents the mean difference between before and after cross listing productivity.

Table A2
Firm productivity among sectors: Before versus after cross-listing (Emerging and Developed countries).

		Emerging countries		Developed countries	
		Difference in means (1)	Propensity-score matching (2)	Difference in means (3)	Propensity-score matching (4)
Energy	After vs Before	0.0461701 (0.1299377)	−0.2354646* (0.12429)	−0.0865209 (0.0888433)	−0.3875209*** (0.1094127)
	Stage (1) vs Before	0.1542884 (0.1520742)	0.0659284 (0.1652617)	0.0294989 (0.1035904)	−0.1565489 (0.1130921)
	Stage (2) vs Before	−0.010827 (0.1350748)	−0.4753608*** (0.1283396)	−0.1711186** (0.0980234)	−0.4291519** (0.2072478)
Basic Materials	After vs Before	−0.1911986* (0.1226408)	−0.4956102*** (0.1259553)	0.1218485*** (0.052169)	0.1775264*** (0.0627995)
	Stage (1) vs Before	−0.1669456 (0.1575157)	−0.1272657 (0.155292)	0.1698312*** (0.0609308)	0.2418042*** (0.0711723)
	Stage (2) vs Before	−0.2048253* (0.1280816)	−0.9192819*** (0.1159523)	0.0860582* (0.06199)	0.0540751 (0.071018)
Consumer Discretionary	After vs Before	0.2657547*** (0.0978376)	0.2065297 (0.1606756)	0.0571059* (0.0403037)	0.1210141*** (0.0428319)
	Stage (1) vs Before	0.3806275*** (0.1174295)	0.2692034** (0.1307523)	0.1048461** (0.0469044)	0.1885042*** (0.0501534)
	Stage (2) vs Before	0.1678463* (0.1147462)	0.2857722* (0.1611523)	0.0181563 (0.047043)	0.0766717 (0.069263)
Health Care	After vs Before	0.4656074*** (0.1295852)	0.6050447*** (0.11395)	0.3204102*** (0.0609899)	0.2382693*** (0.0856288)
	Stage (1) vs Before	0.4762173*** (0.1788286)	0.4749574*** (0.1500771)	0.2569031*** (0.0772577)	0.3884729*** (0.089533)
	Stage (2) vs Before	0.4580864*** (0.1532462)	0.6817563*** (0.1086283)	0.3623372*** (0.0670409)	0.2455281*** (0.0914313)
Industrials	After vs Before	0.1329538* (0.0824708)	0.0913986 (0.1147415)	0.0021995 (0.0333142)	−0.0541987 (0.040395)
	Stage (1) vs Before	0.1921071** (0.0968666)	0.2240627** (0.1080553)	0.0589026* (0.0393787)	0.0544464 (0.0429898)
	Stage (2) vs Before	0.0885888 (0.093409)	-0.0962169 (0.0975481)	−0.0405611 (0.0377481)	−0.0502157 (0.0471448)
Real Estate	After vs Before	0.4625035*** (0.0987271)	0.2070252* (0.1080107)	0.2784582*** (0.0783422)	0.1753106** (0.0886383)
	Stage (1) vs Before	0.6077084*** (0.1143072)	0.287087** (0.1373028)	0.1680993** (0.1012609)	0.338702** (0.1326764)
	Stage (2) vs Before	0.3555104*** (0.1145899)	−0.0509084 (0.1416324)	0.3713435*** (0.0907909)	0.3485915** (0.1627977)
Technology	After vs Before	0.634484*** (0.1856229)	0.3880913** (0.1557528)	-0.0650282 (0.0959488)	0.1381967 (0.1226366)
	Stage (1) vs Before	0.4256329** (0.2507392)	0.3214671 (0.2522109)	−0.0088493 (0.1237133)	0.2504381** (0.1238845)
	Stage (2) vs Before	0.7252888*** (0.1817632)	0.6697413*** (0.187515)	−0.1050765 (0.111404)	−0.2315854 (0.2793629)
Telecommunications	After vs Before	0.3986357** (0.2017176)	0.4150277*** (0.1271795)	−0.2403647* (0.1674026)	0.1033502 (0.12484)
	Stage (1) vs Before	0.343956 * (0.2216878)	0.3781299** (0.1621186)	0.2244274** (0.1328913)	0.405438*** (0.142942)
	Stage (2) vs Before	0.4324507** (0.2322525)	0.4438271*** (0.1435662)	−0.4683759*** (0.1940437)	0.0688457 (0.160264)
Utilities	After vs Before	0.1951414** (0.0958095)	0.292777*** (0.0955584)	−0.2055581*** (0.0700665)	−0.1975676** (0.0867803)
	Stage (1) vs Before	0.2775085** (0.1216341)	0.1594701 (0.1110316)	−0.1349836* (0.0901102)	−0.0072108 (0.0938772)
	Stage (2) vs Before	0.1532936* (0.1034646)	0.1982276 (0.1372317)	−0.2517589*** (0.0725236)	−0.2827388*** (0.0804882)

Notes: Standard errors are in parentheses. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. "Before" stands for Before cross-listing. "After" is After cross-listing. Stage (1) is the first five years after cross-listing. Stage (2) is the remaining years following Stage (1). A statistically significant negative (positive) value indicates a significant decrease (increase) in the latter period compared to the former period. Column "Difference in means" represents the mean difference between before and after cross listing productivity.

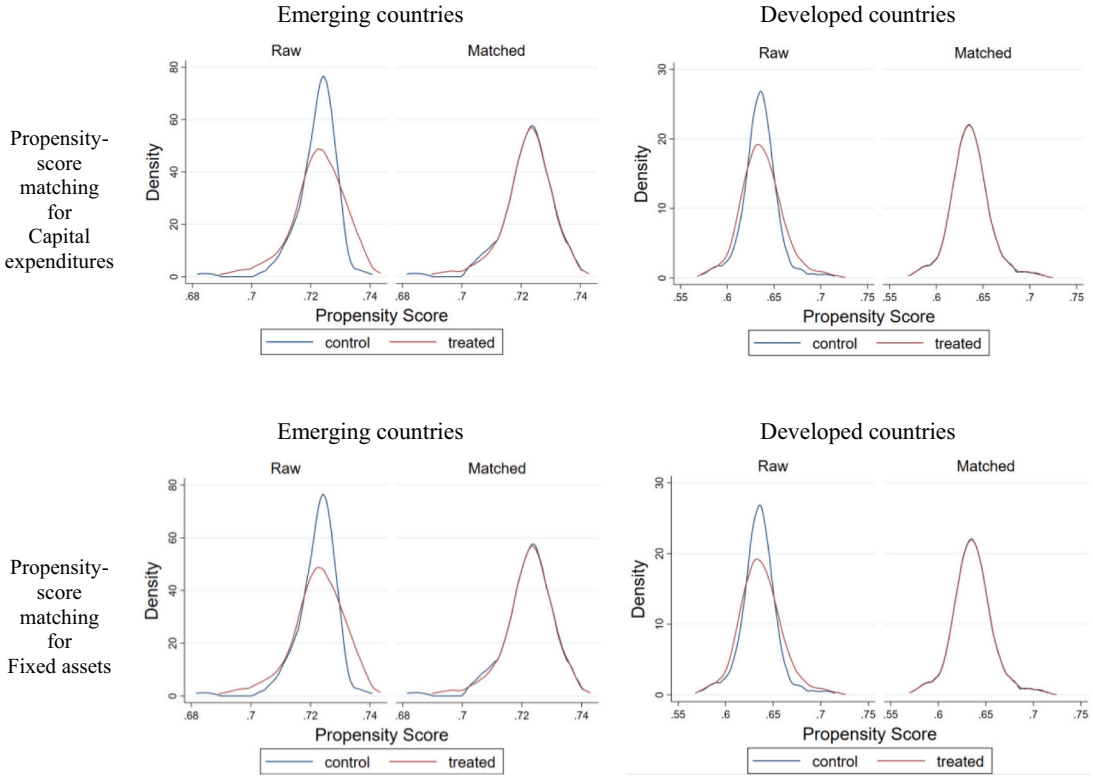


Fig. A1. Kernel density plots to check for covariate balance after estimations of propensity-score matching (Energy sector).

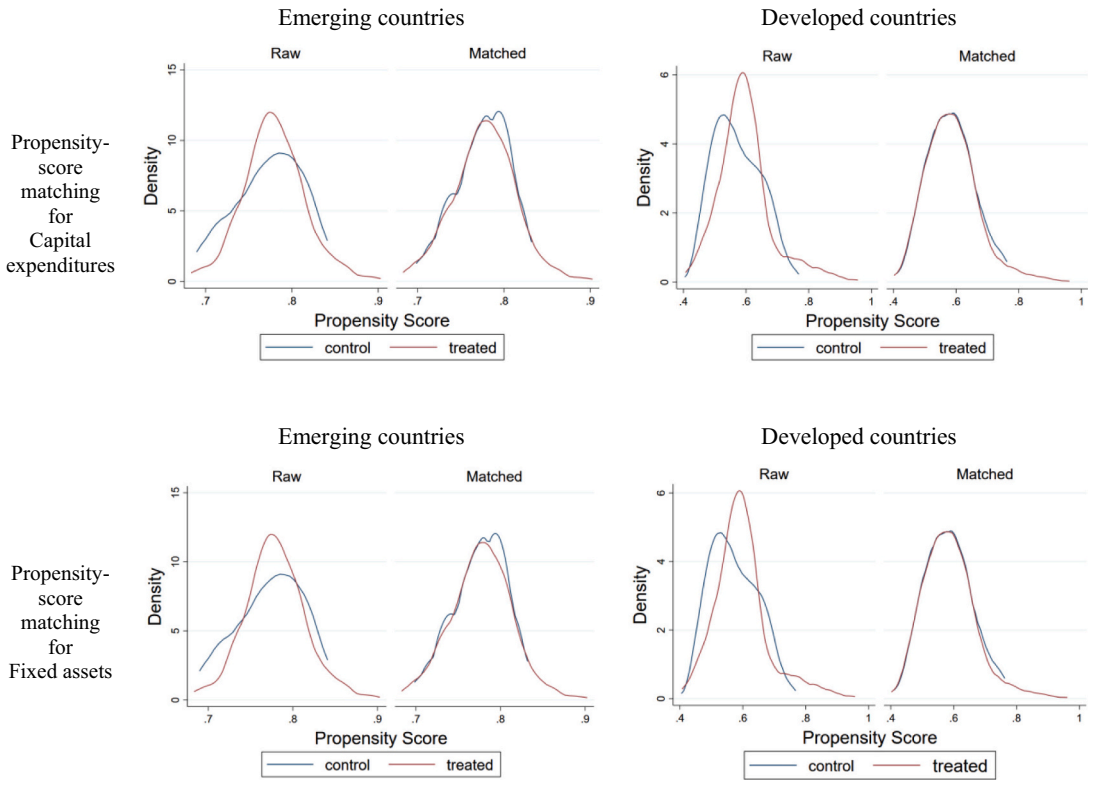


Fig. A2. Kernel density plots to check for covariate balance after estimations of propensity-score matching (Electricity firms).

Table B1
Determinants of firm productivity in Energy sector (Emerging countries).

	(1)		(2)		(3)		(4)	
	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned
capex	0.015*	0.018**	0.022***	0.011	0.017*	0.004	0.038***	0.018*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.011)	(0.010)	(0.011)
cross_listing	0.117	−0.227	−0.053	−0.312**	0.362**	0.452**	0.427**	0.213
	(0.247)	(0.173)	(0.195)	(0.154)	(0.182)	(0.198)	(0.173)	(0.194)
capex cross_listing*	−0.023**	−0.030***	−0.027**	−0.031***	0.011	0.012	−0.013	−0.013
	(0.011)	(0.010)	(0.011)	(0.011)	(0.011)	(0.014)	(0.011)	(0.013)
governance	0.085	0.097	1.348***	1.420***	0.852***	1.014***	1.387***	1.502***
	(0.251)	(0.248)	(0.230)	(0.226)	(0.246)	(0.240)	(0.218)	(0.222)
state_own	−0.120	−0.167	−0.881***	−0.903***	0.120	0.136	−0.244	−0.351
	(0.272)	(0.280)	(0.238)	(0.240)	(0.295)	(0.308)	(0.258)	(0.269)
liquidity	1.968***	1.878***	2.266***	2.304***	1.622***	1.662***	1.830***	1.923***
	(0.594)	(0.604)	(0.395)	(0.400)	(0.437)	(0.441)	(0.402)	(0.404)
Random effects	Yes	Yes	No	No	No	No	No	No
Country fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	389	389	389	389	389	389	389	389
Adjusted R^2	0.123	0.128	0.348	0.353	0.216	0.191	0.442	0.411

Notes: Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. Non-demeaned stands for the regression model with non-demeaned interaction term (i.e., capex*cross_listing). Demeaned stands for the regression model with the demeaned interaction term (i.e., demeaned_capex*cross_listing) which is proposed by Balli and Sørensen (2013).

Table B2
Determinants of firm productivity in Energy sector (Developed countries).

	(1)		(2)		(3)		(4)	
	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned
capex	0.010	0.015*	0.009	0.015**	−0.000	0.002	−0.001	0.004
	(0.006)	(0.008)	(0.006)	(0.007)	(0.008)	(0.009)	(0.008)	(0.009)
cross_listing	0.243	−0.160	0.400**	−0.136	0.593***	0.067	0.344*	−0.099
	(0.189)	(0.126)	(0.175)	(0.118)	(0.173)	(0.148)	(0.200)	(0.148)

(*continued on next page*)

Table B2 (*continued*)

	(1)		(2)		(3)		(4)	
	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned	Non-demeaned	Demeaned
capex cross_listing*	−0.028***	−0.036***	−0.037***	−0.047***	−0.034***	−0.043***	−0.029***	−0.039***
	(0.009)	(0.011)	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
governance	0.339	0.330	0.924***	0.912***	0.403**	0.445***	0.893***	0.874***
	(0.227)	(0.229)	(0.198)	(0.195)	(0.160)	(0.159)	(0.205)	(0.203)
state_own	−0.839***	−0.849***	−1.123***	−1.168***	−0.884***	−1.000***	−0.988***	−1.091***
	(0.231)	(0.230)	(0.191)	(0.194)	(0.234)	(0.241)	(0.230)	(0.230)
liquidity	−0.490	−0.580	−0.469	−0.631*	−0.465	−0.568	−0.477	−0.638*
	(0.568)	(0.603)	(0.350)	(0.378)	(0.323)	(0.356)	(0.351)	(0.385)
Random effects	Yes	Yes	No	No	No	No	No	No
Country fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Year fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Observations	522	522	522	522	522	522	522	522
Adjusted R^2	0.107	0.108	0.170	0.174	0.101	0.102	0.163	0.164

Notes: Robust standard errors are in parentheses, which are regarded to resolve the concerns of autocorrelation and heteroscedasticity. ***, ** and * indicates significance at the 1%, 5% and 10% level, respectively. Non-demeaned stands for the regression model with non-demeaned interaction term (i.e., capex*cross_listing). Demeaned stands for the regression model with the demeaned interaction term (i.e., demeaned_capex*cross_listing) which is proposed by Balli and Sørensen (2013).

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.eneco.2024.107309.

References

Ackerberg, D.A., Caves, K., Frazer, G., 2015. Identification properties of recent production function estimators. Econometrica 83 (6), 2411–2451. https://doi.org/10.3982/ECTA13408.

Ahir, H., Bloom, N., Furceri, D., 2022. The World Uncertainty Index.

Arellano, M., 1987. Computing robust standard errors for within-groups estimators* [doi:10.1111/j.1468-0084.1987.mp49004006.x]. Oxf. Bull. Econ. Stat. 49 (4), 431–434. https://doi.org/10.1111/j.1468-0084.1987.mp49004006.x.

Arellano, M., Bover, O., 1995. Another look at the instrumental variable estimation of error-components models. J. Econ. 68 (1), 29–51. https://doi.org/10.1016/0304-4076(94)01642-D.

Arnold, J.M., Mattoo, A., Narciso, G., 2008. Services inputs and firm productivity in sub-Saharan Africa: evidence from firm-level data. J. Afr. Econ. 17 (4), 578–599.

Baier, S.L., Dwyer Jr., G.P., Tamura, R., 2006. How important are capital and total factor productivity for economic growth? Econ. Inq. 44 (1), 23–49.

Balli, H.O., Sørensen, B.E., 2013. Interaction effects in econometrics. Empir. Econ. 45 (1), 583–603. https://doi.org/10.1007/s00181-012-0604-2.

Balli, F., Agyemang, A., Gregory-Allen, R., Ozer Balli, H., 2022. Corporate dividend smoothing: the role of cross-listing. Finance 72, 102151. https://doi.org/10.1016/j.jcorpfin.2021.102151.

Beck, T., Demirgüç-kunt, A., Maksimovic, V., 2005a. Financial and legal constraints to growth: does firm size matter? J. Financ. 60 (1), 137–177. https://doi.org/10.1111/j.1540-6261.2005.00727.x.

Beck, T., Demirgüç-Kunt, A., Maksimovic, V., 2005b. Financial and legal constraints to growth: does firm size matter? J. Financ. 60 (1), 137–177.

Beck, T., Demirgüç-Kunt, A., Laeven, L., Maksimovic, V., 2006. The determinants of financing obstacles. J. Int. Money Financ. 25 (6), 932–952. https://doi.org/10.1016/j.jimonfin.2006.07.005.

Biagini, B., Sagar, A., 2004. Nongovernmental organizations (NGOs) and energy. In: Cleveland, C.J. (Ed.), Encyclopedia of Energy. Elsevier, pp. 301–314. https://doi.org/10.1016/B0-12-176480-X/00448-4.

Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. J. Econ. 87 (1), 115–143. https://doi.org/10.1016/S0304-4076(98)00009-8.

Boubakri, N., Cosset, J.-C., Saffar, W., 2013. The role of state and foreign owners in corporate risk-taking: evidence from privatization. J. Financ. Econ. 108 (3), 641–658. https://doi.org/10.1016/j.jfineco.2012.12.007.

Bris, A., Cantale, S., Nishiotis, G.P., 2007. A breakdown of the valuation effects of international cross-listing* [article]. Eur. Financ. Manag. 13 (3), 498–530. https://doi.org/10.1111/j.1468-036X.2006.00370.x.

Bruhn, M., Zia, B., 2013. Stimulating managerial capital in emerging markets: the impact of business training for young entrepreneurs. J. Developm. Effectiv. 5 (2), 232–266. https://doi.org/10.1080/19439342.2013.780090.

Brush, T.H., Bromiley, P., Hendrickx, M., 2000. The free cash flow hypothesis for sales growth and firm performance. Strateg. Manag. J. 21 (4), 455–472. http://www.jstor.org.ezproxy.massey.ac.nz/stable/3094238.

Canh, N.P., Binh, N.T., Thanh, S.D., Schinckus, C., 2020. Determinants of foreign direct investment inflows: the role of economic policy uncertainty. Int. Econ. 161, 159–172. https://doi.org/10.1016/j.inteco.2019.11.012.

Coffee, J.C., 1999a. The Future as History: The Prospects for Global Convergence in Corporate Governance and its Implications. Columbia University School of Law.

Coffee, J.C., 1999b. Privatization and corporate governance: the lessons from securities market failure. J. Corp. Law 25, 1.

Constellation, 2023. What is Energy Deregulation? https://www.constellation.com/content/constellation/en/energy-101/energy-choice/what-is-energy-deregulation.html.

Dang, T.H.-N., Nguyen, C.P., Lee, G.S., Nguyen, B.Q., Le, T.T., 2023. Measuring the energy-related uncertainty index. Energy Econ. 124, 106817 https://doi.org/10.1016/j.eneco.2023.106817.

Ding, S., Guariglia, A., Harris, R., 2016. The determinants of productivity in Chinese large and medium-sized industrial firms, 1998–2007. J. Prod. Anal. 45 (2), 131–155. https://doi.org/10.1007/s11123-015-0460-0.

Dodd, O., 2013. Why do firms cross-list their shares on foreign exchanges? A review of cross-listing theories and empirical evidence. Rev. Behaviour. Finance 5 (1), 77–99. https://doi.org/10.1108/RBF-05-2013-0020.

Domowitz, I., Glen, J., Madhavan, A., 1998. International cross-listing and order flow migration: evidence from an emerging market. J. Financ. 53 (6), 2001–2027. https://doi.org/10.1111/0022-1082.00081.

Dong, Y., Men, C., 2014. SME financing in emerging markets: firm characteristics, banking structure and institutions. Emerg. Mark. Financ. Trade 50 (1), 120–149 doi: 10.2753/REE1540-496X50010710.2753/REE1540-496X500107.

Dowrick, S., Nguyen, D.-T., 1989. OECD comparative economic growth 1950-85: catch-up and convergence. Am. Econ. Rev. 1010–1030.

Duchateau, L., Janssen, P., 1997. An example-based tour in linear mixed models. In: Verbeke, G., Molenberghs, G. (Eds.), Linear Mixed Models in Practice: A SAS-Oriented Approach. Springer, New York, pp. 11–61. https://doi.org/10.1007/978-1-4612-2294-1_2.

Edison, H.J., Warnock, F.E., 2008. Cross-border listings, capital controls, and equity flows to emerging markets. J. Int. Money Financ. 27 (6), 1013–1027. https://doi.org/10.1016/j.jimonfin.2008.05.001.

Eun, C.S., Sabherwal, S., 2003. Cross-border listings and price discovery: evidence from U.S.-listed Canadian stocks. J. Financ. 58 (2), 549–575. https://doi.org/10.1111/1540-6261.00537.

Fairfield, P.M., Whisenant, J.S., Yohn, T.L., 2003. Accrued earnings and growth: implications for future profitability and market mispricing. Account. Rev. 78 (1), 353–371. http://www.jstor.org.ezproxy.massey.ac.nz/stable/3203307.

Farid, S., Karim, S., Naeem, M.A., Nepal, R., Jamasb, T., 2023. Co-movement between dirty and clean energy: a time-frequency perspective. Energy Econ. 119, 106565 https://doi.org/10.1016/j.eneco.2023.106565.

Fernandes, N., Ferreira, M.A., 2008. Does international cross-listing improve the information environment. J. Financ. Econ. 88 (2), 216–244. https://doi.org/10.1016/j.jfineco.2007.06.002.

Figal Garone, L., López Villalba, P.A., Maffioli, A., Ruzzier, C.A., 2020. Firm-level productivity in Latin America and the Caribbean. Res. Econ. 74 (2), 186–192. https://doi.org/10.1016/j.rie.2020.04.004.

Fiorini, M., Sanfilippo, M., Sundaram, A., 2021. Trade liberalization, roads and firm productivity. J. Dev. Econ. 153, 102712 https://doi.org/10.1016/j.jdeveco.2021.102712.

Fons-Rosen, C., Kalemli-Ozcan, S., Sørensen, B.E., Villegas-Sanchez, C., Volosovych, V., 2021. Quantifying productivity gains from foreign investment. J. Int. Econ. 131, 103456 https://doi.org/10.1016/j.jinteco.2021.103456.

Frijns, B., Gilbert, A., Tourani-Rad, A., 2010. The dynamics of price discovery for cross-listed shares: evidence from Australia and New Zealand. Future Stock Exchang. Globaliz. World 34 (3), 498–508. https://doi.org/10.1016/j.jbankfin.2009.08.014.

Hail, L., Leuz, C., 2009. Cost of capital effects and changes in growth expectations around U.S. cross-listings. J. Financ. Econ. 93 (3), 428–454. https://doi.org/10.1016/j.jfineco.2008.09.006.

Heil, M., 2019. Finance and productivity: a literature review. In: Contemporary Topics in Finance, pp. 151–182. https://doi.org/10.1002/9781119565178.ch6.
Hill, A., 2021. Excessive entry and investment in deregulated markets: evidence from the electricity sector. J. Environ. Econ. Manag. 110, 102543 https://doi.org/10.1016/j.jeem.2021.102543.
IEA & ICL, 2023. ASEAN Renewables: Opportunities and Challenges. I. C. L. A. T. I. E. Agency. https://www.imperial.ac.uk/business-school/faculty-research/research-centres/centre-climate-finance-investment/research/asean-renewables/.
Jensen, M.C., 1986. Agency costs of free cash flow, corporate finance, and takeovers. Am. Econ. Rev. 76 (2), 323–329. http://www.jstor.org.ezproxy.massey.ac.nz/stable/1818789.
Jensen, M.C., Meckling, W.H., 1976. Theory of the firm: managerial behavior, agency costs and ownership structure. J. Financ. Econ. 3 (4), 305–360. https://doi.org/10.1016/0304-405X(76)90026-X.
Jin, M., Zhao, S., Kumbhakar, S.C., 2019. Financial constraints and firm productivity: evidence from Chinese manufacturing. Eur. J. Oper. Res. 275 (3), 1139–1156. https://doi.org/10.1016/j.ejor.2018.12.010.
Karolyi, G.A., 2006. The world of cross-listings and cross-listings of the world: challenging conventional wisdom*. Rev. Finance 10 (1), 99–152. https://doi.org/10.1007/s10679-006-6980-8.
Khurana, I.K., Martin, X., Periera, R., 2008. Cross-listing and firm growth*. Rev. Finance 12 (2), 293–322. https://doi.org/10.1093/rof/rfm031.
King, M.R., Mittoo, U.R., 2007. What companies need to know about international cross-listing. J. Appl. Corp. Financ. 19 (4), 60–74. https://doi.org/10.1111/j.1745-6622.2007.00160.x.
Knack, S., Xu, L.C., 2017. Unbundling institutions for external finance: worldwide firm-level evidence. Finance 44, 215–232. https://doi.org/10.1016/j.jcorpfin.2017.02.003.
Lambrecht, B.M., Myers, S.C., 2012. A Lintner model of payout and managerial rents. J. Financ. 67 (5), 1761–1810. https://doi.org/10.1111/j.1540-6261.2012.01772.x.
Lang, M., Lins, K.V., Miller, D.P., 2003. ADRs, analysts, and accuracy: does cross listing in the United States improve a Firm's information environment and increase market value? J. Account. Res. 41 (2), 317–345. https://doi.org/10.1111/1475-679X.00106.
Levinsohn, J., Petrin, A., 2003. Estimating production functions using inputs to control for unobservables. Rev. Econ. Stud. 70 (2), 317–341. https://doi.org/10.1111/1467-937X.00246.
Li, K., Guo, Z., Chen, Q., 2021. The effect of economic policy uncertainty on enterprise total factor productivity based on financial mismatch: evidence from China. Pac. Basin Financ. J. 68, 101613 https://doi.org/10.1016/j.pacfin.2021.101613.
Lins, K.V., Strickland, D., Zenner, M., 2005. Do non-U.S. firms issue equity on U.S. stock exchanges to relax capital constraints? J. Financ. Quant. Anal. 40 (1), 109–133. http://www.jstor.org/stable/27647188.
Luong, H., Moshirian, F., Nguyen, L., Tian, X., Zhang, B., 2017. How do foreign institutional investors enhance firm innovation? J. Financ. Quant. Anal. 52 (4), 1449–1490.
Merton, R.C., 1987. A simple model of capital market equilibrium with incomplete information. J. Financ. 42 (3), 483–510. https://doi.org/10.1111/j.1540-6261.1987.tb04565.x.
Mittoo, U.R., 2003. Globalization and the value of US listing: revisiting Canadian evidence. Future Stock Exchang. Globaliz. World 27 (9), 1629–1661. https://doi.org/10.1016/S0378-4266(03)00093-1.
Naeem, M.A., Peng, Z., Suleman, M.T., Nepal, R., Shahzad, S.J.H., 2020. Time and frequency connectedness among oil shocks, electricity and clean energy markets. Energy Econ. 91, 104914 https://doi.org/10.1016/j.eneco.2020.104914.
Naeem, M.A., Bouri, E., Costa, M.D., Naifar, N., Shahzad, S.J.H., 2021. Energy markets and green bonds: a tail dependence analysis with time-varying optimal copulas and portfolio implications. Res. Policy 74, 102418. https://doi.org/10.1016/j.resourpol.2021.102418.
Naeem, M.A., Hasan, M., Arif, M., Suleman, M.T., Kang, S.H., 2022. Oil and gold as a hedge and safe-haven for metals and agricultural commodities with portfolio implications. Energy Econ. 105, 105758 https://doi.org/10.1016/j.eneco.2021.105758.
Naeem, M.A., Farid, S., Yousaf, I., Kang, S.H., 2023. Asymmetric efficiency in petroleum markets before and during COVID-19. Res. Policy 86, 104194. https://doi.org/10.1016/j.resourpol.2023.104194.
Nakatani, R., 2023. Debt maturity and firm productivity—the role of intangibles. Res. Econ. 77 (1), 116–121. https://doi.org/10.1016/j.rie.2023.01.009.
Nickell, S., 1981. Biases in dynamic models with fixed effects. Econometrica 49 (6), 1417–1426. https://doi.org/10.2307/1911408.
Oberg, A.L., Mahoney, D.W., 2007. Linear mixed effects models. In: Ambrosius, W.T. (Ed.), Topics in Biostatistics. Humana Press, pp. 213–234. https://doi.org/10.1007/978-1-59745-530-5_11.
Olley, G.S., Pakes, A., 1996. The dynamics of productivity in the telecommunications equipment industry. Econometrica 64 (6), 1263–1297. https://doi.org/10.2307/2171831.
Pagano, M., Röell, A.A., Zechner, J., 2002. The geography of equity listing: why do companies list abroad? J. Financ. 57 (6), 2651–2694. http://www.jstor.org/stable/3094540.
Park, K., Jang, S., 2013. Capital structure, free cash flow, diversification and firm performance: a holistic analysis. Int. J. Hosp. Manag. 33, 51–63. https://doi.org/10.1016/j.ijhm.2013.01.007.
Pascual, R., Pascual-Fuster, B., Climent, F., 2006. Cross-listing, price discovery and the informativeness of the trading process. J. Financ. Mark. 9 (2), 144–161. https://doi.org/10.1016/j.finmar.2006.01.002.
Peng, M.W., Su, W., 2014. Cross-listing and the scope of the firm. J. World Bus. 49 (1), 42–50. https://doi.org/10.1016/j.jwb.2012.11.002.
Raikar, S., Adamson, S., 2020. Financing the new energy economy. In: Raikar, S., Adamson, S. (Eds.), Renewable Energy Finance. Academic Press, pp. 1–8. https://doi.org/10.1016/B978-0-12-816441-9.00001-5.
Reese, W.A., Weisbach, M.S., 2002. Protection of minority shareholder interests, cross-listings in the United States, and subsequent equity offerings. J. Financ. Econ. 66 (1), 65–104. https://doi.org/10.1016/S0304-405X(02)00151-4.
Rehman, M.U., Naeem, M.A., Ahmad, N., Vo, X.V., 2023. Global energy markets connectedness: evidence from time–frequency domain. Environ. Sci. Pollut. Res. 30 (12), 34319–34337. https://doi.org/10.1007/s11356-022-24612-2.
Reiter, N., 2021. Investor communication and the benefits of cross-listing. J. Account. Econ. 71 (1), 101356 https://doi.org/10.1016/j.jacceco.2020.101356.
Ren, X., Zhang, X., Yan, C., Gozgor, G., 2022. Climate policy uncertainty and firm-level total factor productivity: evidence from China. Energy Econ. 113, 106209 https://doi.org/10.1016/j.eneco.2022.106209.
Rosenbaum, P.R., Rubin, D.B., 1983. The central role of the propensity score in observational studies for causal effects. Biometrika 70 (1), 41–55. https://doi.org/10.2307/2335942.
Shi, Y., Magnan, M., Kim, J.-B., 2012. Do countries matter for voluntary disclosure? Evidence from cross-listed firms in the US. J. Int. Bus. Stud. 43 (2), 143–165. https://doi.org/10.1057/jibs.2011.38.
Stern, D.I., 1993. Energy and economic growth in the USA: a multivariate approach. Energy Econ. 15 (2), 137–150. https://doi.org/10.1016/0140-9883(93)90033-N.
Stern, D.I., 2000. A multivariate cointegration analysis of the role of energy in the US macroeconomy. Energy Econ. 22 (2), 267–283. https://doi.org/10.1016/S0140-9883(99)00028-6.
Stulz, R.M., 1999. Globalization, corporate finance, and the cost of capital. J. Appl. Corp. Financ. 12 (3), 8–25. https://doi.org/10.1111/j.1745-6622.1999.tb00027.x.
Syverson, C., 2011. What determines productivity? J. Econ. Lit. 49 (2), 326–365. https://doi.org/10.1257/jel.49.2.326.
The World Bank, 2023a. Energy Overview. https://www.worldbank.org/en/topic/energy/overview#1.
The World Bank, 2023b. Propensity Score Matching - Dimewiki. https://dimewiki.worldbank.org/Propensity_Score_Matching.
Thompson, M.A., Rushing, F.W., 1999. An empirical analysis of the impact of patent protection on economic growth: an extension. J. Econ. Dev. 24 (1), 67–76.
Tian, G.Y., Twite, G., 2011. Corporate governance, external market discipline and firm productivity. Financ. Flexibil. Corp. Liquid. 17 (3), 403–417. https://doi.org/10.1016/j.jcorpfin.2010.12.004.
Titman, S., Wei, K.C.J., Xie, F., 2004. Capital investments and stock returns. J. Financ. Quant. Analys. 39 (4), 677–700. http://www.jstor.org.ezproxy.massey.ac.nz/stable/30031881.
Umar, M., Farid, S., Naeem, M.A., 2022. Time-frequency connectedness among clean-energy stocks and fossil fuel markets: comparison between financial, oil and pandemic crisis. Energy 240, 122702. https://doi.org/10.1016/j.energy.2021.122702.
UNEP, 2023. Why does energy matter? U. E. Programme. http://www.unep.org/explore-topics/energy/why-does-energy-matter.
Verbeke, G., Molenberghs, G., 2000. A model for longitudinal data. In: Molenberghs, G., Verbeke, G. (Eds.), Linear Mixed Models for Longitudinal Data. Springer, New York, pp. 19–29. https://doi.org/10.1007/978-1-4419-0300-6_3.
Veronica, S., Manlio, D.G., Shlomo, T., Antonio, M.P., Victor, C., 2020. International social SMEs in emerging countries: do governments support their international growth? J. World Bus. 55 (5), 100995 https://doi.org/10.1016/j.jwb.2019.05.002.
Windmeijer, F., 2005. A finite sample correction for the variance of linear efficient two-step GMM estimators. J. Econ. 126 (1), 25–51. https://doi.org/10.1016/j.jeconom.2004.02.005.
Wooldridge, J.M., 2009. On estimating firm-level production functions using proxy variables to control for unobservables. Econ. Lett. 104 (3), 112–114. https://doi.org/10.1016/j.econlet.2009.04.026.
Xu, J., Liu, Y., Abdoh, H., 2022. Foreign ownership and productivity. Int. Rev. Econ. Financ. 80, 624–642. https://doi.org/10.1016/j.iref.2022.02.079.