Energy Policy 146 (2020) 111803

Contents lists available at ScienceDirect

Energy Policy

journal homepage: http://www.elsevier.com/locate/enpol

Has Chinese outward foreign direct investment in energy enhanced China's energy security?

Yong Zhao [a], Xunpeng Shi [b], Feng Song [c,*]

[a] School of Economics, Renmin University of China, China
[b] Australia-China Relations Institute, University of Technology Sydney, Australia
[c] School of Applied Economics, Renmin University of China, China

ARTICLE INFO

Keywords:
China
Outward foreign direct investment
Energy security
Oil import

ABSTRACT

China's soaring outward foreign direct investment (OFDI) in the energy sector has attracted increasing attention, which is arguably intended to enhance China's energy security given its large oil deficit. This study attempts to empirically examine whether OFDI in the energy sector can help to enhance China's energy security by conducting an econometric analysis using a micro-level dataset. The results show that China's OFDI in energy does enhance its energy security by increasing the volume of oil imports from host countries for the investment and by diversifying China's sources of imports. On average, a 1% increase in energy OFDI to a country leads to a 1.2% increase in the probability of importing from that country and a 0.071% increase in the firm-level import volume. In addition, we find that the effects do not differ by investment mode (i.e. mergers and acquisitions or greenfield investments) but do differ by country type, as investments in developing countries can positively contribute to oil imports, whereas investments in developed countries do not have the same effect.

1. Introduction

Alongside its dramatic economic growth over the past four decades, China has become the world's largest energy consumer, accounting for 21% of the world's energy consumption, and was a net importer of coal, oil, and natural gas in 2018 (BP, 2019). In the same year, China imported 460 million tonnes of crude oil and surpassed the US as the world's largest oil importer. Its oil import dependence rate also reached a record high of nearly 70% (IEA, 2019). In this context, energy security, especially oil security, is considered the top concern of China's policymakers (Gholz et al., 2017).

China's outward foreign direct investment (OFDI) has grown significantly since the 2000s, and its investment in the overseas energy sector has particularly increased (Gholz et al., 2017; Leung, 2011; Zhang, 2011). Although strengthening energy security is the widely cited motivation for China's OFDI in the energy sector, the effectiveness of this investment is under debate, and quantitative studies of the issue are limited. China's government and many scholars consider OFDI in the energy sector as an instrument for enhancing China's energy security (Duan et al., 2018; Tang et al., 2017). The argument that OFDI has a positive effect on energy security is also made regarding observations of the non-commercial behaviour of national oil companies (NOCs), which is considered to be driven by security reasons (Bradsher, 2011; Wolfe and Tessman, 2012).

However, some experts raise the opposing argument that OFDI has enhanced China's energy security only marginally or not at all. Incidental observations suggest that China's equity oil has not necessarily been returned to China (Downs, 2007; Leung, 2011; Zhang, 2011; Zhang, 2012) and that the NOCs' behaviour is profit-driven (Kong, 2011; Odgaard and Delman, 2014).

Although these previous studies provide pioneering research on the relationship between China's OFDI in the energy sector and its energy security, quantitative and comprehensive studies on this topic are notably lacking. The majority of them only consider incidental evidence, which may lead to conflicting conclusions depending on the case selected. Thus, further clarifying this debate is important not only for academics but also for both Chinese policymakers and international stakeholders. As a major energy consumer in an integrated world in which domestic policies are inseparable from foreign policies, China's energy security will have a significant global impact.

Our study contributes to this debate by conducting a rigorous regression analysis to explore whether China's energy OFDI contributes to its energy security. We use a dataset created by merging China Global Investment Tracker data with Chinese Customs oil import data. We focus

* Corresponding author.
E-mail addresses: joyong@ruc.edu.cn (Y. Zhao), xunpeng.shi@uts.edu.au (X. Shi), songfeng@ruc.edu.cn (F. Song).

https://doi.org/10.1016/j.enpol.2020.111803
Received 30 January 2020; Received in revised form 26 July 2020; Accepted 27 July 2020
Available online 17 August 2020
0301-4215/

on oil because it is the primary topic of concern in discussions about energy security (Leung, 2011; Li et al., 2016; Yao et al., 2018). To the best of our knowledge, this study is the first to empirically quantify the impact of China's OFDI in energy resources on its energy security using micro-level data.

We also contribute to the emerging literature on the behaviour of China's OFDI, which has increased substantially over the past decade and is playing a larger role in shaping the global economy. Studies are starting to investigate the determinants of China's choices of investment type and location as well as the impacts of its investments. For example, Cozza et al. (2015) and Huang and Zhang (2017) investigate whether China's OFDI enhances firms' performance, and Hao et al. (2019) examine whether it affects the host country's environmental quality. Our study complements these existing studies by examining whether China's OFDI has successfully improved national energy security.

The estimation results provide supporting evidence for the hypothesis that China's energy OFDI enhances its energy security. Specifically, OFDI in a country helps to increase the probability of importing oil from that country, meaning that it helps to diversify oil imports, and it also increases the volume of oil imports from the host country. Further analysis reveals that the effects do not differ by investment mode but do differ by country type. Investments in developing countries can positively contribute to oil imports, whereas investments in developed countries do not have the same effect.

The remainder of the paper proceeds as follows. The next section briefly presents the facts and debates on China's OFDI related to energy security. Section 3 presents the empirical model. Results on the relation between OFDI and China's energy imports are presented in Section 4. The last section concludes and provides policy implications.

2. Background and literature review

2.1. China's energy OFDI

The Chinese government has long promoted OFDI in the energy sector. In the 10th Five-Year Plan (2001–2005), the Chinese government began proposing to make full use of both domestic and foreign resources and launch the 'going out' strategy. The following 11th Five-Year Plan stated that China will accelerate mutually beneficial cooperation in exploring, developing, and processing energy resources worldwide. In China's 12th Five-Year Plan period, overseas oil investment, strategic petroleum reserves, and unconventional gas development were considered the key elements of China's energy security strategies (Wu, 2014). The 'going out' strategy was further strengthened in the 13th Five-Year Plan with 'openness' and capacity cooperation with the 'Belt and Road' countries (NDRC, 2016).

Partially owing to these encouraging policies, the scale of China's energy OFDI increased from 6.6 billion USD to 55.2 billion USD between 2005 and 2017. Although China's energy OFDI was initially concentrated in resource-rich countries, it has notably shifted toward OECD countries, such as the EU, the US, and Canada, since 2011 (Jiang and Ding, 2014). As of the end of 2017, China's energy OFDI has spread to 49 countries or regions worldwide. North America received the most accumulative investment between 2005 and 2017, with 24% of total investment, followed by South America, with 22% of the total. Russia and other Western Asia countries (including Kazakhstan, Mongolia, and Kazakhstan) accounted for about 17% of total investment. Fig. 1 illustrates this regional distribution.

Additionally, overseas investments can take one of two basic modes: greenfield investment and cross-border merger and acquisition (M&A). Greenfield investment involves building operations from the ground up, whereas M&A involves transferring existing assets from local firms to foreign investors. A closer look at the project-level data shows that China's investments mainly take the form of cross-border M&A. Specifically, among the 123 oil investment projects in the data, 34 are greenfield investments, accounting for 24% of the total, with M&A projects accounting for the remaining 76%.

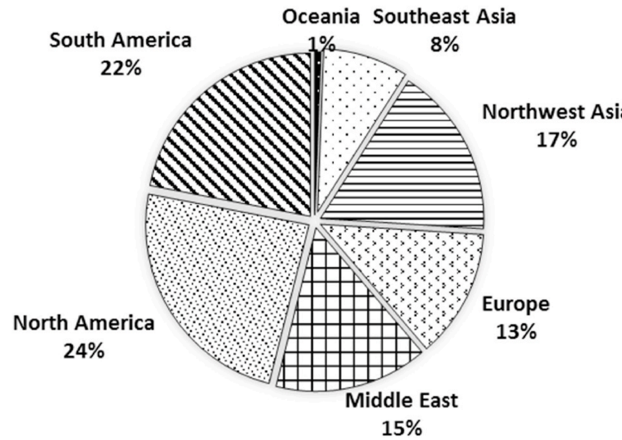

Fig. 1. Regional distribution of China's overseas investment in energy. Data source: China Global Investment Tracker data.

2.2. China's oil imports

China's oil imports have three notable characteristics. First, its oil imports have substantially increased over time. Although China prefers to ensure its energy security through self-reliance, its rapid economic growth, urbanization, and increasing standard of living have created a significant gap in domestic supply and demand. Since China became a net oil importer in 1993, its net imports have continued to rapidly rise, reaching 460 million tonnes in 2018 and accounting for 21% of total global oil trade. Even with slower economic growth within the 'New Normal' economic environment, China's oil consumption and its important dependencies are expected to continue to grow over the next two decades (IEA, 2017).

Second, China's sources of oil imports are concentrated in a few countries, mainly in the Middle East and Africa, although they have diversified over time. The data for 2005 to 2017, as illustrated in Fig. 2, show several specific trends. China's sources of oil imports have become more diversified, as the number of importing countries has increased from 37 to 48. Although the Middle East remains the most important region for imports, its share of imports declined slightly from 47% to 43%. Imports from Africa declined substantially from 30% to 20%. Imports from South America increased from less than 3%–14%, and imports from Russia increased from 10% to 14%.

Third, although importing firms are also concentrating, the number of importers has increased over time with the gradual liberalization of importer restrictions. The Chinese government controls who can import oil with a quota system. State-owned enterprises used to control almost all oil imports because they were thought to better serve energy security purposes. Since China's entry into the WTO in 2001, however, more firms, including foreign firms, have been allowed to import oil, leading the total number of importing firms to increase from 20 to 74 between 2002 and 2016. The number of foreign firms increased from four to fourteen, their import volume increased six fold, and their import share has fluctuated around 10% over time.

2.3. Literature review

2.3.1. Energy security

The literature describes different concepts of energy security. A narrower definition of energy security focuses on its most important aspect: the availability of the energy supply and its maintenance at a stable level to satisfy the demand required for national development (IEA, 2017). A more comprehensive definition includes many other dimensions, including physical availability, price affordability, and

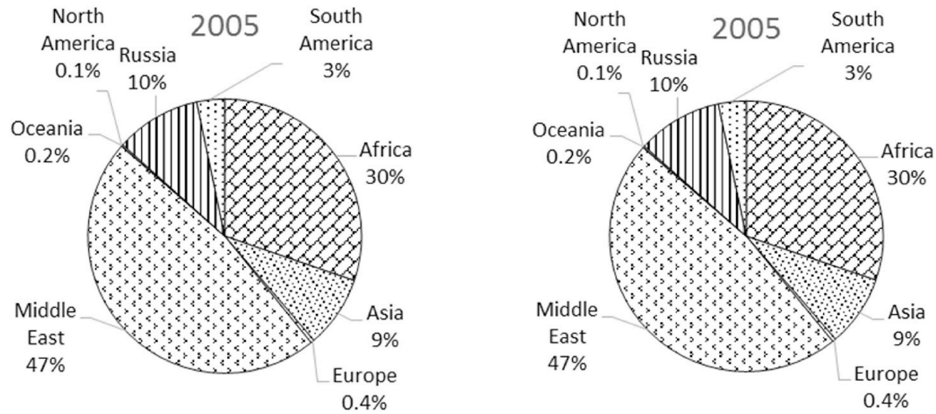

Fig. 2. Regional distribution of China's oil import sources: 2005 *vs.* 2017.
Data source: Chinese Customs Database

environmental sustainability (Brown and Huntington, 2018).

For oil-importing countries, oil is the key to energy security, as concerns about the security of oil imports dominate policy discussions and policymaking (Vivoda, 2009). In addition to securing the necessary quantity of oil to meet domestic demand, the diversification of the sources of oil imports is used by oil-importing countries as a strategy to enhance energy security. In general, relying on a single source of oil imports is much riskier than importing oil from multiple sources. Having multiple suppliers provides security and reduces vulnerability if a temporary or permanent supply disruption occurs (Cohen et al., 2011; Vivoda, 2009).

2.3.2. China's OFDI and its energy security

As early as the 1990s, NOCs were encouraged to make overseas investments to expand their reserves and production. These investments involve purchasing exploration and drilling rights, securing a guaranteed percentage of production from the host country, and acquiring foreign firms. The equity oil of Chinese NOCs' overseas investment has increased substantially to over 200 million tonnes annually and has already exceeded China's annual domestic oil output since 2018 (Ministry of Natural Resource of the People's Republic of China, 2019). Many studies also accept the premise that China's energy OFDI can help to promote energy security by increasing oil and gas reserves, expanding production, and diversifying oil supply sources (e.g. Dong et al., 2011; Kong et al., 2019; Wu, 2014).

Some researchers argue that China's energy OFDI can also indirectly help to enhance oil security through several channels in addition to helping China secure equity oil, including promoting long-term relationships with oil-producing countries, investing and lobbying for the construction of transportation routes which favour China, and enhancing the international oil supply (Leung, 2011; Zhang, 2012).

Opposing arguments have also been raised. Specifically, it is argued that Chinese NOCs are profit-seeking investors and do not prioritize energy security beyond their business operations. Moreover, NOCs' non-commercial behaviour may be driven by other factors besides energy security. Jiang and Ding (2014) claim that partnering with international oil companies can help Chinese NOCs acquire management experience and technology in such areas as unconventional oil and gas, deep water, and liquefied natural gas. Zhang (2012) argues that energy OFDI can help the Chinese government diversify its foreign exchange reserves away from low-yielding financial instruments, such as US Treasury Bonds. Lai et al. (2014) argue that the investments of China's NOCs can be best explained by the 'sectoral specialization' hypothesis along with a consideration for strategic assets.

Given this discussion, our main hypothesis is that China's energy OFDI can help to enhance its energy security by increasing its volume of imports and diversifying its import source countries. Overseas investment in a host country can bring new oil suppliers through two channels. First, China may acquire oil assets in the country and, thus, gain more control over oil resources. Second, the learning and information effects of the investment can reduce uncertainty around oil imports for Chinese oil importers.

In response to the notion that energy OFDI flows to developed countries to acquire technology and management experience rather than to implement a governmental energy security strategy, we investigate whether the energy security effects differ by destination country type. In addition, we investigate whether the energy security effects differ by investment type (i.e. greenfield investment vs. M&A).

3. Modelling the impact of China's energy OFDI on energy security

3.1. Estimation model and identification strategy

We address whether China's energy OFDI enhances its energy security from two angles: whether it helps diversify China's import sources by increasing the probability of importing from a host country (extensive margin) and whether it increases the imported volume from a destination country (intensive margin). Although the data show that China's oil imports have increased substantially to meet its domestic demand and that its sources of oil have diversified over the past decade, the causal relationship between overseas investments and this diversification needs to be examined more carefully.

To evaluate the impact of OFDI on the diversification of oil imports, we specify a logit model to estimate the likelihood of importing from a given country, as follows:

$$\Pr(y_{ijt} > 0) = a + \lambda * \log(EI_{it}) + \boldsymbol{X}\beta + u_i + e_j + v_t + \varepsilon_{ijt} \tag{1}$$

Similarly, the impact of China's energy OFDI on its volume of oil imports is specified as follows:

$$\mathrm{Log}(y_{ijt}) = \beta + \gamma * \log(EI_{it}) + \boldsymbol{X}\beta + u_i + e_j + v_t + \zeta_{ijt}, \tag{2}$$

where Pr is the probability of a firm importing from a given country, y_{ijt} is firm j's imported oil from country i in year t. EI_{it} is China's cumulative energy investments in country i as of year t and the variable of interest.[1] The coefficient λ measures the probability of an increase in oil imports if investment increases by one percent, and the coefficient γ measures the impact of increasing investment on import volumes. $\boldsymbol{X}$ is a vector of control variables that may affect oil imports from country i in year t. u_i denotes country fixed effects and captures many of the time-invariant

[1] Annual OFDI is deflated by the US GDP deflator and is expressed in 2010 dollars.

unobserved country-specific characteristics included in the gravity model, such as geographic distance, among others. e_j represents firm fixed effects and allows us to take into account unobserved heterogeneity across firms that is potentially correlated with their import decisions. v_t is a vector of year dummies used to capture time-variant unobserved heterogeneity. Finally, ε_{ijt} and ζ_{ijt} are the error terms, which may be correlated within a firm.

Based on previous studies of the oil trade (Kashcheeva and Tsui, 2015; Mityakov et al., 2013; Sheng et al., 2015), we use a set of control variables that can affect oil imports from different countries. First, GDP measures the market size of a source country and is expected to positively impact the oil trade flow as a major driver of trade volume. Second, GDP per capita measures the income of a source country. A high income implies that the source country has higher energy demand, and, thus, it negatively affects China's imports from that country. Third, country risk may negatively affect imports from a country, as importers may rationally reduce their imports from high-risk countries. Finally, oil production and consumption in the import source country are measured in terms of annual barrels of oil production and consumption, respectively. Oil production should positively affect China's imports, whereas oil consumption should have a negative impact.

A challenge in estimating Eqs. (1) and (2) is the potential endogeneity concern that may arise from the reverse causality between overseas investments and oil imports. To mitigate this endogeneity issue, we estimate Eqs. (1) and (2) using micro-level data. In all the estimations, the dependent variable is annual oil imports at the firm-destination level, and the key explanatory variable, overseas investment, is aggregated at the destination country level. The aggregate-level variables should affect the individual variables, but the reverse does not hold. Thus, the potential endogeneity problem caused by reverse causality should be mitigated. However, regressing individual variables on aggregate variables can lead to seriously downward-biased standard errors (Moulton, 1990). To address this issue, we cluster all regressions at the firm level.

Another challenge in the estimation stems from the zero-value problem in import trade. In Eq. (2), the logarithm of the volume of imports excludes observations with zero-value imports. If the process for eliminating these zero values is non-random, sample selection bias is inevitable. To address this issue, we employ the EK-Tobit model proposed by Eaton and Kortum (2001). Zero trade may arise for several reasons; it may reflect actual trade transactions, or the exporter or importer may have chosen to report only data above a certain threshold. Thus, Eaton and Kortum (2001) suggest that the threshold value could be a maximum likelihood estimation of the censoring point, as implied by trade models with fixed trade costs. They therefore replace zero values with the minimum trade value exported by a certain company to a certain country and use an interval regression for estimation.

Compared with the traditional Tobit model, the EK-Tobit model not only has no exclusion restrictions but also better controls for country or country pair effects. Head and Mayer (2014) compare a variety of different zero-value trade processing methods, affirm the validity of the EK-Tobit model estimation, and consider that method to be one of the most effective methods in this setting. Furthermore, this method is currently widely used in the estimation and identification of trade models (Cheptea et al., 2015; Gaigné et al., 2018). We therefore estimate model (2) using the EK-Tobit method, replacing zero import flows with a truncation point specific to each firm defined as the minimum non-zero import value by that firm.

3.2. Data

The data are compiled from several sources. Data on oil imports are obtained from the Chinese Customs Database, which contains transaction-level information, including the time, importer, transaction value, quantity, and importing source country.[2] These data can therefore be aggregated according to the import source country and year. The data on energy OFDI come from the China Global Investment Tracker (American Enterprise Institute and Heritage Foundation, 2018), which covers Chinese investments announced in the open-source media with values over $100 million. These data can serve as a reasonable proxy for China's large-scale investments (Luo et al., 2017).[3]

GDP and GDP per capita are taken from the World Bank Development Indicator Database, the indicator of country risk is taken from the Economist Intelligence Unit Country Risk Model Database,[4] and oil production and consumption come from the BP Statistical Review of World Energy (BP, 2019). Our final dataset has 100,748 observations for 178 importing firms and 164 countries, covering the period 2005–2013. Table 1 presents summary statistics for the variables used in our regressions.

4. Results and discussion

4.1. Baseline results

Table 2 reports the baseline estimation results for Eqs. (1) and (2). Year, country, and firm fixed effects are included in all models, but the results are not reported here owing to limited space. Columns (1) and (2) report the results of estimating Eq. (1) using OLS and logit models, respectively. This regression examines whether overseas oil investment

Table 1
Summary statistics.

Variable name	Max	Min	Mean	S.D.
Market size (trillion US dollars)	16.7	0.0042	0.081	2.02
Income (1000 US dollars)	102.9	0.50	18.3	20.5
Economic risk	89.7	9.0	42.9	14.7
Oil production (billion barrels)	4.25	0	0.44	0.79
Oil consumption (billion barrels)	7.59	0	0.39	0.94
Cumulative OFDI (billion US dollars)	12.8	0	0.51	1.74
Cumulative greenfield investment (billion US dollars)	5.66	0	0.16	0.74
Cumulative M&A (billion US dollars)	10.2	0	0.35	1.39
Oil imports (1000 tonnes)	37,090	0	18.1	418
Entry dummy (whether a firm has a positive value of imports)	1	0	0.015	0.12

[2] Imported oil products are defined as those assigned the eight-digit Harmonized System code 27090000.

[3] Several sources provide data on China's OFDI, including some official data sources, such as China's Ministry of Commerce, the National Bureau of Statistics, and the State Administration of Foreign Exchange. At the aggregate level, the tracker data and the official data reported by the Ministry of Commerce have few discrepancies. However, the tracker dataset records the final destinations of investments, whereas the official data from the Ministry of Commerce only records the first destination, leading to a large amount of bias. The disadvantage is that the tracker may under-represent smaller scale investments (i.e. those smaller than $100 million). Because energy-related investments often involve large amounts of money, the tracker can be considered to have good representativeness.

[4] The Country Risk Model is developed by the Economist Intelligence Unit. It provides risk scores that can be compared across countries and over time for six risk categories (i.e. sovereign debt, currency, the banking sector, political structure, economic structure, and overall country risk). We use the overall country risk index to measure the host countries' market risk conditions. More details on the database can be found at the following website. https://www.eiu.com/handlers/publicDownload.ashx?mode=m&fi=risk-section/country-risk-model.pdf.

Table 2
Baseline results.

Variables	Extensive Margin		Intensive Margin	
	OLS	LOGIT	OLS	EK-TOBIT
	(1)	(2)	(3)	(4)
OFDI	0.000291***	0.0116*	0.00570***	0.0711**
	(9.75e-05)	(0.00613)	(0.00180)	(0.0333)
Market size	0.0390***	1.740*	0.740***	8.023*
	(0.0124)	(0.902)	(0.242)	(4.483)
Income	−0.0389***	−1.919**	−0.737***	−9.445**
	(0.0123)	(0.836)	(0.241)	(4.080)
Economic risk	−0.000111	−0.00723	−0.00233	−0.0313
	(0.000125)	(0.00894)	(0.00232)	(0.0493)
Oil production	0.0110***	0.591***	0.180***	3.420***
	(0.00348)	(0.217)	(0.0595)	(1.234)
Oil consumption	−0.00621	−0.596	−0.111	−3.557
	(0.00671)	(0.669)	(0.125)	(3.281)
Constant	−0.771***	−34.84*	−14.21***	−143.4
	(0.240)	(20.14)	(4.600)	(98.82)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
R^2	0.186		0.205	
Observations	100,748	64,512	100,748	99,050

Notes: Robust standard errors clustered at the firm level are reported in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

in a country increases the probability of importing oil from that country. Because the logit model results have more explicit economic meanings than the OLS results have, we discuss the results of the logit model. The estimation shows that China's energy OFDI in a country is positively associated with the probability of importing oil from that country. The point estimate of the OFDI coefficient is 0.012, which corresponds to an odds-ratio value of $EXP(0.012) = 1.012$, implying that a 1% increase in China's investment in a host country's oil sector leads to a 1.2% increase in the probability of importing from that country on average at the firm level.

Columns (3) and (4) report the results for Eq. (2) using OLS and EK-Tobit estimators, respectively. This model aims to determine whether investment in a country increases the volume of imports from that country. The coefficients of OFDI are statistically significant and positive in all regressions, implying that OFDI in a host country's energy sector positively impacts the volume of oil imports from that country. Specifically, the point estimate of the OFDI coefficient in the EK-Tobit model is 0.071. This result implies that 1% increase in a host country's oil sector investment leads to an approximately 0.071% increase in imports from that country on average at the firm level. Our results support the argument that China's energy OFDI helps to promote China's energy security by diversifying the source countries and increasing imports. Although there are some incidental observations that the equity oil may not be shipped back to China, the overall oil imports from the host country increase with investment.

Finally, the coefficients of the control variables are consistent with our expectations. Specifically, the coefficients of market size and oil production are significantly positive, and the coefficients of the income variables are significantly negative. This result suggests that, ceteris paribus, a Chinese firm imports more oil from countries with greater market size and oil production and less oil from countries with higher incomes. This significant role of market size and production is also consistent with the findings of previous studies, such as those of Buckley et al. (2007) and Urdinez et al. (2014). The coefficients of economic risk and oil consumption are not statistically significant, indicating that they do not affect oil imports.

4.2. Robustness checks

In this section, we examine the robustness of our baseline results. The first check is excluding foreign firms. Although domestic enterprises, especially state-owned enterprises, have always been the main driver of oil imports, the import volumes of foreign-owned enterprises have also increased following the financial crisis. Oil imports by foreign and domestic firms may play different roles in oil security. Thus, as a robustness check, we run regressions excluding foreign firms (including wholly foreign-owned firms and foreign joint ventures). Column (1) in Table 3 presents the extensive margin effect of OFDI, and column (2) shows the intensive margin effect. In all models excluding foreign firms, the coefficients of OFDI are still positive and significant, indicating the robustness of our baseline result. Furthermore, the magnitude of the coefficient of OFDI is greater in this model than in the baseline model, implying that OFDI affects the imports of domestic firms more than those of the foreign firms.

The second check is excluding superstar firms. To avoid reverse causality, we use energy OFDI at the country level as an explanatory variable for firm-level imports because the aggregate level variable may affect the individual variable, but the reverse does not hold. However, sufficiently large individual firms (i.e. superstar firms) may be able to affect the aggregate level. This so-called granular effect is drawing increasing attention in the trade literature (Bernard et al., 2018; Freund and Pierola, 2015; Gaubert and Itskhoki, 2018). Thus, we define the firm with the greatest volume of imports in a given market in a year as a superstar firm, and we exclude all superstar firms from the sample and run the regressions given by Eqs. (1) and (2) again. Columns (3) and (4) in Table 3 show that the coefficients of all variables barely change, indicating the robustness of the baseline results. [5]

4.3. Heterogeneous impacts by investment mode and country type

In this section, we explore two potential heterogeneous impacts of China's OFDI on energy security. To explore whether the investment type matters when estimating the effect of OFDI on oil imports, we run separate estimations for greenfield investment and M&A. Harms and Méon (2018) argue that greenfield investment can contribute more to expand a host country's capital stock than M&A does because the latter is more like a rent that accrues to the previous owners. Similar logic applies in this context. Greenfield investment can help to expand local production capacity more than M&A does, leading to more oil supply as a result. In this sense, greenfield investment can provide Chinese investors with more control. However, the estimation results in Table 4 show that greenfield investment and M&A both positively affect the diversification of source countries and the volume of oil imports. A *t*-test shows that the coefficients of these two variables are not statistically different, and, thus, we find no evidence for heterogeneous effects by investment mode.

Using our rich dataset, we can also examine whether the relationship between energy OFDI and oil imports depends on whether the destination country is developing or developed. We speculate that OFDI flows to developed countries may be used to seek technology and management experience, whereas flows to developing countries are more commonly used to seek energy resources. If so, energy OFDI flows to developed countries may not increase imports from the destination countries. Table 5 shows the results of testing whether the effects of energy OFDI differ for developing and developed countries. In all regressions, investment in developing countries has a statistically positive impact on oil imports at both the extensive and intensive margins. In contrast, neither M&A nor greenfield investment in developed countries results in positive impacts on oil imports. The results support our hypothesis that energy OFDI affects energy security differently in developing and developed countries. The results are also consistent with previous

[5] The mean group estimation is also conducted. As our dataset is a panel with large N and very small T, the estimated coefficients show similar signs to the baseline results but statistically insignificant due to large standard errors.

Table 3
Robustness checks: excluding foreign and superstar firms.

Variables	Excluding foreign firms		Excluding superstar firms	
	Extensive margin	Intensive margin	Extensive margin	Intensive margin
	LOGIT	EK-TOBIT	LOGIT	EK-TOBIT
	(1)	(2)	(3)	(4)
OFDI	0.0129**	0.0826**	0.0110*	0.0694*
	(0.00606)	(0.0346)	(0.00645)	(0.0354)
Market size	2.476**	11.23**	1.576*	7.866*
	(0.973)	(5.081)	(0.843)	(4.293)
Income	−2.682***	−13.09***	−1.977**	−10.36**
	(0.891)	(4.586)	(0.787)	(4.029)
Economic risk	−0.0141	−0.0690	−0.00847	−0.0346
	(0.0107)	(0.0600)	(0.0108)	(0.0639)
Oil production	0.727***	3.952***	0.753***	4.640***
	(0.244)	(1.353)	(0.280)	(1.775)
Oil consumption	−0.590	−2.819	−0.564	−3.788
	(0.790)	(3.869)	(0.701)	(3.701)
Constant	−49.71**	−217.9*	−34.21*	−153.5*
	(22.56)	(117.4)	(18.24)	(87.05)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	54,784	80,372	42,667	98,713

Notes: Robust standard errors clustered at the firm level are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 4
Heterogeneous impacts by investment mode.

Variables	Extensive margin	Intensive margin
	(1) LOGIT	(2) EK-TOBIT
Greenfield investment	0.0146*	0.0872**
	(0.00809)	(0.0415)
M&A	0.0139**	0.0875**
	(0.00603)	(0.0361)
Market size	1.717*	7.926*
	(0.895)	(4.466)
Income	−1.940**	−9.599**
	(0.838)	(4.097)
Economic risk	−0.00494	−0.0169
	(0.00889)	(0.0471)
Oil production	0.590***	3.412***
	(0.217)	(1.230)
Oil consumption	−0.509	−3.067
	(0.665)	(3.258)
Constant	−35.75*	−149.1
	(19.90)	(98.32)
Year FE	Yes	Yes
Country FE	Yes	Yes
Firm FE	Yes	Yes
Observations	64,512	99,050

Notes: Robust standard errors clustered at the firm level are reported in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5
Heterogeneous impacts of investment countries.

	Variables	Intensive Margin		Extensive Margin	
		EK-TOBIT	EK-TOBIT	LOGIT	LOGIT
		(1)	(2)	(3)	(4)
Developing markets	OFDI	0.0660*		0.0108*	
		(0.0349)		(0.00645)	
	Greenfield investment		0.0974**		0.0157*
			(0.0431)		(0.00825)
	M&A		0.0721*		0.0120*
			(0.0391)		(0.00665)
	Observations	72,275	72,275	44,240	44,240
Developed markets	OFDI	0.0397		0.0148	
		(0.125)		(0.0271)	
	Greenfield investment		0.328		0.0489
			(0.581)		(0.0502)
	M&A		0.0542		0.0175
			(0.127)		(0.0285)
	Observations	26,775	26,775	4446	4446

Notes: Robust standard errors clustered at the firm level are reported in parentheses for the sample of developing markets, whereas non-robust standard errors are reported for the sample of developed markets owing to the unavailability of robust standard errors. The coefficients in the sample of developed markets are still insignificant even with non-robust standard errors, which are downward biased in the regressions. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Year, country, and firm fixed effects are included in all regressions.

studies' argument that China may invest in less developed countries with lower political stability and poorer economic governance for energy security reasons (Buckley et al., 2007; Luo et al., 2017; Ramasamy et al., 2012).

5. Conclusion and policy implications

Although the link between China's energy OFDI and energy security is an unsettled academic issue with significant national and international policy implications, empirical investigation of this issue has been limited by data availability. We investigate whether China's OFDI helps to diversify its oil import sources (extensive margin) and boost the volume of imports from source countries (intensive margin). Our empirical results show that China's OFDI has enhanced China's energy security both extensively and intensively. The estimations show that China's energy OFDI in a host country is positively associated with the probability of importing oil from that country as well as the volume of imports from that country. On average, a 1% increase in energy OFDI to a country leads to a 1.2% increase in the probability of importing from that country and an approximately 0.071% increase in imports at the firm level. In addition, we find that energy security effects do not differ by energy investment mode (M&A or greenfield investment) but do differ by investment country. Investments in a developing countries can help to increase the import volumes and the probability of importing from those countries, but investments in developed countries do not.

Our findings clearly indicate that China's 'going out' strategy for securing energy is effective. Investments in developing countries with rich energy resources can help to enhance energy security. However, such countries often suffer from a lack of a sound, stable institutional environment, posing significant challenges for foreign investors. Proper management of China's overseas investment projects, including risk management and the avoidance of conflicts between Chinese investors and local stakeholders, is needed.

In addition, our findings do not undermine the argument that China's investments can increase the global supply of oil and, thus, can benefit global energy security. China's investments in developed countries do not increase its own oil imports but rather may help to increase local proven reserves, production capacity, or R&D research, all of which can contribute to the global market. In developing countries, Chinese investment can bring capital and techniques. Even though the equity oil can be shipped back to China, there may be spillover effects that help local producers to improve their techniques, proven reserves, and production capacity.

Although this study focuses on the supply side of energy security, it is equally important to highlight the importance of demand-side energy security policies. These policies include improvements in oil use efficiency, the development of electric vehicles, the promotion of public transportation, and the optimization of urban design to minimize transportation needs.

CRediT authorship contribution statement

Yong Zhao: Conceptualization, Methodology. **Feng Song:** Conceptualization, Writing - original draft, Writing - review & editing.

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.

Acknowledgemets

This work is supported by the Ministry of Education of Humanities and Social Sciences Project (18YJA790068, 19YJA790125), National Natural Science Foundation of China (No. 71828401) and Beijing Municipal Fund for Building World Class Universities of Renmin University of China.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2020.111803.

References

American Enterprise Institute & Heritage Foundation, 2018. China global investment tracker. http://www.aei.org/china-global-investment-tracker/.

Bernard, A.B., Jensen, J.B., Redding, S.J., Schott, P.K., 2018. Global firms. J. Econ. Lit. 56, 565–619. https://doi.org/10.1257/jel.20160792.

Brown, P.S., Huntington, H.G., 2018. Oil supply disruptions, U.S. economic activity and oil security. Energy Pol. 116, 297–298.

BP, 2019. BP Statistical Review of World Energy. British Petroleum. London. http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf.

Bradsher, K., 2011. China's Utilities Cut Energy Production, defying Beijing. New York Times 24 May 2011.

Buckley, P.J., Clegg, L.J., Cross, A.R., Liu, X., Voss, H., Zheng, P., 2007. The determinants of Chinese outward foreign direct investment. J. Int. Bus. Stud. 38, 499–518. https://doi.org/10.1057/palgrave.jibs.8400277.

Cheptea, A., Emlinger, C., Latouche, K., 2015. Do exporting firms benefit from retail internationalization? Evidence from France. CEPII Working Paper 2015-21.

Cohen, G., Joutz, F., Loungani, P., 2011. Measuring energy security: trends in the diversification of oil and natural gas supplies. Energy Pol. 39 (9), 4860–4869.

Cozza, C., Rabellotti, R., Sanfilippo, M., 2015. The impact of outward FDI on the performance of Chinese firms. China Econ. Rev. 36, 42–57.

Dong, Y., Li, K.W., Zhang, D.Y., 2011. Determinants of Chinese and American outward investment. Chin. Econ. 44, 58–78.

Downs, E.S., 2007. The Fact and Fiction of Sino-African Energy Relations, vol. 3. China Security, pp. 42–68.

Duan, F., Ji, Q., Liu, B.Y., Fan, Y., 2018. Energy investment risk assessment for nations along China's Belt & Road Initiative. J. Clean. Prod. 170, 535–547. https://doi.org/10.1016/j.jclepro.2017.09.152.

Eaton, J., Kortum, S., 2001. Trade in capital goods. Eur. Econ. Rev. 45, 1195–1235. https://doi.org/10.1016/S0014-2921(00)00103-3.

Freund, C., Pierola, M.D., 2015. Export superstars. Rev. Econ. Stat. 97, 1023–1032. https://doi.org/10.1162/REST_a_00511.

Gaigné, C., Latouche, K., Turolla, S., 2018. Vertical ownership and export performance: firm-level evidence from the food industry. Am. J. Agric. Econ. 100, 46–72. https://doi.org/10.1093/ajae/aax071.

Gaubert, C., Itskhoki, O., 2018. Granular Comparative Advantage. NBER Working Paper 24807.

Gholz, E., Awan, U., Ronn, E., 2017. Financial and energy security analysis of China's loan-for-oil deals. Energy Res. Soc. Sci. 24, 42–50. https://doi.org/10.1016/j.erss.2016.12.021.

Hao, Y., Guo, Y., Guo, Y., Wu, H., Ren, S., 2019. Does outward foreign direct investment (ofdi) affect the home country's environmental quality? the case of china. Struct. Change Econ. Dynam. 52.

Harms, P., Méon, P.G., 2018. Good and useless FDI: the growth effects of greenfield investment and mergers and acquisitions. Rev. Int. Econ. 26, 37–59. https://doi.org/10.1111/roie.12302.

Head, K., Mayer, T., 2014. Gravity equations: workhorse, toolkit, and cookbook. In: Handbook of International Economics, vol. 4, pp. 131–195. https://doi.org/10.1016/B978-0-444-54314-1.00003-3.

Huang, Y., Zhang, Y., 2017. How Does Outward Foreign Direct Investment Enhance Firm Productivity? A Heterogeneous Empirical Analysis from Chinese Manufacturing. China Economic Review.

IEA, 2019. World Energy Statistics [WWW Document], 7.10.19. https://www.iea.org/classicstats/relateddatabases/worldenergystatistics/.

IEA, 2017. World Energy Outlook 2017. OECD Publishing. Paris.

Jiang, J., Ding, C., 2014. Update on Overseas Investments by China's National Oil Companies: Achievements and Challenges since 2011. OECD/IEA. Paris.

Kashcheeva, M., Tsui, K.K., 2015. Political oil import diversification by financial and commercial traders. Energy Pol. 82, 289–297. https://doi.org/10.1016/j.enpol.2015.02.025.

Kong, B., 2011. Governing China's energy in the context of global governance. Global Pol. 2, 51–65. https://doi.org/10.1111/j.1758-5899.2011.00124.x.

Kong, Z., Lu, X., Jiang, Q., Dong, X., Liu, G., Elbot, N., 2019. Assessment of import risks for natural gas and its implication for optimal importing strategies: a case study of China. Energy Pol. 127, 11–18.

Lai, H., O"Hara, S., Wysoczanska, K., 2014. Rationale of internationalization of china's national oil companies: seeking natural resources, strategic assets or sectoral specialization? Asia Pacific Business Review 21 (1), 77–95.

Leung, G.C.K., 2011. China's energy security: perception and reality. Energy Pol. 39, 1330–1337. https://doi.org/10.1016/j.enpol.2010.12.005.

Li, Y., Shi, X., Yao, L., 2016. Evaluating energy security of resource-poor economies: a modified principle component analysis approach. Energy Econ. 58, 211–221. https://doi.org/10.1016/j.eneco.2016.07.001.

Luo, L., Zhen, Q., Hubbard, P., 2017. Not looking for trouble: understanding large-scale Chinese oversea investment by sector and owership. China Econ. Rev. 46.

Ministry of Natural Resource of the People's Republic of China, 2019. China's equity oil production has increased. http://www.mnr.gov.cn/dt/kc/201903/t20190326_2402970.html.

Mityakov, S., Tang, H., Tsui, K.K., 2013. International politics and import diversification. J. Law Econ. 56, 1091–1121. https://doi.org/10.1086/674132.

Moulton, B.R., 1990. An illustration of a pitfall in estimating the effects of aggregate variables on micro units. Rev. Econ. Stat. 72, 334–338. https://doi.org/10.2307/2109724.

NDRC, 2016. 13th Five Year Plan of Energy Development (能源发展"十三五"规划).

Odgaard, O., Delman, J., 2014. China's energy security and its challenges towards 2035. Energy Pol. 71, 107–117. https://doi.org/10.1016/j.enpol.2014.03.040.

Ramasamy, B., Yeung, M., Laforet, S., 2012. China's outward foreign direct investment: location choice and firm ownership. J. World Bus. 47, 17–25. https://doi.org/10.1016/j.jwb.2010.10.016.

Sheng, Y., Wu, Y., Shi, X., Zhang, D., 2015. Energy trade efficiency and its determinants: a Malmquist index approach. Energy Econ. 50, 306–314. https://doi.org/10.1016/j.eneco.2015.05.019.

Tang, B.J., Zhou, H.L., Chen, H., Wang, K., Cao, H., 2017. Investment opportunity in China's overseas oil project: an empirical analysis based on real option approach. Energy Pol. 105, 17–26. https://doi.org/10.1016/j.enpol.2017.02.023.

Urdinez, F., Masiero, G., Ogasavara, M., 2014. China's quest for energy through FDI: new empirical evidence. J. Chin. Econ. Bus. Stud. 12, 293–314. https://doi.org/10.1080/14765284.2014.952516.

Vivoda, V., 2009. Diversification of oil import sources and energy security: a key strategy or an elusive objective? Energy Pol. 37 (11), 4615–4623.

Wolfe, W.M., Tessman, B.F., 2012. China's global equity oil investments: economic and geopolitical influences. J. Strat. Stud. 35, 175–196. https://doi.org/10.1080/01402390.2011.635467.

Wu, K., 2014. China's energy security: oil and gas. Energy Pol. 73, 4–11. https://doi.org/10.1016/j.enpol.2014.05.040.

Yao, L., Shi, X., Andrews-Speed, P., 2018. Conceptualization of energy security in resource-poor economies: the role of the nature of economy. Energy Pol. 114, 394–402. https://doi.org/10.1016/j.enpol.2017.12.029.

Zhang, Z.X., 2012. The overseas acquisitions and equity oil shares of Chinese national oil companies: a threat to the west but a boost to China's energy security? Energy Pol. 48, 698–701. https://doi.org/10.1016/j.enpol.2012.05.077.

Zhang, Z.X., 2011. China's energy security, the Malacca dilemma and responses. Energy Pol. 39, 7612–7615. https://doi.org/10.1016/j.enpol.2011.09.033.