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RESEARCH ARTICLE

The impact of electricity prices and supply on attracting FDI to South Africa

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Abstract
Inward Foreign Direct Investment (FDI) plays an important role on the overall economic conditions of host countries, particularly the ones that are still in low developmental stages. South Africa (SA) as an example of this group of countries has also experienced intermittent electricity supply and increasing electricity tariffs since 2008. As the literature suggests that attracting FDI depends on the conditions of the host country, the main purpose of this study is to examine the impact that electricity prices and supply, as representatives of the energy conditions of SA as a host country, had to the attractiveness of FDI to SA. To do so, this study uses the Autoregressive Distributed Lag (ARDL) cointegration approach for the period 1985 to 2018. The findings of the study indicated that indeed the initial hypotheses have been confirmed: (1) electricity supply is a positive contributor to inward FDI, ceteris paribus, and (2) electricity prices are a negative contributor to inward FDI, ceteris paribus.

Keywords Electricity prices · Electricity generation · Inward FDI · South Africa · Economic growth

Introduction

In the literature, it is discussed and evidenced that Foreign Direct Investment (FDI) plays an indisputably important role in the global economic dynamics, particularly for low- and medium-income countries that have been the hosts of the majority of worldwide FDI (Garsous et al., 2020). Although the money flow is towards the host countries, studies have shown that both host and investor countries benefit from the investment primarily by means of technological and know-how transfers and good trade relationships. The host countries specifically get benefitted by inward FDI flows by the inflow of new expertise, technologies and human and physical capital as well as organization methods and production patterns (De Mello Jr, 1997).

Almost universally agreed is the fact that the decision in favour of FDI and the geographical preference of such an investment is highly dependent on the conditions of the host country. Since the 1970s, the main elements that act as catalysts for FDI attraction are traditionally considered the price and quality of natural resources, physical infrastructure, macroeconomic conditions of the host country and its political stability and investment certainty (Boateng et al., 2015; Dunning, 2009). As Boateng et al. (2015) mention, FDI is chosen to be directed to a country that enables a market that reduces costs and risk and promotes competitive advantage. During the last couple of decades, energy has become a strong factor of production to complement the other three main factors of production: natural resources, capital and labour. The availability of energy whenever needed in the production process is a crucial determinant of the viability of a business and its capabilities for profit maximization. At the same time, the energy component of the cost structure of the production process is not minor or negligent as used to be in the past. Therefore, when investors evaluate the direction of their FDI flows, the energy factor (supply availability and reliability, as well as costing) is in the heart of the debate.

On this reliability and security of energy supply, especially developing countries oftentimes suffer from frequent power

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cuts that affect operations even for the local producers, and policymakers have made great efforts to control the energy consumption and balance with energy supply capacity of the countries, such as in China for example (Hao et al., 2019). Similar conditions for price fluctuations in the energy markets overall or specific coal or electricity tariffs have affected the economic growth potential of countries such as China (Shi & Sun, 2017; Zhang et al., 2019).

South Africa is one of those developing countries whose electricity supply and provision has been erratic since 2008 when the first wave of power cuts was experienced with severe consequences to the economy. Since then loadshedding (rolling blackouts) are a common occurrence in the country with the most significant and long waves experienced again in 2014 and 2019. In the same period, since 2008, the electricity prices in the country underwent a restructuring: with approximately an annual increase of 33% from 2008 until 2018 (Department of Energy, 2018) in real average electricity prices. These increases have significantly altered the weight of electricity costs in the business budgets as well as the attractiveness of the country as a destination for business where the production costs are affordable. Analysts had attributed some of the losses in investors' confidence partially to these interruptions, the unreliable provision of electricity and the increasing costs of electricity (BizNews, 2020).

In South Africa, FDI decreased by 15% in 2019, and the decrease in 2020 is expected to be much higher due to the Covid-19 pandemic and the restrictions internationally, according to UN (Guterres, 2020), that also sees a plunge of global FDI of up to 40% in 2020. For the post-Covid-19 recovery of South Africa, this can be proven detrimental, as the country's economic and financial conditions had not been stellar before the pandemic either. The country's *National Development Plan (NDP)* (South Africa, National Planning Commission, 2012) has recognized the attraction of FDI into the economy as a crucial factor for igniting economic growth, decreasing economic poverty and income inequality. Since 2018, the president of the country set a target to attract foreign investors up to 100 billion dollars by 2023—target set long before the pandemic hit the global economy.

The main purpose of this study is to examine the impact that electricity prices and supply had to the attractiveness of FDI (inward FDI) to South Africa for the period 1985 to 2018. The paper contributes to the limited literature that puts the conditions of the electricity market among the significant factors for inward FDI, along with the rest of the socioeconomic conditions of the host country, particularly from a point of view of a developing economy. The timing of this study is also of importance as developing countries develop their strategies in a post-Covid-19 era that will provide long-term sustainable recovery. Appropriate allocation of the stimulus packages to policies that will ensure returns and will boost the economy recovery is of paramount importance. Finally, the South African electricity sector has been for more than a decade in a constrained situation: providing quantitative evidence for its importance not only for the economic conditions within the national boundaries but also for the attractiveness of international investment will provide room for future policy implementation.

Brief empirical literature review

In order to understand the dynamics of FDI flows, the literature is extensive but agrees that the overall economic, investment and infrastructure climate of the destination countries are crucial determinants. According to Stern (2003), not only the current institutional and socioeconomic environments play a role but also the future predictions and how the risks and returns are perceived by the markets.

The tax incentivization or relief is at the centre of the FDI attraction debates for many decades now, for example, decreased business tax directed to Japanese investors achieved higher FDI inflow to Ireland from Japan (Coy and Cormican, 2013), with other studies confirming a general negative relationship between corporate taxes and inward FDI (Desai et al., 2004; Scholes and Wolfson, 1989). Investment climate generally can be affected by financing constraints, unreliable banking systems and difficulties in starting a business and subsequently discourage investors into the country (Kinda, 2010). It is interesting however that even though various studies follow different perspectives (and hence different sets of variables), they all converge that any element describing the economic and market conditions of the host country can encourage or discourage FDI. For example, Masron and Abdullah (2010) examined the inwards FDI determinants in five South Asian countries by looking at trade openness, market size and human capital while on the other side, Dollar et al. (2006) used low customs clearance times, infrastructure and financial services.

One of the reasons why investors decide to explore the possibility for outward FDI is a comparatively lenient environmental regulation of the destination country compared to their own. This is true for general tax structures and environmental regulation. The literature refers to this phenomenon overall as the creation of "pollution havens" where host countries might receive the benefits of FDI inflows but at the same time, their environmental conditions degrades. On the other side, the "pollution halo hypothesis" postulates that FDI provides host countries with access to advanced technologies and experience and hence allowing them to achieve cleaner production levels and more efficient consumption of energy (Hao et al., 2020). In reality, mostly developing countries are in the role of the host country in a "pollution haven" hypothesis and through relaxing their environmental regulations, they manage to attract FDI, however, of the production of "dirty" goods (Adom et al., 2019; Kivyiro and Arminen, 2014).

Taking into consideration the importance of costing structures related to the energy and environmental profiles of the investors, Garsous et al. (2020) examined the impact of energy prices on outward FDI using disaggregated firm data for 24 OECD countries. Their results showed that the motivation for firms to proceed with FDI activities came from the differential of energy prices of the home countries to the destination countries. In addition, there was some asymmetric reaction to changes in relative energy prices: only firms observing increases in relative energy prices reacted with regard to their international assets, while the decreases in relative energy prices did not affect them. Sato and Dechezleprêtre (2015) contribute to this debate stressing the role of energy price differentials on international competitiveness with regard to trade and investments. Within this line of literature, Barteková and Ziesemer (2019) state that electricity prices in the host country influence total production costs and disadvantage certain countries' producers which may lead to discouragement of investors. Garsous et al. (2020) particularly point out low energy costs and weak environmental regulation in developing countries are important reasons for the recent international trends in FDI. Even more, the global transition from fossil fuel-based generation of energy to supply based on renewables that past electricity pricing structures have altered substantially in recent years.

The literature specifically on the impact of electricity prices (and in general electricity market conditions) in inward FDI is limited in the recent years. Bilgili, Tuluce and Dogan (2012) explored the effect not only of electricity prices but also of prices of various energy types, such as petroleum and other fossil fuels, confirming that electricity prices are indeed a contributor to inward FDI for the country. For the European countries, Barteková and Ziesemer (2019) looked at specifically the influence of electricity prices on inwards FDI for the period 2003 to 2013. The basis of their study is that the net FDI is highly depended on production costs and so electricity costs should be a big component of it. Their results show that electricity costs are indeed among the decisive contributing factors for attracting FDI along with unit labour costs and advantage in secondary education (translated into availability of skills in the labour market).

The difference between developing and already industrialized economies is also discussed in the literature, particularly through the lens of infrastructure networks and reliability of energy supply. US investors evaluate the infrastructure quality of a country as significant factor to direct their investment but only for developing countries; the factor is less of importance of developed countries that have an already established network of infrastructure (Wheeler and Mody, 1992). In the same strand of the literature, the results of Suh and Bae (2002) suggest the same differentiation between developed and less developed countries as hosts of FDI. Although studies such as Gerlagh and Mathys (2011) and Sato and Dechezleprêtre (2015) included the availability of energy in the discussion of FDI, they did so from an export competitiveness perspective of a producer country and eventually, its capacity for outward FDI. Energy security, in the form of continuous, reliable and uninterrupted provision of electricity services within a country by a modern infrastructure network, is a factor that investors consider for the profitable operation of their business.

This paper aims at filling the gap in the literature that examines extensively the relationship between energy/electricity demand and FDI (Adom et al., 2019; Amri, 2016; Bekhet and Othman, 2011, 2014) with proposing the investors evaluate the electricity availability and infrastructure of the destination country to which they will direct their investment. The limited literature on the impact of electricity prices on attracting FDI does not include single-country studies, so this study contributes in the literature from that point of view as well.

Research method

Theoretical framework and a priori expectations

The overall theoretical approach of the study is a combination of the conceptual frameworks as proposed in the studies by Boateng et al. (2015), Barteková and Ziesemer (2019) and Garsours et al. (2020). As discussed in Boateng et al. (2015) and borrowed from the study by Dunning (2015):

[…] a country's propensity to attract inward FDI is a combined function of three broad variables. First is the existence of ownership advantages as embodied in a firm's resources and capabilities; second the host country's location-specific advantages, consisting of tangible and intangible resources that serve to create an attractive business environment; and third, the organizational forms by which firms combine their ownership advantages with location advantages to maintain and improve their competitive positions.

In this study, we focus on the location-specific advantages as the country's particular factors that can impact the potential and the risk of the local market as well as the opportunity for immediate and future maximization of profits. The foreign investors plan to locate their investment in markets where the risk is relatively lower than other locations (Kiymaz, 2009). Boateng et al. (2015) proceed to explain that FDI should be directed where the investment will benefit from the new market and where the environment is beneficial, decreases potential costs and provides opportunities for competitive advantage. In our study, the two main variables of interest are electricity prices (ELECTPR) and electricity supply/generation (ELECTGEN), while the other variables that describe these location-specific characteristics are Gross Domestic Product (GDP),[1] exchange rate (EXCHG), real

[1] For robustness purposes, we provide the results of the same analysis using Gross Domestic Product per capita (GDPPC) at the second part of the Empirical results

interest rate (INTRATE), inflation (INFL) and money supply (M3). Our empirical investigation involves two specifications the one containing ELECTGEN as the proxy for the electricity conditions of the country (model (1)) and the other one ELECTPR as the proxy for the electricity conditions (model (2)).

Model (1):

$$\mathrm{FDI_t} = \beta_0 + \beta_1 \mathrm{LNELECTGEN}_t + \beta_2 \mathrm{LNGDP}_t + \beta_3 \mathrm{LNEXCHG}_t + \beta_4 \mathrm{INTRATE}_t + \beta_5 \mathrm{INF}_t + \beta_6 \mathrm{LNM3}_t + \beta_7 \mathrm{DUM}_t + \varepsilon_t. \quad (1)$$

Model (2):

$$\mathrm{FDI}_t = \beta_0 + \beta_1 \mathrm{LNELECT}PR_t + \beta_2 \mathrm{LNGDP}_t + \beta_3 \mathrm{LNEXCHG}_t + \beta_4 \mathrm{INTRATE}_t + \beta_5 \mathrm{INF}_t + \beta_6 \mathrm{LNM3}_t + \beta_7 \mathrm{DUM}_t + \varepsilon_t. \quad (2)$$

DUM is a dummy variable (equal zero if $t < 2007$ and unity if $t \geq 2008$) representing:

1. the period from which the country has been experiencing electricity shortages in the form of frequent disruptions in electricity provision,
2. the period since when price restructuring begun with electricity prices increasing annually and
3. the global financial crisis with impacts on the national and global economy.

More specifically, based on our analysis thus far, β_1 is expected to be negative, ceteris paribus: the higher the electricity tariffs in South Africa, and hence, the energy costs of production, the more reluctant are investors to promote FDI *to* South Africa. Also, β_2 is expected to be positive, ceteris paribus: the more reliable the electricity supply is, the higher the FDI into the country.

Econometric method

Before we proceed with any estimation, all the variables are tested with regard to their univariate characteristics to establish their order of integration and confirm the choice of ARDL. To test the presence of long-run relationship between variables under investigations, we use the Autoregressive Distributed Lag (ARDL) approach introduced by Pesaran et al. (2001). The ARDL approach has many advantages over other cointegration techniques. First, the ARDL model performs efficiently in small samples cases contrary to the method of Johansen (1992) which needs a large sample for validity. Second, the ARDL approach does not require the same order of integration for the cointegration test but allow variables if they are I(0), I(1) or mixture of both I(0) and I(1), relaxing statistical constraint that variables should be integrated in the same level. Third, the ARDL method allow for dummy variables in the cointegration test process which not the case of Johansen's method (in the specific country case that assists with capturing specific characteristics).

According to Pesaran et al. (2001), Eqs. 1 and 2 can be written in the unrestricted error correction model (UECM) versions of the ARDL model as follows:

Model (1):

$$\Delta \mathrm{FDI}_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta \mathrm{FDI}_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta \mathrm{LNELECTGEN}_{t-i} + \sum_{i=1}^{p} \alpha_{4i} \Delta \mathrm{LNEXCHG}_{t-i} + +\sum_{i=1}^{p} \alpha_{5i} \Delta \mathrm{INTRATE}_{t-i} + \sum_{i=1}^{p} \alpha_{6i} \Delta \mathrm{INF}_{t-i} + \sum_{i=1}^{p} \alpha_{7i} \Delta \mathrm{LNM3}_{t-i} + \gamma_1 \mathrm{FDI}_{t-1} + \gamma_2 \mathrm{LNELECTGEN}_{t-1} + \gamma_3 \mathrm{LNGDP}_{t-i} + \gamma_4 \mathrm{LNEXCHG}_{t-1} + \gamma_5 \mathrm{INTRATE}_{t-1} + \gamma_6 \mathrm{INF}_{t-1} + \gamma_7 \mathrm{LNM3}_{t-1} + \rho \mathrm{DUM}_t + u_t. \quad (3)$$

Model (2):

$$\Delta \mathrm{FDI}_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta \mathrm{FDI}_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta \mathrm{LNELECTPR}_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta \mathrm{LNGDP}_{t-i} + \sum_{i=1}^{p} \alpha_{4i} \Delta \mathrm{LNEXCHG}_{t-i} + \sum_{i=1}^{p} \alpha_{5i} \Delta \mathrm{INTRATE}_{t-i} + \sum_{i=1}^{p} \alpha_{6i} \Delta \mathrm{INF}_{t-i} + \sum_{i=1}^{p} \alpha_{7i} \Delta \mathrm{LNM3}_{t-i} + \gamma_1 \mathrm{FDI}_{t-1} + \gamma_2 \mathrm{LNELECTPR}_{t-1} + \gamma_3 \mathrm{LNGDP}_{t-i} + \gamma_4 \mathrm{LNEXCHG}_{t-1} + \gamma_5 \mathrm{INTRATE}_{t-1} + \gamma_6 \mathrm{INF}_{t-1} + \gamma_7 \mathrm{LNM3}_{t-1} + \rho \mathrm{DUM}_t + u_t, \quad (4)$$

where u_t is white noise error term, α_0 is the drift component, α_i $(i > 0)$ are the error correction dynamics and γ_i correspond to the long-run dynamics.

Once the models are estimated, we can execute the ARDL Bounds test to detect the presence of long-run relationship between variables. To this aim, the *F*-statistic is computed under the null hypothesis of no cointegration (no long-run), i.e., $H_0 : \gamma_i = 0$ against alternative $H_1 : \gamma_i \neq 0$ and compared to the bound critical values (Pesaran et al., 2001). If the estimated *F*-statistic is greater than the upper bound critical value, then the null hypothesis of no cointegration is rejected suggesting the presence of long-run relationship between variables. If the estimated *F*-statistic is smaller than the lower bound critical

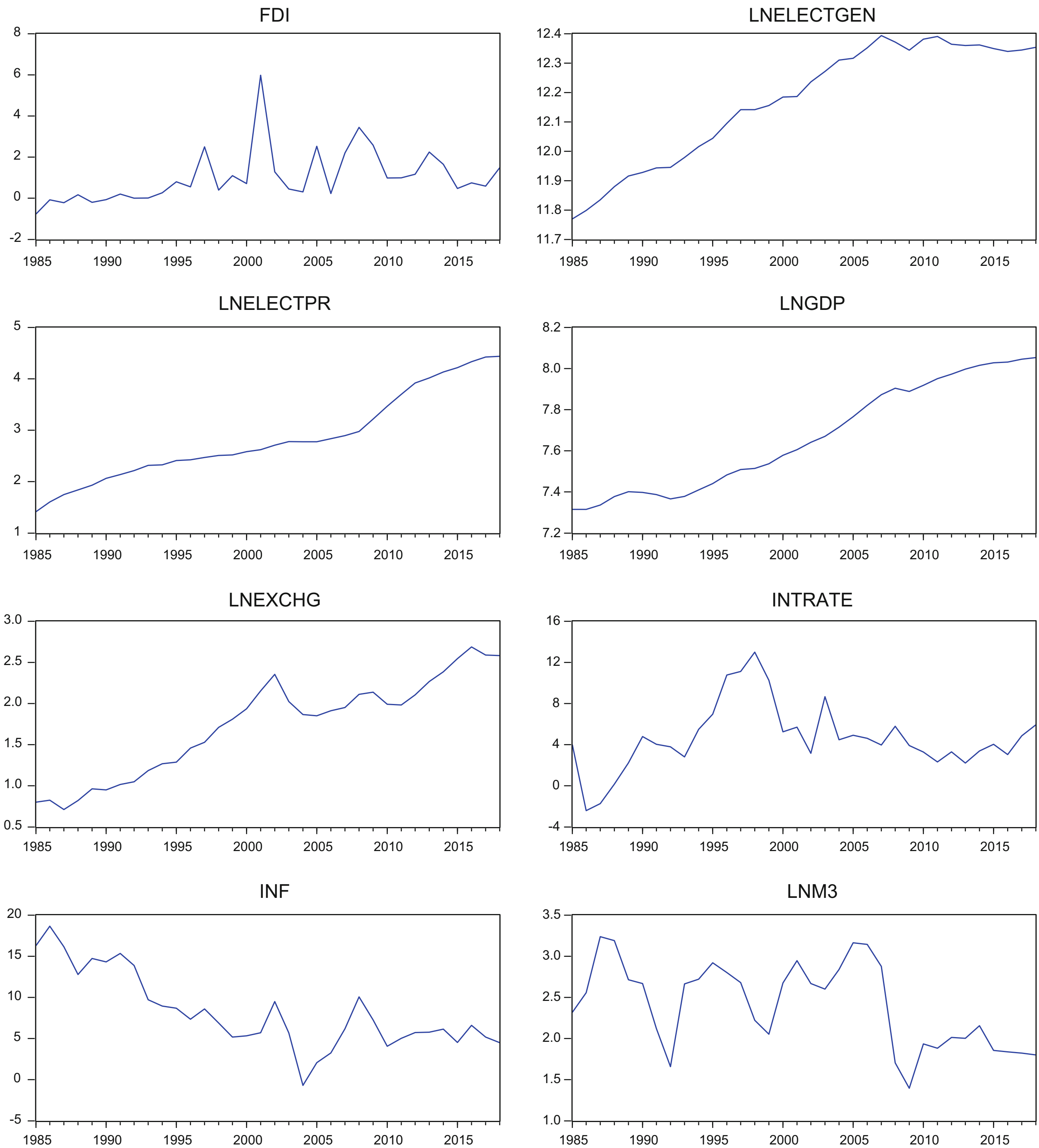

Fig. 1 Graphical representation of dataset

value, then the null hypothesis of no cointegration is accepted suggesting no long-run relationship between variables. If the estimated *F*-statistic falls between the lower and the upper bound critical value, then the results of the test are inconclusive.

When the ARDL Bounds test confirms the existence of cointegration among variables, then the impact of long-run and short-run coefficients on dependent variable is discussed. The goodness of fit of the ARDL model is test by a number of diagnostic tests on its residuals as the Breusch-Godfrey Serial Correlation LM test, the ARCH and the Breusch-Pagan-Godfrey tests for heteroscedasticity. The stability of the ARDL model is tested using the CUSUM and CUSUM of squares tests.

Table 1 Descriptive statistics

	FDI	LNELECTGEN	LNELECTPR	LNGDP	LNEXCHG	INTRATE	INF	LNM3
Mean	1.021	12.170	2.845	7.665	1.729	4.648	8.215	2.407
Median	0.649	12.210	2.664	7.622	1.889	4.033	6.737	2.578
Maximum	5.983	12.393	4.438	8.053	2.688	12.99	18.65	3.238
Minimum	− 0.766	11.769	1.415	7.315	0.711	− 2.406	− 0.692	1.394
Std. dev.	1.307	0.2016	0.854	0.262	0.595	3.263	4.578	0.513
Skewness	1.834	− 0.5432	0.496	0.158	− 0.236	0.509	0.603	− 0.105
Kurtosis	7.304	1.8712	2.246	1.465	1.846	3.843	2.622	1.822
Jarque-Bera	45.33(0.000)	3.477(0.175)	2.203(0.332)	3.476(0.175)	2.201(0.332)	2.476(0.289)	2.265(0.322)	2.026(0.363)

Data

The data on FDI inflows (FDI) in South Africa from 1985 to 2018 were derived from the World Bank, and the variables was measured as % to GDP. The electricity generation series (ELECTGEN) in GWh is derived from StatsSA while electricity prices are sourced from the South African Energy Department of Energy (DOE) Energy Price report (2018), measured as South African rand (ZAR) per kWh. Gross Domestic Product in total (GDP) and per capita (GDPPC) both measured in national currency are sourced from IMF while exchange rate (EXCHG) (ZAR per US$), real interest rate (%) (INTRATE), inflation (%) and money supply are all derived from the World Bank. Variables are transformed to their natural logarithms (where appropriate) to allow for coefficients to be interpreted as elasticities.

Figure 1 shows that LNELECTGEN, LNELECTPR and LNGDP variables exhibit a linear distinct upward and deterministic trend in pattern. However, the other variables exhibit a linear and upward trend with a marginally explosive behaviour. Also, descriptive analysis of data is provided in Table 1,

Table 2 Unit root test results

	Level		First difference		Conclusion
	Intercept	Intercept and trend	Intercept	Intercept and trend	
ADF test					
FDI	0.0010[a]	0.0015[a]	–	–	I(0)
LNELECTGEN	0.0279[b]	0.9942	–	0.0027[a]	I(0)/I(1)
LNELECTPR	0.9595	0.5065	0.0189[b]	0.0896[c]	I(1)
LNGDP	0.8663	0.5899	0.0342[b]	0.0452[b]	I(1)
LNEXCHG	0.8198	0.3328	0.0022[a]	0.0123[b]	I(1)
INTRATE	0.2129	0.4880	0.0000[a]	0.0000[a]	I(1)
INF	0.2912	0.3552	0.0001[a]	0.0001[a]	I(1)
LNM3	0.0600[c]	0.0228[b]	–	–	I(0)
PP test					
FDI	0.0011[a]	0.0016[a]	–	–	I(0)
LNELECTGEN	0.0376	0.9942	–	0.0023[a]	I(0)/ I(1)
LNELECTPR	0.9604	0.8686	0.0466[b]	0.0920[c]	I(1)
LNGDP	0.9606	0.6334	0.0307[b]	0.0614[c]	I(1)
LNEXCHG	0.8177	0.5561	0.0036[a]	0.0200[b]	I(1)
INTRATE	0.1816	0.4885	0.0000[a]	0.0000[a]	I(1)
INF	0.3737	0.4874	0.0000[a]	0.0000[a]	I(1)
LNM3	0.2116	0.1973	0.0000[a]	0.0000[a]	I(1)

Note: ADF and PP denote augmented Dickey-Fuller and Philips-Perron, respectively

[a] Statistical significance at 1% level

[b] Statistical significance at 5% level

[c] Statistical significance at 10% level

Table 3 ARDL Bounds test

Models	*F*-test	95% critical bounds		99% critical bounds	
		Lower bound I(0)	Upper bound I(1)	Lower bound I(0)	Upper bound I(1)
Model (1)	10.185	2.45	3.61	3.15	4.43
Model (2)	5.904				

which shows some common statistics of all the variables. The statistics of Jarque-Bera provide clear evidence that all variables follow a normal distribution, excepting FDI.

Empirical results

Next, we check the integration order of each variable. To this aim, we implement two traditional unit root tests, namely, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. Under the null hypothesis, ADF and PP test the presence of unit root against stationarity under alternative hypothesis. Also, both tests are conducted at level and first difference for the cases of intercept and intercept and trend. The results of ADF and PP unit root tests are reported in Table 2. The test statistics show that results are mix between stationary in level I(0) and/or in first difference I(1) but none of the variables are I(2). Consequently, the choice of using the ARDL bounds test is valid.

The next step consists on testing the presence of long-run relationship among variables in Eqs. 3 and 4 using the bounds test. In Table 3, the computed value of the Fisher statistic is equal to 10.185 and 5.904 for models (1) and (2), respectively. These values are greater than the upper bound I(1) of 4.43 at 1% significance level suggesting the presence of long-run relationship among variables.

In Table 4, the long-run results are represented in the upper panel and the short-run results in the lower panel. A reminder here for the reader that the FDI variables is measured as a percentage to GDP annually so all the interpretations from here onwards should be viewed with that in mind. Analysing the long-run relationship, we show that all coefficients are statistically significant except the interest rate (INTRATE) for model (1) and inflation (INF) and interest rate (INTRATE) for model (2).

More precisely for the two variables in focus, the electricity generated (LNELECTGEN) has a positive long-run relationship with the FDI in South Africa. In fact, if the electricity generated (LNELECTGEN) increases by 1%, then the FDI will increase by 17.257%, ceteris paribus. For model (2), a 1% increase of the price of electricity (LNELECTPR) leads to a 2.801% decrease of the FDI, ceteris paribus.

In what concerns the other variables, a 1% increase in the change of the Gross Domestic Product (LNGDP), the exchange rate (LNEXCHG) and the money supply (LNM3) will increase the FDI by 14.595% (4.295%), 1.785% (2.728%) and 2.332 (1.418) in models (1) and (2), respectively, ceteris paribus. Also, model (1) reveals that the FDI will increase by 0.098% for every 1% increase in the inflation (INF), ceteris paribus. In addition, the dummy variable exerts a positive impact on the FDI for both models.

In the short-run model, the results are alike to the long-run case except for the real interest rate (INTRATE) which is negative and statistically significant at 10% level. In fact, a

Table 4 Long- and short-run results

Variables	Model (1)		Model (2)	
	Coefficient	*P* value	Coefficient	*P* value
Long-run results				
LNELECTGEN	17.257	0.0000[a]	–	–
LNELECTPR	–	–	− 2.801	0.0002[a]
LNGDP	14.595	0.0001[a]	4.295	0.0537[c]
LNEXCHG	1.785	0.0047[a]	2.728	0.0007[a]
INF	0.098	0.0789[c]	0.127	0.1927
INTRATE	− 0.080	0.1423	0.055	0.3200
LNM3	2.332	0.0022[a]	1.418	0.0497[b]
C	− 106.732	0.0007[a]	− 13.520	0.8487
DUM	3.098	0.0025[a]	3.338	0.0044[a]
Short-run results				
ΔLNELECTGEN	28.926	0.0001[a]	–	–
ΔLNELECTPR	–	–	− 3.852	0.0007[a]
ΔLNGDP	18.050	0.0050[a]	8.620	0.0738[c]
ΔLNEXCHG	5.621	0.0017[a]	3.752	0.0035[a]
ΔINF	0.164	0.0867[c]	0.038	0.6674
ΔINTRATE	− 0.134	0.0594[c]	0.076	0.3187
ΔLNM3	2.732	0.0103[b]	1.951	0.0407[b]
ECT(− 1)	− 0.676	0.0000[a]	− 0.375	0.0000[a]

[a] Statistical significance at 1% level
[b] Statistical significance at 5% level
[c] Statistical significance at 1% level

Table 5 Model diagnostic tests results

Tests	Model (1)	Model (2)
Breusch-Godfrey Serial Correlation LM test	0.7219	0.8019
Breusch-Pagan-Godfrey Heteroskedasticity test	0.6277	0.7530
ARCH test	0.6716	0.9484

Note: Values represent *P* values

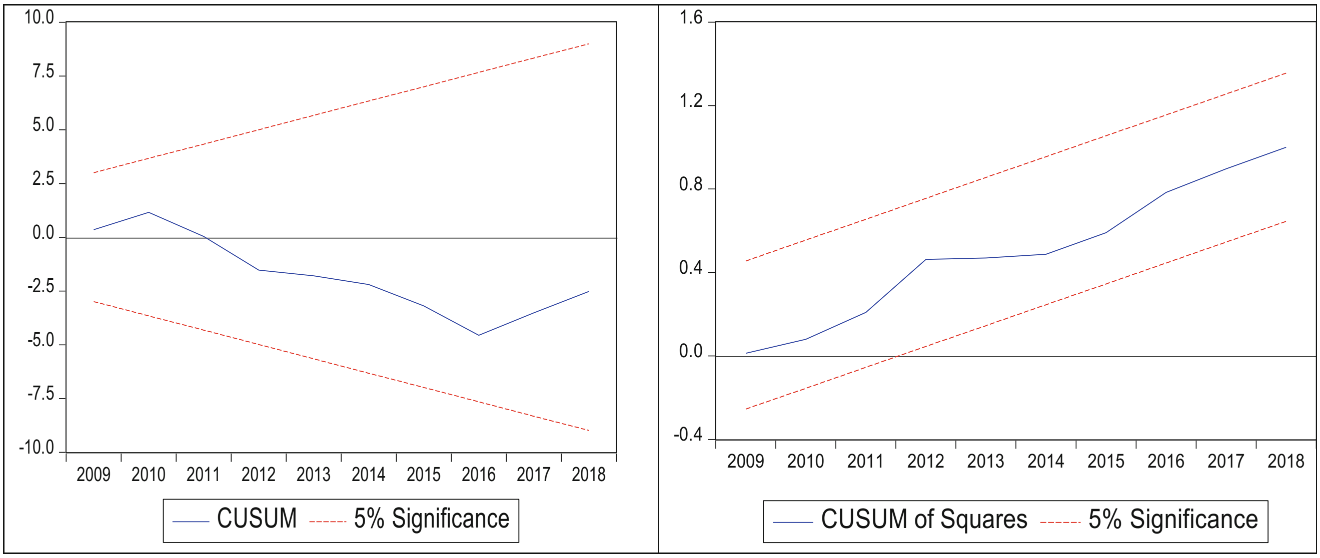

Fig. 2 Plots of cumulative sum and sum of squares of recursive residuals for model (1)

1% increase of the real interest rate (INTRATE) leads to a 0.134% decrease of the FDI in model (1), ceteris paribus. More precisely, if the electricity generated (LNELECTGEN) increases by 1%, then the FDI will increase by 28.926%, ceteris paribus. For model (2), a 1% increase of the price of electricity (LELECTPR) leads to a 3.852% decrease of the FDI, ceteris paribus. Also, a 1% increase in the change of the Gross Domestic Product (LNGDP), the exchange rate (LNEXCHG) and the money supply (LNM3) will increase the FDI by 18.050% (8.620%), 5.621% (3.752%) and 2.732 (1.951) in models (1) and (2), respectively, ceteris paribus. Also, model (1) reveals that the FDI will increase by 0.164% for every 1% increase in the inflation (INF), ceteris paribus. Likewise, the error correction terms (ECT) are negative and statistically significant at 1% level confirming the long-run relationship between the selected variables. The ECT significance affirms that the speed of adjustment of variables from the short- to the long-run equilibrium is about 68% (37%) per year for the models (1) and (2), respectively.

In order to test the validity of the estimated models, we employ a number of relevant diagnostic tests such as Breusch-Godfrey Serial Correlation LM test, the ARCH and the Breusch-Pagan-Godfrey tests for heteroscedasticity and the cumulative sum (CUSUM) and the CUSUM of squares tests for stability. From Table 5, the residual diagnostic tests support the absence of serial correlation and that residuals are homoscedastic in models (1) and (2). Moreover, the results of the CUSUM and CUSUM of squares tests are displayed in Figs. 2 and 3 for models (1) and (2), respectively. The stability of the parameters is confirmed over the sample period for both models as the values of tests remain within the critical values at 5%.

In terms of robustness analysis, we introduce the GDPPC in logarithm form (LNGDPPC) to replace the GDP (see models (3) and (4)).

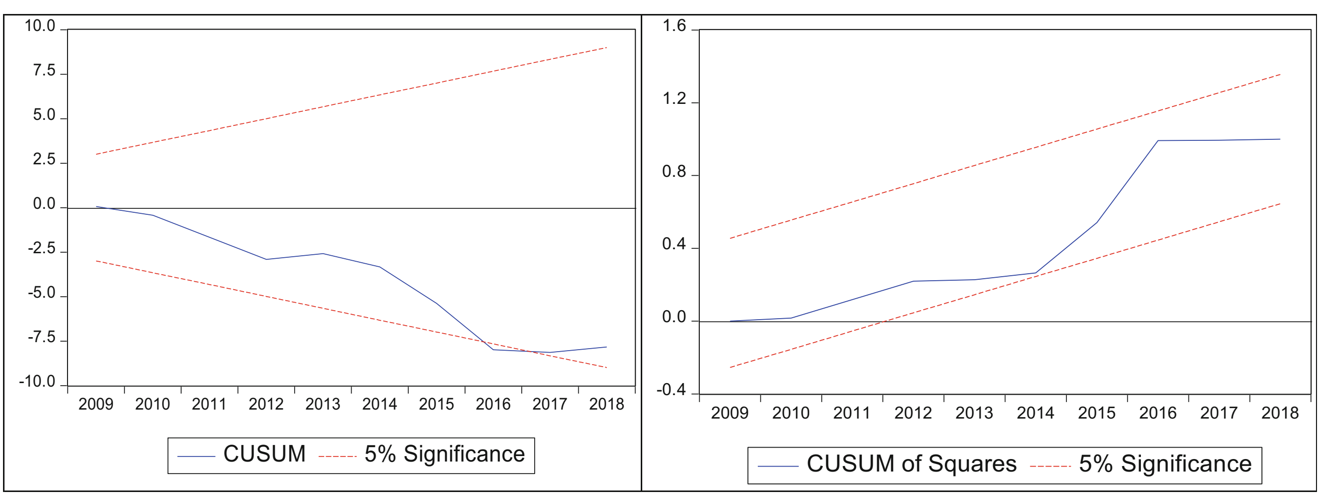

Fig. 3 Plots of cumulative sum and sum of squares of recursive residuals for model (2)

Table 6 ARDL Bounds test

Models	*F*-test	95% critical bounds		99% critical bounds	
		Lower bound I(0)	Upper bound I(1)	Lower bound I(0)	Upper bound I(1)
Model (3)	4.924	2.45	3.61	3.15	4.43
Model (4)	6.340				

Model (3):

$$\Delta FDI_t = \alpha_0 + \sum_{i=1}^{p}\alpha_{1i}\Delta FDI_{t-i} + \sum_{i=1}^{p}\alpha_{2i}\Delta LNELECTGEN_{t-i} + \sum_{i=1}^{p}\alpha_{3i}\Delta LNGDPPC_{t-i} + \sum_{i=1}^{p}\alpha_{4i}\Delta LNEXCHG_{t-i} + \sum_{i=1}^{p}\alpha_{5i}\Delta INTRATE_{t-i} + \sum_{i=1}^{p}\alpha_{6i}\Delta INF_{t-i} + \sum_{i=1}^{p}\alpha_{7i}\Delta LNM3_{t-i} + \gamma_1 FDI_{t-1} + \gamma_2 LNELECTGEN_{t-1} + \gamma_3 LNGDPPC_{t-i} + \gamma_4 LNEXCHG_{t-1} + \gamma_5 INTRATE_{t-1} + \gamma_6 INF_{t-1} + \gamma_7 LNM3_{t-1} + \rho DUM_t + u_t \quad (5)$$

Model (4):

$$\Delta FDI_t = \alpha_0 + \sum_{i=1}^{p}\alpha_{1i}\Delta FDI_{t-i} + \sum_{i=1}^{p}\alpha_{2i}\Delta LNELECTPR_{t-i} + \sum_{i=1}^{p}\alpha_{3i}\Delta LNGDPPC_{t-i} + \sum_{i=1}^{p}\alpha_{4i}\Delta LNEXCHG_{t-i} + \sum_{i=1}^{p}\alpha_{5i}\Delta INTRATE_{t-i} + \sum_{i=1}^{p}\alpha_{6i}\Delta INF_{t-i} + \sum_{i=1}^{p}\alpha_{7i}\Delta LNM3_{t-i} + \gamma_1 FDI_{t-1} + \gamma_2 LNELECTPR_{t-1} + \gamma_3 LNGDPPC_{t-i} + \gamma_4 LNEXCHG_{t-1} + \gamma_5 INTRATE_{t-1} + \gamma_6 INF_{t-1} + \gamma_7 LNM3_{t-1} + \rho DUM_t + u_t \quad (6)$$

Table 7 Long- and short-run results

Variables	Model (3)		Model (4)	
	Coefficient	*P* value	Coefficient	*P* value
Long-run results				
LNELECTGEN	11.480	0.0052[a]	–	–
LNELECTPR	–	–	− 2.944	0.0001[a]
LNGDPPC	9.013	0.0219[b]	3.250	0.0682[c]
LNEXCHG	0.561	0.0414[b]	2.970	0.0001[a]
INF	0.262	0.0070[a]	0.141	0.1306
INTRATE	− 0.025	0.7343	0.045	0.4374
LNM3	1.742	0.0167[b]	1.442	0.0427[b]
C	− 16.487	0.6581	− 14.26028	0.6635
DUM	1.058	0.0005[a]	3.549	0.0024[a]
Short-run results				
ΔLNELECTGEN	6.391	0.0232[b]	–	–
ΔLNELECTPR	–	–	− 4.058	0.0003[a]
ΔLNGDPPC	4.771	0.0331[b]	8.604	0.0623[c]
ΔLNEXCHG	0.690	0.0742[c]	4.094	0.0012[a]
ΔINF	0.322	0.0158[b]	0.030	0.7419
ΔINTRATE	− 0.031342	0.0736[c]	0.062	0.4356
ΔLNM3	2.142	0.0117[b]	1.988	0.0343[b]
ECT(−1)	− 0.229	0.0000[a]	− 0.378	0.0000[a]

[a] Statistical significance at 1% level
[b] Statistical significance at 5% level
[c] Statistical significance at 10% level

The ARDL bounds test (Table 6) reveals that the *F*-statistic is equal to 4.924 (6.340) for model (3) (model (4)), respectively, which is above the I(1) upper bound critical value (4.43) at 1% significance level. This result confirms the long-run relationship among variables.

Results of long-run and short-run representation are reported in Table 7. Overall, results are the same as the main analysis. Mainly, the electricity generated (LNELECTGEN) (the price of electricity (LNELECTPR)) impact positively (negatively) the FDI, ceteris paribus. The coefficients of the Gross Domestic Product per capita (LNGDPPC), the exchange rate (LNEXCHG) and the money supply (LNM3) are significant and affect positively the FDI in long-run and short-run robustness check models, ceteris paribus. Considering the ECT, we report that the speed of adjustment to long-run equilibrium is about 23% and 38% per year for models (3) and (4), respectively.

As the analysis above, the models (3) and (4) are homoscedastic and free from serial correlation (Table 8), and the stability of the parameters is confirmed (Figs. 4 and 5). In other

Table 8 Model diagnostic tests results

	Model (3)	Model (4)
Breusch-Godfrey Serial Correlation LM test	0.5130	0.6503
Breusch-Pagan-Godfrey Heteroskedasticity test	0.2310	0.4394
ARCH test	0.5984	0.9829

Note: Values represent *P* values

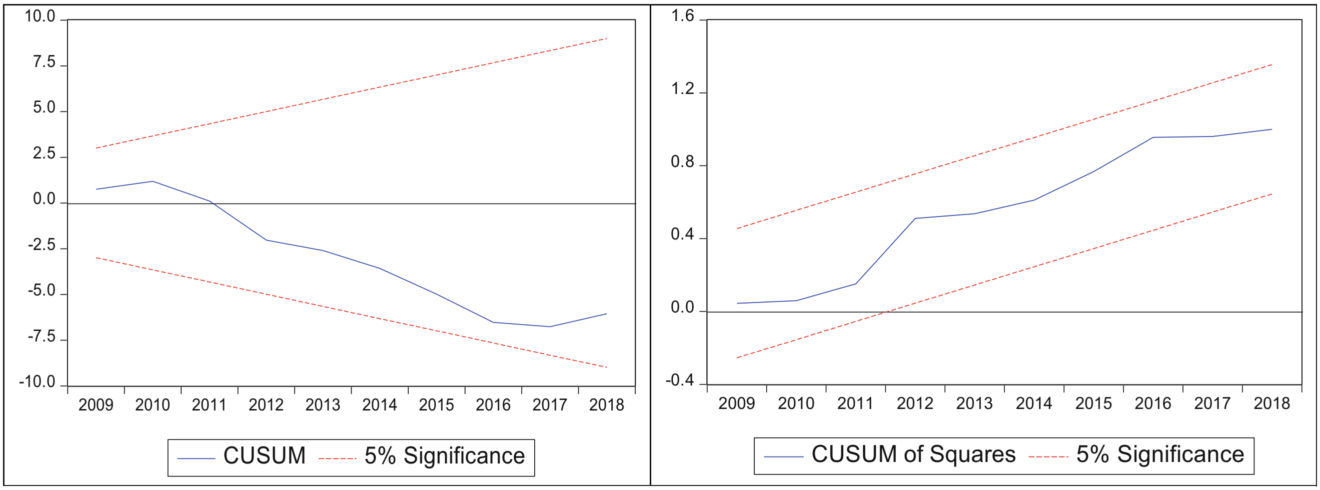

Fig. 4 Plots of cumulative sum and sum of squares of recursive residuals for model (3)

words, models for robustness analysis are well specified and confirm the results of models (1) and (2) that electricity prices are a negative contributor to attracting FDI to the country while electricity generation (availability) is a positive one.

Conclusion and policy implications

Attracting FDI has long been identified one of the factors that can promote economic growth in a country (in South Africa), it was been recognized as one of the key elements for a post-Covid-19 recovery and a long-term sustainable and prosperous economic future. The literature stresses that the conditions (socioeconomic, political and geographical) of the host country play a decisive role for the investors to move. FDI is directed to markets that show potential for profit maximization, risk reduction and promotion of competitive advantage currently and in the future.

This paper focused specifically on the electricity conditions of the South African economy and how these conditions act as an inviting or restricting factor to FDI for the period 1985 to 2018, using an ARDL cointegration technique. Availability of electricity (proxied by generation capacity in this study) is a sign for investors for continuous provision of one of the main factors of production nowadays for many industries. At the same time, high costs of electricity will affect their potential for profit maximization affecting the costs of production. This strand of the literature refers also to the environmental side of the argument with the concept of "pollution havens": FDI is being attracted in countries and regions where environmental regulation and pricing of carbon is more relaxed than others are.

These questions are more than relevant for the case of South Africa that experiences frequent power interruptions since 2008 as well as significant tariff increases in the same period.

The findings of the study indicated that indeed the initial hypotheses have been confirmed: (1) electricity supply is a positive contributor to inward FDI, ceteris paribus, and (2) electricity prices are a negative contributor to inward FDI,

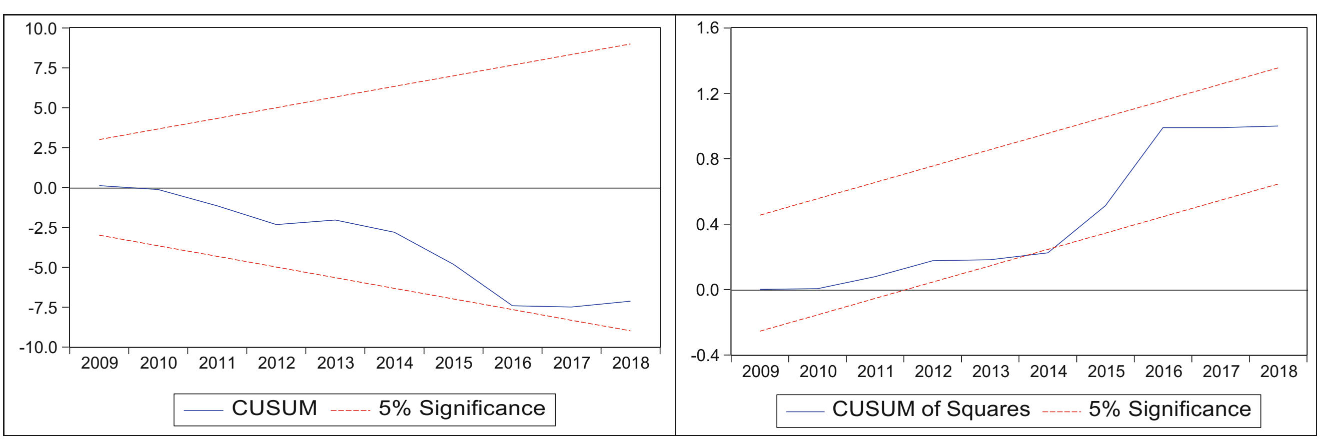

Fig. 5 Plots of cumulative sum and sum of squares of recursive residuals for model (4)

ceteris paribus. These results were confirmed for all different specifications of models both in the long- and short-run, confirming their robustness. In other words, for South Africa in the period 1985 to 2018, the higher electricity prices (particularly from 2008 onwards) and the frequent disrupted electricity distribution can be proven reasons that might discourage FDI.

From a policy point of view, it almost goes without saying that energy policy makers ought to look for solutions to the problem of interrupted supply of electricity. For more than a decade now, such interruptions have been affecting the local economy, as the producers have to either lose revenue during power cuts. Due to that and the rising costs of electricity, many producers proceeded in exploring alternative types of access to electricity and self-generation. This of course had two main consequences among others: (a) they needed access to finance to fund the investment in capital and (b) the losses in revenue of the state utility by those that stop using the electricity from the national grid. This discussion, of course, is beyond the scope of this study. However, international investors account for all of these before their decision to invest in a specific country and according to our findings, if such issues were not present, the FDI (as a % to GDP) would have been higher for the South African economy.

Policy makers could potentially consider electricity subsidization programmes to attract investors in the country, an example of such an approach is offered by India and how the country dealt with internet availability, speed and costs (BBC, 2019). Another suggestion could also be that policy makers could promote other technological avenues for accessing energy to investors, alternative to their purchasing electricity from the national grid. If investors, before decision making, evaluate the conditions in the country and conclude that installation and maintenance of self-generation of electricity are substantially more cost-effective in South Africa than in other countries, that will be considered an asset for the country.

Limitations of the study can be observed in the aggregated nature of the analysis looking at the economic as a whole and FDI as if directed from a specific country or economic sector. Future research that emanates from the current study that has a macroeconomic point of view is the exploration of the various components of the electricity/energy costs and if they have a separate influence to FDI attraction to the country (see carbon taxes, other taxes). Furthermore, a disaggregated study of the countries that invest in South Africa and the industrial disaggregation potentially down to the product level would shed more light in the dynamics between inward FDI and the electricity/energy market conditions of the South African case.

Authors' contributions Roula Inglesi-Lotz initiated the project, provided the data and worked on the all parts of the paper. Ahdi Noomen Ajmi estimated the methodology and worked on the analysis. The authors have agreed for authorship and read and approved the manuscript.

Data availability All data are available upon request.

Declarations

Ethical approval Not applicable.

Consent to participate Not applicable.

Consent to publish Not applicable.

Competing interests 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.

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