Energy Research & Social Science 72 (2021) 101830

Contents lists available at ScienceDirect

Energy Research & Social Science

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

Original research article

The off-grid catch-22: Effective institutions as a prerequisite for the global deployment of distributed renewable power

Michaël Aklin

Department of Political Science and Graduate School of Public and International Affairs, University of Pittsburgh, 4600 Posvar Hall, 230 S. Bouquet St., Pittsburgh, PA 15260, USA

ARTICLE INFO

Keywords:
Off-grid electrification
Distributed power
Institutions
Democracy
Energy poverty

ABSTRACT

Off-grid electric systems powered by renewable sources are appealing because they could reduce energy poverty in a sustainable manner. Yet their deployment has been uneven across the world. In this article, I argue that the deployment of such technology pre-requires effective institutions. This is because the off-grid power industry faces two problems: governments (who may reverse policies on short notice) and customers (who may fail to pay their bills). More democratic regimes, which tend to uphold the rule of law, can mitigate these risks and facilitate long-term investments. Empirically, I show that countries that are democratic deployed considerably more off-grid renewable energy capacity. An increase in the democratic score by one standard deviation leads to an increase in deployed capacity by 40% (95% CI: [20%, 63%]). Further, I show that this effect operates through supply-side institutions, such as the protection of the rule of law. I find little evidence for a competing interpretation of my main results based on the demand side: democracies do not provide more off-grid power in countries with stronger demand for it. These results suggest that institutions are a prerequisite for a successful growth of the off-grid renewable energy industry and raise concerns over the ability of its technologies to penetrate the most destitute regions.

1. Introduction

Off-grid electricity, powered by renewable sources, could address two important problems. One is low electrification rates in developing countries. Worldwide, almost one billion people — mostly concentrated in the rural areas of Sub-Saharan Africa and Asia — lack reliable access to electric power [1]. The consequences of energy poverty are dire, with losses in income, health, and overall welfare [2–6]. Off-grid technologies, such as solar-powered micro-grids, offer a flexible and increasingly affordable solution to this problem.

The other problem is sustainable development. Many emerging countries are growing rapidly. Powering this growth with fossil fuel would cause significant environmental damage, ranging from air pollution to climate change. Instead, relying on renewable energy could allow developing countries to leapfrog over fossil fuels to a decarbonized electric infrastructure [7]. This would be welcome from a climatic perspective. Off-grid systems generate considerably fewer greenhouse gas emissions over their life cycle [8]. The success of the climate regime, especially since the Paris agreement, depends on the rapid spread of renewable energy [9,10].

As a result, stakeholders have placed considerable hope and resources into deploying off-grid energy [11–14]. The IEA predicts that "[by] 2030, renewable energy sources power over 60% of new [electricity] access, and off-grid and mini-grid systems provide the means for almost half of new access" ([15], p.12). A report by BloombergNEF anticipates sales of off-grid solar items to reach more than \$3 billion by 2020 and to benefit almost 100 million households [16]. But despite its promises, renewable energy technology – both grid and off-grid – has encountered several setbacks and its progress has been uneven [17–21]. Even countries with high levels of unelectrified households have struggled to prop up off-grid capacity. The aim of this paper is to understand some of the most crucial challenges faced by the off-grid sector.

The starting point of my analysis is that the off-grid industry in many countries is characterized by a high level of involvement by the private sector [22,23]. This stands in stark contrast to the grid, which is typically maintained by public or quasi-public agencies. As a result of its private nature, the off-grid renewable energy sector face two major contractual risks: between firms and governments (who may reverse policies on short notice), and between firms and customers (who may fail to pay their bills). Investments face particularly high risks of this sort in emerging countries, where off-grid needs are strongest [24,25]. This

E-mail address: aklin@pitt.edu.

https://doi.org/10.1016/j.erss.2020.101830
Received 27 June 2020; Received in revised form 7 October 2020; Accepted 23 October 2020

points at a fundamental problem, which is that this industry must deal with a particularly high amount of uncertainty. Institutional theory argues that well-functioning legal institutions, such as those that defend the rule of law, can overcome contractual risks [26–28].

The importance of institutional governance in the off-grid sector has been noted in several studies [29–32]. The novel angle in this paper is its focus on contractual risks between states, firms, and customers and how institutions can address these risks. In environments characterized by robust legal systems, the off-grid renewable energy industry can flourish because investors will not be deterred. In contrast, states that offer poor legal protection are unlikely to capitalize on the development of off-grid technology. Thus, I argue that reliable legal institutions are a prerequisite for the emergence of a dynamic off-grid energy market. Since such legal institutions are often more effective in democracies, I conjecture that off-grid is more likely to be deployed in countries with more democratic regimes.

Studying deployment patterns in the developing world between 2008 and 2017, I show that off-grid capacity was extremely sensitive to a country's level of democracy. More democratic countries were substantially more likely to have high deployments of off-grid capacity. The effect of an increase of the index of democracy by one standard deviation increases off-grid capacity by about 40% (95% CI: [20%, 63%]). These effects are based on within-subregion variation and adjust for several potential confounders.

I then examine the legal institutional mechanisms linking levels of democracy to off-grid electricity. I find that countries that protect the rule of law and have low levels of corruption have deployed considerably more off-grid renewable capacity. The effect is large: increasing one of the indices used in this analysis by one standard deviation increases the uptake of off-grid renewables on a per-capita basis by about 25 to 39%, depending on the indicator. In contrast, I find little support for a competing mechanism that explains the relation between democracy and off-grid capacity through the former's tendency to be more responsive to public demands. Democracies are believed to respond to public desires more rapidly [33], and this may have been the reason for the positive relation between off-grid and levels of democracy.

In the conclusion, this paper points at a catch-22 situation. The conventional wisdom is that governments and the private energy sector are substitutes: resource-poor governments can be supported by private energy providers (which may or may not be for-profits). For instance, a recent report co-authored by an off-grid trade association and international organizations argued that "[w]here governments lack the resources to deliver universal energy access through subsidized grid extension, the private sector can play a vital role in filling the gap" ([34], p.10). While technically correct, this paper adds a condition: the private sector requires a state that performs its primary functions – enforcing a well-functioning legal system – reasonably well. This narrows down the set of countries in which the private sector can be an effective contributor.

And herein lies the catch-22: while off-grid technologies are most needed by some of the poorest populations in the world, their deployment requires pre-existing well-functioning institutions. But if these countries already had well-functioning institutions, then they would be less likely to need off-grid technologies because they tend to have well-functioning economies in the first place [33,35]. In other words, off-grid energy is less likely to be successful among those who need it most. Off-grid technology is more likely to reduce energy poverty 'from the top': the first beneficiaries will be populations living under well-functioning states. Those who do not, however, face a hard question: how can renewable energy grow in countries with weak institutions? I return to this in the conclusion.

2. Theory

2.1. Background

Historically, access to electricity has been granted by expanding the national grid. Yet in several countries, geographic challenges, economic constraints, and poor public policy conspire to exclude large populations from its benefits [36]. This is particularly true in many developing countries, which are often characterized by higher levels of poverty and weak states. Recent estimates place about one billion individuals among those lacking proper access to electricity [15]. Even those who are nominally connected to the grid face regular blackouts and voltage fluctuations.

Off-grid, or distributed energy, may contribute to tackling this challenge. In contrast to large-scale grids, these systems generate and distribute electricity locally. Their scope varies and ranges from the simplest one-household solar home system to micro-grids that can power hundreds of households. Distributed power systems have appealing characteristics [37]. Installing them can be cheaper than extending transmission lines into rural areas. Their power can be tailored to the needs of are that may be quite different from the demands from urban settings. They can be installed on short notice without long-term plans. Furthermore, off-grid technologies powered by renewable sources such as the sun or wind require little expenses in terms of fuels.

Distributed power has grown significantly across the world. Based on the most recent data available, more than 6 GW of generating capacity from off-grid renewable systems has been deployed across the developing world [38]. The International Renewable Energy Agency (IRENA) estimates that, as of 2016, about 30 million individuals had access to electricity through solar home systems or mini-grids, and an additional 100 million benefitted from solar lamps ([39], p.2). India and Indonesia have both installed for more than 1 GW of generating capacity [38]. Other countries, such as Bangladesh or China have also spent considerable resources to promote off-grid energy.

Yet these headline numbers mask considerable variation. Fig. 1 maps the state of the world as of 2017. It highlights both the success cases (e.g., Kenya) but also the countries where off-grid systems have not yet been able to establish a foothold. And indeed, in many countries progress has been too slow to meet basic energy needs [19]. Given the potential of off-grid technology to contribute to clean and sustainable development, these discrepancies beg the question of the barriers that their deployment has been facing.

2.2. Legal institutions and markets

Under what conditions does off-grid technology flourish? My starting point is the role played by institutions in the establishment and growth of markets. By institutions, I mean a set of laws and rules, backed by the state, that constrain social behavior [40,26,41].

As a general rule, institutions solve two market failures connected to contractual issues. The first relates to transactions between firms and customers [42]. In a state of nature, exchanges are hazardous: counterparts can break promises, willingly or not. Well-functioning institutions design the legal framework around private transactions and define how the law will be enforced. An institution, then, is the structure that enforces legal rights for stakeholders. In practice, this means that the aggrieved party can enforce its rights thanks to an effective judicial and legal system [43,28].

The other market failure consists in some states' tendencies that can destabilize markets, the most severe form of which is expropriation [44–46]. Governments may be tempted to take possession of the assets of vulnerable members of the private sector. A more benign – but still problematic – version of this problem is inconsistency. Newly empowered rulers may disagree with the policies implemented by their predecessors. They could find it tempting to overturn previously agreed-upon programs, such as subsidies, and therefore breach implicit or explicit contracts, which creates political risks [47,48]. Such risk depresses investments, because it reduces expected profits.

I hypothesize that the renewable energy sector, and especially its off-grid component, depends strongly on reliable legal institutions. There are several reasons for this. First, it is an industry that was developed in response to a public bad. Renewable energy expanded in response to the

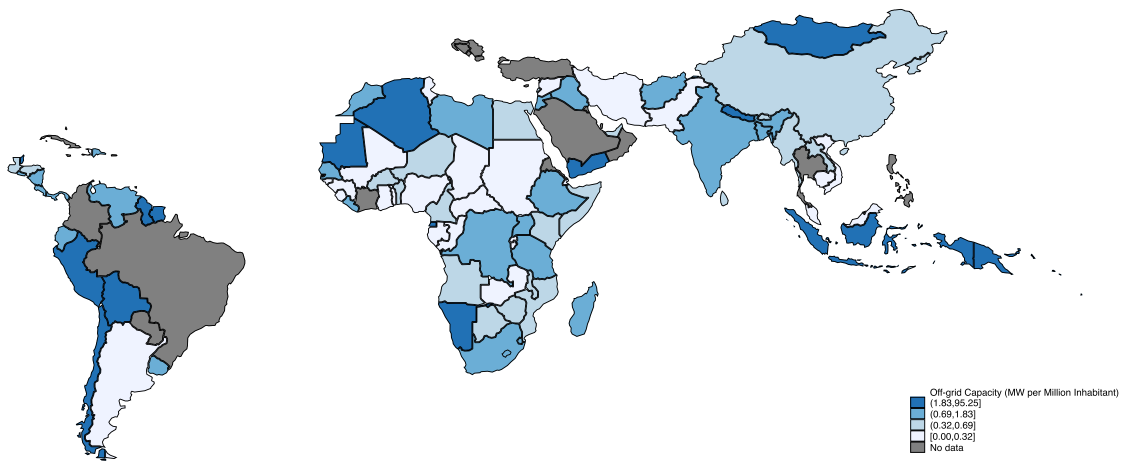

Fig. 1. Off-grid deployment, in log of MW per capita. The color scheme divides countries by percentile.

environmental and energy challenges [49]. Fossil fuels generate both local and global negative externalities. Renewables, by and large, are much cleaner [8]. This imbalance delayed the development of renewables as an alternative to fossil fuels (and nuclear power). Despite declining cost, off-grid technology remains expensive and necessitates public support to be financially viable [50,51]. Yet governments are sometimes unpredictable counterparts in this sector [24,25,21]. They may decide to cut subsidies and tax credits on short notice and therefore undercut the business model of firms operating in the renewable energy sector. In some cases, government officials may use access to electricity as a political tool to increase public support [52].

Policy instability can have significant consequences for the off-grid sector. For instance, China decided in 2018 to reduce subsidies for its solar projects.[1] The Financial Times described this shock in the following terms: "Beijing's new policy … for new solar generation will slash demand in the world's largest solar market and increase volatility in an industry that has been prone to boom and bust cycles." An industry representative referred to China's decision as a "solarcoaster." In response, the industry begged the government to overturn its decision.[2] Long-term commitments were key in the argument put forth by the industry: "the producers said the sector had racked up huge debts to ensure it could compete with traditional power generators, and still needed another three to five years of government backing." Estimates suggested that the decision could reduce renewable capacity in China by 20 GW, which underscores the magnitude of the industry's dependence on reliable government action. And while China was targeting renewables connected to the grid, the logic applies to off-grid industries as well.

The second reason that makes institutions important concerns cash flows. In many countries, the off-grid renewable energy sector is primarily run by private firms. Whether they are for- or non-profits, they need a reliable stream of income to operate. The challenge is that this technology is particularly valuable for the poorest segments of the population. Energy poverty is most prevalent among rural populations, who also happen to be excluded from high-paying jobs. Farmers and day laborers are particularly vulnerable to unanticipated adverse shocks. A bad harvest or a downturn can ruin entire regions and delay payments. More generally, off-grid technology can be expensive and create costs that are difficult to manage for customers [11]. As a result, non-payment often represent a serious risk to these firms' cash flow [53,54].

Besides bill collection, theft represents another threat to the finances of off-grid power providers. Theft can take several forms, ranging from hooking power lines to tampering electric meters [55]. The burden for suppliers is considerable. One estimate puts the cost of theft at about $60 billion per year across developing countries [56]. While public providers can, in theory, weather these costs through subsidies, private providers must face this challenge on their own. A report by ClimateGroup noted that "[t]his potential for non-payment is a significant risk for anyone wishing to invest in a [distributed renewable energy] project" ([57], p.2). Stakeholders have responded by finding creative payment strategies (e.g., pre-paid contracts) to reduce such risk. Ultimately, however, self-enforcing contracts hardly compensate for a well-functioning legal environment.

To summarize: legal institutions that enforce contracts and reliably protect property rights are essential for well-functioning private markets. Worries over contracts deter investments and discourage the growth of private firms. Given that many countries adopted an off-grid program led by the private sector, this implies that legal institutions are critical for the growth of the off-grid sector. Otherwise, contractual failures limit their scope. In the conclusion, I discuss the prospects of a state-led off-grid sector.

Note that off-grid firms themselves can worsen these issues. They can engage into illegal billing practices and corrupt state officials. Likewise, they can adopt non-competitive strategies, either by bullying other firms or entering into cartel-like arrangements. The argument presented so far does not hinge on firms being innocent actors. Instead, the argument focuses on two contractual risks: one between firms and the government and another between firms and consumers.

These fundamental threats to the off-grid sector are most likely to be fended off in democracies. The more democratic a state's regime is, the more likely it is to protect and enforce legal rights. There are several reasons for this. First, democratic states tend to be more transparent in their operations, which allows audiences to know whether the government or the public fails to fulfill its contract [58,59]. Second, upon observing a failure to complete contracts, the public can punish elected officials if they fail to adopt better policies [60–63]. As a result, democracies should be more likely to avoid the kind of market and political failures that threaten the off-grid sector. And indeed, a considerable literature finds that democracies perform better than autocracies on a range of economic outcomes [64,41,65,66]. This, of course, does not mean that democracies always do well in absolute terms. Several studies show that democracies such as India suffer from political uncertainty and political meddling in bill payments [67,52]. Instead, the argument put forward here is that democracies tend, on average, to have more effective institutions than autocracies and that this partly explains why they are more successful at deploying off-grid power.

From here, I formulate this paper's core hypothesis:

[1] "China's solar desire dims" *Financial Times*, June 8, 2018

[2] "Chinese solar panel makers urge government to delay subsidy cuts" *South China Morning Post*, June 7, 2018.

Hypothesis 1: on average, the deployment of off-grid renewable energy increases as a country is more democratic.

The first (and primary) mechanism underpinning Hypothesis 1 is rooted in institutions that protect firms from a poor business environment. Specifically, I focus on key features of institutions such as the rule of law and protection against corruption. Effective institutions have been shown to protect against the two problems identified above, namely (1) the failure to uphold contracts between off-grid firms and private customers, and (2) broken relations between governments and off-grid businesses. Several studies in development economics emphasize the importance of the rule of law and associated variables in meeting these two problems. Haggard and Tiede [68] note that the rule of law can be understood both as the enforcement of contracts (which addresses the first problem) [69–71] and checks on government misbehavior (which is tied to the second problem) [61].

Thus, sound institutions are crucial for a healthy renewable energy sector. They protect entrepreneurs and investors from unexpected changes in public support and customers who might not fulfill their obligations. Likewise, off-grid renewable energy is unlikely to grow in regions in which governments can overturn their promises on short notice, or in which customers can get away without paying their bills. By the same token, off-grid firms would struggle if they were perceived as unreliable counterparts by customers and governments. A robust legal system is therefore predicted to be a prerequisite for the deployment of off-grid renewable energy.

Hypothesis 2 (institutional mechanism): the effect of democracy operates through the presence of institutions that protect firms, such as those that protect the rule of law or reduce corruption.

An alternative mechanisms could link democracy to off-grid power: government responsiveness [62]. The idea is the following. Democratic governments have a strong incentive to respond to their constituents' demands [33]. Failure to do so could result in electoral losses. Countries with low electrification rates can safely be assumed to have strong demand for off-grid power. One would then expect that democratic regimes would try to meet their public's demand. In this alternative mechanism, the effect of democracy comes from the responsiveness of democratic regimes rather than their institutional setup.

Hypothesis 3 (demand mechanism): on average, the effect of democracy on off-grid capacity increases as demand for electricity becomes stronger.

3. Research design

I next describe the data and the statistical models that allow me to test the three hypotheses, in line with best practices [72]. I focus on large-N tests to examine the plausibility of my primary hypothesis and the mechanisms that underpin it. Future studies may consider obtaining qualitative evidence as to the relative importance of contractual concerns over other challenges faced by the renewable energy industry.

3.1. Data

I use renewable energy data, 2007–2017, from IRENA [38].[3] IRENA collects data from a wide range of sources: questionnaires by IRENA itself, government reports, official statistics, industry surveys, and so forth. Comparisons between the IRENA database and government-reported numbers suggest that the data are of good quality. Data are available for 105 countries across the emerging and developing world. See Table 1 for descriptive statistics.

My key outcome variable is the level of aggregate off-grid generating capacity. Capacity reflects the willingness of all market participants to implement off-grid projects, and therefore closely matches the perspectives of this industry. Over the time period covered her, the average country deployed 45 MW of off-grid capacity. Average capacity stands at 62 MW in the last year for which data are available. Overall, 16 countries have more than 50 MW of capacity and 11 more than 100 MW. To stabilize the distribution of the variable, I take the log of capacity. Using the log of per-capita capacity yields almost identical results (Table A6).

Starting with Hypothesis 1, I examine whether the deployment of off-grid power depends on the degree to which a country has democratic regime. I expect a positive relation between a country's level of democracy and off-grid deployment. To measure democracy, I use the Polity IV score, an index ranging from −10 to 10, where higher values represent more democratic regimes [73]. The index is constructed by combining sub-indices on electoral institutions, constraints on governments, and guarantees on civil rights. As such, it follows closely the underlying quantities from the theoretical framework offered in this paper. Among indices of democracy, the Polity score remains one of the most widely used [74]. In the appendix, I replicate the main results using V-Dem's electoral democracy index, with qualitatively identical results (Table A5) [75].

In Hypothesis 2, I argue that the positive correlation between democracy and off-grid power stems from the former's tendency to nurture more effective legal institutions. These institutions prevent the type of behavior from the state itself or from consumer that could deter off-grid businesses. I measure such institutions in two main ways: protection of the rule of law and protection against corruption. The data come from PRS Group, a firm that collects intelligence on political risks across the world and used in several influential studies (e.g. [76,77]). To measure the rule of law, experts assesses the strength and impartiality of a country's legal system, as well as the degree to which the law is observed (33 [78]). Corruption is similarly measured by structural issues such as unfair ties between governments and businesses (31 [78]). The commonality between the two variables is that they capture a state's ability to implement clear market rules and enforce them. Both variables range from 0 to 1, where higher values indicate more effective institutions.

In addition to these indicators, I examine whether a country's type of legal system matters. The literature on legal origins argues that English common law more effectively protects investors' interests than French civil law [79]. Shareholders tend to benefit from a higher degree of protection under common law. French civil law, in contrast, is believed to protect the interests of the state over those of private agents [80]. This conjecture has received empirical support. La Porta and colleagues note that they "have found that common law is associated with … better contract enforcement and greater security of property rights" ([28], p.286). Besides a dummy variable for English common law, I also include an indicator for German law. In a separate article, La Porta and colleagues note that "German civil law … countries fall in between [common and civil law], although comparatively speaking they have stronger protection of creditors" ([81], p.8). I therefore expect both types of legal systems to lead to more deployment compared to French civil law. This being said, there are relatively few cases of German legal systems in the dataset, which suggests caution in interpreting this parameter. The data are obtained from La Porta et al. [28] and expanded in time.

On the demand side, I proxy need for off-grid capacity as the share of the population (between 0 and 1) that does not have electricity. The data come from Aklin and colleagues [82], with missing years interpolated. In the sample, the unelectrified share is about 59% of the population, though this rate has declined considerably over the last decades.

3.2. Statistical models

To follow a principled approach to model building, I follow the implied theoretical model in which the effect of democracy is channeled

[3] Some variables used in this analysis are only available for a shorter time window. This is the case of for the protection of the rule of law and corruption, which are only available until 2016.

Table 1
Descriptive statistics of the variables used in the analysis.

	Mean	Median	S.D.	Min.	Max	Obs.
Offgrid Capacity (MW)	45.96	3.0	201.7	0.0	1884.0	908
Renewable Off-Grid Capacity (log of MW)	1.16	1.1	2.3	−5.8	7.5	908
Democracy	2.63	5.0	5.6	−10.0	10.0	803
Rule of Law	0.50	0.5	0.2	0.1	0.8	571
Control of Corruption	0.35	0.3	0.1	0.0	0.8	571
English Legal System	0.40	0.0	0.5	0.0	1.0	900
German Legal System	0.02	0.0	0.1	0.0	1.0	900
French Legal System	0.58	1.0	0.5	0.0	1.0	900
Electrification Demand [0,1]	0.59	0.7	0.4	0.0	1.0	772
Demand*Democracy	1.65	1.6	3.3	−6.5	8.6	762
GDP per Capita (log)	7.67	7.8	1.1	5.4	10.6	860
Urban Population (log)	15.04	15.4	2.2	8.6	20.5	902
Rural Population (log)	15.19	15.7	2.2	7.9	20.6	897
Population Density (log)	4.11	4.2	1.3	1.0	7.3	896

via its effect on legal institutions. One of the key principles behind these graphs consists in building a model that avoids 'bad' control variables [83,84]. Another is to block carefully backdoor paths.

To test H1, I estimate variants of the following model:

$$\text{Off-Grid Renewable Capacity}(\log)_{i,t} = \beta \text{Democracy}_{i,t} + \mathbf{X}_{i,t}^{'}\gamma + \phi_k + \tau_t + \varepsilon_{i,t},$$

in which i indexes countries, t years, and k subregions. The model includes year fixed effects, which account for changes in the cost of off-grid technology (τ_t). The models are estimated with ordinary least squares and standard errors are heteroskedastic-robust (Newey-West standard errors, which correct for serial correlation, generate almost identical results; see Table A2).

The key parameter of interest is β, which is expected to be positive (more democratic regimes lead to more off-grid renewables, *ceteris paribus*). A sharp identification strategy for β would rely on information from exogenous institutional shocks within countries (i.e. country fixed effects). However, institutions change rarely (and legal systems do not change at all during the time span studied here) and off-grid power only grew over the last few years, leaving little variation to draw estimates from. Therefore, within-country variation cannot serve as a basis to measure β in a reliable manner. Instead, I rely on subregional variation. I use the definition of subregions from the United Nations, which divides the world in 22 areas. These subregions contain fairly homogeneous sets of countries in terms of geographical (e.g. solar irradiance) or socio-cultural factors. Given that only mid- and low-income countries are included in the sample, the effective number of areas is 13.[4]

Subregional fixed effects are insufficient to rule out spurious correlations. I adjust for a range of potential confounders. To begin, I include the log of population in all models, which accounts for differences in country size. Then, I add geographic factors. Countries with denser population concentration might simultaneously have stronger institutions and lesser need for off-grid technology. I also include separately urban and rural populations (in log). Larger rural populations, in particular, should stimulate the off-grid market. Lastly, the model includes GDP per capita, which captures wealth effects, whereby more affluent societies might have varying abilities to invest in new technologies. Population, population density, and GDP per capita are obtained from the World Bank.

To test the first set of mechanisms (institutional mechanisms; H2), I augment the previous model with a set of institutions discussed previously. The models remain the same. I continue to include democracy, which blocks the path from institutions to off-grid deployment that operates via the demand side. The parameter attached to democracy ($\beta^{'}$) should not be interpreted, because the true effect of democracy is now partly captured by institutions.

$$\text{Off-Grid Renewable Capacity}(\log)_{i,t} = \psi \text{Institutions}_{i,t} + \beta^{'} \text{Democracy}_{i,t} + \mathbf{X}_{i,t}^{'}\gamma + \phi_k + \tau_t + \varepsilon_{i,t},$$

To test the second mechanism (demand mechanism; H3), I include a country's electrification share (from 0 to 1). In one model, I interact it with democracy.

$$\begin{aligned}\text{Off-Grid Renewable Capacity}(\log)_{i,t} = {} & \lambda \text{Electrification Demand}_{i,t} \\ & + \beta \text{Democracy}_{i,t} + \mu \text{Dem}\cdot\text{Demand}_{i,t} \\ & + \mathbf{X}_{i,t}^{'}\gamma + \phi_k + \tau_t + \varepsilon_{i,t}.\end{aligned}$$

Electrification demand captures the strength of needs for off-grid power (λ is expected to be positive). The other key parameter is μ, which, if H3 is correct, should be positive: the effect of demand should be strongest under highly democratic regimes. Conversely, the effect of democratic regimes should tend toward zero as demand declines. Adjusting our estimates for democracy blocks the path operating via the supply side of institutions.

One potential concern is that high collinearity among the key independent variables reduces the precision of our estimates. Table A1 reports the correlation matrix of these variables. To verify the robustness of my findings, I report the main analysis without the democracy indicator in Table A3. The estimates (and significance levels) are qualitatively the same as those reported below.

4. Results

4.1. Main results

To assess the plausibility of Hypothesis 1, Fig. 2 plots the deployment of off-grid power (log of MW per capita) against a country's level of democracy. As anticipated, the relation between the two is positive.

I test this relationship more systematically in Table 2, models 1–4. Each column gradually includes additional adjustments for confounders (model 2), year fixed effects (model 3), and sub-region fixed effects (model 4).

Across all specifications, I find that the effect of democracy is positive, statistically significant, and substantially large. An increase of the democracy index by one standard deviation (about 5 units) is estimated to increase off-grid renewable energy capacity by 40% (95% CI: [20%, 63%]). Even a smaller one-unit increase in the democratic index would lead us to expect capacity to increase by 6%. The estimates are remarkably stable across all four specifications.

The inclusion of subregional fixed effects cannot entirely address the risk of omitted variable bias. To explore this further, I examine the change in deployment among countries that underwent an episode of

[4] These are: the Caribbean, Central America, Eastern Africa, Eastern Asia, Melanesia, Middle Africa, North Africa, South America, South Eastern Asia, Southern Africa, Western Africa, and Western Asia.

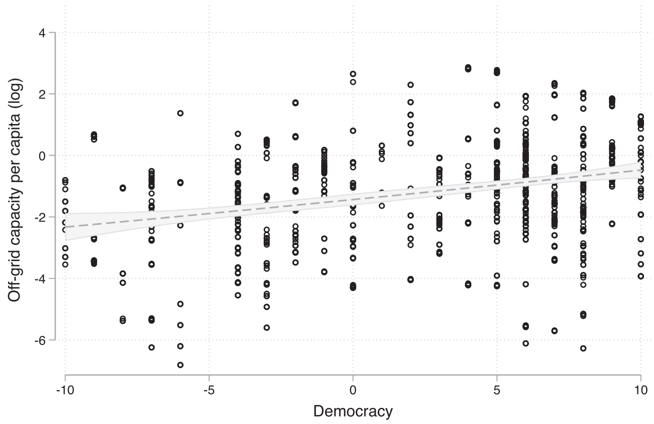

Fig. 2. Off-grid deployment, in log of MW per capita, as a function of democracy (Polity score, where −10 is least and +10 is most democratic). The line represents the quadratic best fit with 95% confidence interval.

democratization and those that experienced autocratic reversals. In Table 3, I find that off-grid grew slowly if at all among countries that moved toward more autocratic regimes (about 141 percent higher in 2017 than in 2008 on average), whereas it grew strongly (growth of more than 4,000 percent) among those that became more democratic. While the number of countries that experienced either type of transitions remains small, it further confirms that building more democratic regimes helps the renewable energy sector.

Thus, the main hypothesis finds support in the data: democracies deployed more renewable off-grid capacity, holding a range of socio-economic and geographic factors constant. The benign effect of democracies does not stem from them doing otherwise more poorly with regular electric supply, as model (8) shows. The exact mechanisms explaining this effect are discussed next.

4.2. Mechanisms

Next, I examine the mechanisms through which democracy may affect off-grid power. The two competing mechanisms are (a) that democracies have more effective legal institution (e.g., via stronger rule of law and lower levels of corruption), and (b) that democracies are more responsive to people's demand for electrification. The results are reported in Table 2, models 6–9. Columns 6 and 7 test the first mechanism (friendlier institutions; H2) and columns 8 and 9 the second one (responsiveness to demand; H3).

I find considerable evidence supportive of the institutional mechanism. The effect of an increase in the index for the rule of law by one standard deviation leads to an expected increase of capacity by 39% (95% CI: [23%, 58%]). Likewise, improving performances gainst corruption increases capacity by an estimated 26% (95%CI: [5%, 51%]).

Evidence is much more mixed when considering legal traditions. I find no evidence that common law is superior to civil law in this context. If anything, common law countries perform more poorly. Detecting an effect was likely to be challenging, given that there is not much variation to draw inferences from. The effect of German law is positive and large, with deployment levels almost 4 times larger than those of civil law countries. However, given that only a very small number of countries

Table 3
Democratic transitions and changes in off-grid capacity deployment, 2008–2017. Δ *democracy score* refers to the change a country's Polity score between 2008 and 2017. *Off-grid capacity growth* is the change, in percent, in off-grid renewable capacity between the same years.

Democratic Transitions and Changes in Off-grid Capacity Deployment, 2008–2017		
Δ democracy score	Off-grid capacity growth	Number of cases
−2 or less	141%	6
−1 to +1	1272%	40
+2 and higher	4434%	17

Table 2
Dependent variable: log of off-grid renewable capacity. Robust standard errors in parentheses. Symbols: $*: p < 0.1$; $**: p < 0.05$; $***\, p < 0.01$.

Explaining Off-Grid Renewable Deployment (log of MW)									
	Democracy (H1)				Institutions (H2)			Demand (H3)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Democracy	0.05***	0.10***	0.09***	0.06***	0.14***	0.12***	0.07***	0.06***	0.15***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.03)
Rule of Law					2.05***				
					(0.40)				
Control of Corruption						1.46**			
						(0.58)			
English Legal System							−0.33*		
							(0.18)		
German Legal System							1.67***		
							(0.43)		
Electrification Demand [0,1]								0.05	0.28
								(0.31)	(0.33)
Demand*Democracy									−0.16***
									(0.03)
GDP per Capita (log)		0.46***	0.45***	0.10	−0.23**	−0.17*	0.17	0.09	0.11
		(0.08)	(0.08)	(0.10)	(0.10)	(0.10)	(0.11)	(0.10)	(0.11)
Urban Population (log)		−0.11	−0.16*	−0.08	−0.08	−0.05	−0.14	−0.07	−0.08
		(0.09)	(0.09)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)
Rural Population (log)		1.14***	1.18***	1.16***	1.17***	1.15***	1.22***	1.15***	1.18***
		(0.09)	(0.09)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.10)
Population Density (log)		−0.33***	−0.36***	−0.24***	−0.05	−0.14*	−0.24***	−0.23***	−0.27***
		(0.05)	(0.05)	(0.06)	(0.08)	(0.08)	(0.06)	(0.07)	(0.06)
Sub-Region FE				✓	✓	✓	✓	✓	✓
Year FE			✓	✓	✓	✓	✓	✓	✓
Observations	803	755	755	755	545	545	755	724	724
R^2	0.02	0.47	0.53	0.61	0.68	0.67	0.61	0.60	0.62

(which includes China) in this sample operate under German law, I caution against interpreting this effect with too much confidence.

To push the analysis further, I report two split sample analyses in the appendix. In Table A4, I split the sample between democracies and autocracies. The effect of well-functioning institutions – rule of law, corruption, and English legal systems – should be conditional on the pre-existence of more democratic regime. Strong protection of the rule of law or low corruption are unlikely to overcome the deficit faced by authoritarian regimes. The effect of the institutional variables indeed appears larger under democratic regimes. One exception is common law, which has a positive effect under autocracies.

Turning to the demand-side mechanism: I find no evidence that the effect of democracy is conditioned by demand. In fact, the sign of the interaction effect is negative, which suggests that the effect of democracy is stronger under weak demand for off-grid. This finding falsifies Hypothesis 3. Note that model (8) also shows that the positive impact of democracy does not result from democracies doing more poorly with grid electricity provision, since the effect remains after including the share of unelectrified households.

The lack of effect of demand also hints at the fundamental catch-22 of off-grid power: the deployment of off-grid power is strongest when institutions are sound and demand weak. The next section concludes with a discussion on how to overcome it.

5. Conclusion

Off-grid energy systems is believed to offer a promising contribution to end energy poverty. They are increasingly cheap and represent a flexible response to meet basic energy needs. Yet their deployment has been uneven. Given the urgent needs of hundreds of million people, what explains this delay?.

In this paper, I offered an explanation rooted in institutional theory. As a nascent sector, the renewable energy industry is dependent on well-functioning legal institutions. Threatened by the twin risks of policy reversals and poor customer payment rates (and, possibly, by the sector's own uncompetitive practices), the renewable energy industry is living off a very thin margin. As a result, it is unlikely to succeed where governments rule in an arbitrary way or where it lets customers get away without paying their dues. In contrast, states characterized by sound payment practices and trustworthy governments should offer fertile ground to the growth of this industry. Empirically, I show that effective legal institutions are indeed crucial to booming off-grid renewables.

From a policy perspective, this raises a problem. On the one hand, distributed power is often argued to be particularly helpful to help those populations that live in the poorest regions. On the other hand, such places may be too rough business-wise for off-grid providers to flourish. Instead, the latter may be more successful in regions that have decently well-functioning institutions. Yet these areas will generally not be the ones that need help the most. This tension is illustrated in Fig. 3.

How can off-grid energy then meet needs in the harshest conditions? A natural starting point would be address the problem at its roots and strengthen a country's contractual environment. Studies have explored how state capacity can be expanded to reduce concerns over contractual disputes [44]. In these cases, institutional shortcomings are either addressed directly via reforms or overcome indirectly. Examples of the former include studies on educational reforms and ways to reduce absenteeism [85]. For the latter, research has investigated how corruption can be overcome via new technologies [86]. Yet in the case of energy markets, such solutions are hard to deploy. Some innovations, such as pre-paid contracts, help reduce some of the concerns that customers and firms may have, but their ability to be scaled up remains to be seen.

Thus, more practical advice is needed. One answer is that the industry does not need to be based in the countries with the weakest institutions. One may imagine, for instance, a firm based in a country with well-functioning institutions and do business abroad. Of course, there will be residual risks, but these would not be about losing core assets. Yet it is unclear if this is realistic. Many off-grid renewable energy firms are small in scale and unlikely to be internationally competitive. Even though the renewable energy market is global, it is also very fragmented. Furthermore, many studies emphasize how important it is to have local connections and knowledge to sustain a profitable renewable energy business.

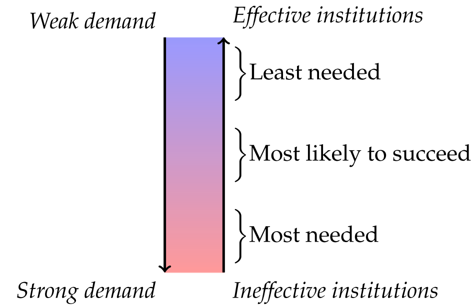

Fig. 3. The catch-22 of off-grid power as a solution to electricity poverty.

Another solution comes from international donors. Organizations such as multilateral development banks could offer financial guarantees to sustain this industry. For instance, a regional bank could offer guaranteed loans to potential customers. Yet this would create new challenges: lack of local buy-in (from consumers) and moral hazard (on the providers' side).

Perhaps a more promising path comes from historical models on how to overcome difficult environments [42]. One may imagine the development of industry-wide insurance schemes. Just like guilds of the past helped unlucky merchants overcome temporary shocks [87], modern trade associations could provide support to off-grid businesses in times of hardship. By pooling risks, possibly across borders, such a trade association could help overcome the most challenging institutional environments its members have to face. International associations, possibly with the backing of organizations such as IRENA, could help address these political and market failures.

Lastly, one can imagine a scenario in which governments that have a desire to reduce energy poverty could themselves invest in distributed power. In countries such as Indonesia, authorities have taken a more proactive role in the deployment of off-grid technology [88]. In such situations, the lower cost of distributed power may help bypass an otherwise dysfunctional electricity market. By re-centering the off-grid sector on the state, many of the contractual issues could be alleviated. Comparisons between state- and private sector-led approaches to off-grid remain rare, and yet they could shed light on the pros and cons of competing energy strategies. Off-grid power may then still help meet people's needs.

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.

Acknowledgement

Thanks to Graeme Auld, Colin Kuehl, three anonymous reviewers, and Benjamin Sovacool for outstanding feedback. I am also grateful to the participants to workshops at ETHZ, the University of Lucerne, MPSA, and APSA for their comments. All errors are mine.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.erss.2020.101830. A replication package is available at https://github.com/michaelaklin/replicationfiles.

References

[1] IEA, Energy access outlook 2018. World Energy Outlook Special Report, 2018.
[2] Shahidur R. Khandker, Douglas F. Barnes, Hussain Samad, Nguyen Huu Minh, Welfare impacts of rural electrification: Evidence from Vietnam. World Bank Policy Research Working Paper 5057, 2009.
[3] Taryn Dinkelman, The effects of rural electrification on employment: new evidence from South Africa, Am. Econ. Rev. 101 (7) (2011) 3078–3108.
[4] Reza Kowsari, Hisham Zerriffi, Three dimensional energy profile: a conceptual framework for assessing household energy use, Energy Policy 39 (12) (2011) 7505–7517.
[5] Nicholas L. Lam, Kirk R. Smith, Alison Gauthier, Michael N. Bates, Kerosene: a review of household uses and their hazards in low- and middle-income countries, J. Toxicol. Environ. Health Part B 15 (6) (2012) 396–432.
[6] Shahidur R. Khandker, Douglas F. Barnes, Hussain A. Samad, Welfare impacts of rural electrification: a panel data analysis from Vietnam, Econ. Dev. Cult. Change 61 (3) (2013) 659–692.
[7] Hisham Zerriffi, Elizabeth Wilson, Leapfrogging over development? Promoting rural renewables for climate change mitigation, Energy Policy 38 (4) (2010) 1689–1700.
[8] Andrew Bilich, Kevin Langham, Roland Geyer, Love Goyal, James Hansen, Anjana Krishnan, Joseph Bergesen, Parikhit Sinha, Life cycle assessment of solar photovoltaic microgrid systems in off-grid communities, Environ. Sci. Technol. 51 (2) (2017) 1043–1052.
[9] Robert O. Keohane, David G. Victor, Cooperation and discord in global climate policy, Nat. Clim. Change 6 (6) (2016) 570–575.
[10] Joeri Rogelj, Alexander Popp, Katherine V Calvin, Gunnar Luderer, Johannes Emmerling, David Gernaat, Shinichiro Fujimori, Jessica Strefler, Tomoko Hasegawa, Giacomo Marangoni, et al., Scenarios towards limiting global mean temperature increase below 1.5) c, Nat. Clim. Change 8(4) (2018) 325.
[11] Benjamin K. Sovacool, Deploying off-grid technology to eradicate energy poverty, Science 338 (2012) 47–48.
[12] Johannes Urpelainen, Grid and off-grid electrification: an integrated model with applications to india, Energy Sustain. Develop. 19 (2014) 66–71.
[13] Peter Alstone, Dimitry Gershenson, Daniel M. Kammen, Decentralized energy systems for clean electricity access, Nat. Clim. Change 5 (4) (2015) 305–314.
[14] Johannes Urpelainen, Semee Yoon, Solar products for poor rural communities as a business: lessons from a successful project in uttar pradesh, India, Clean Technol. Environ. Policy 18 (2) (2016) 617–626.
[15] IEA, Energy access outlook 2017: From poverty to prosperity. World Energy Outlook Special Report, 2017.
[16] Bloomberg New Energy Finance. Off-grid solar market trends 2016. Report, February 2016.
[17] Helene Ahlborg, Linus Hammar, Drivers and barriers to rural electrification in tanzania and mozambique – grid-extension, off-grid, and renewable energy technologies, Renew. Energy 61 (2014) 117–124.
[18] Leah C. Stokes, Power politics: renewable energy policy change in us states (Ph.D. Dissertation), 2015.
[19] Tania Urmee, Md. Anisuzzaman, Social, cultural and political dimensions of off-grid renewable energy programs in developing countries, Renew. Energy 93 (2016) 159–167.
[20] Varun Sivaram, Taming the Sun: Innovations to Harness Solar Energy and Power the Planet Taming the Sun: Innovations to Harness Solar Energy and Power the Planet, MIT Press, Cambridge, MA, 2017.
[21] Michaël Aklin, How robust is the renewable energy industry to political shocks? evidence from the 2016 U.S. elections, Business Politics 20 (4) (2018) 523–552.
[22] World Bank, Reliable and affordable off-grid electricity services for the poor. Report, 2016.
[23] Oliver Waissbein, Hande Bayraktar, Christoph Henrich, Tobias S. Schmidt, Abhishek Malhotra, Derisking renewable energy investment: Off-grid electrification. Report, December 2018.
[24] Tobias S. Schmidt, Low-carbon investment risks and de-risking, Nat. Clim. Change 4 (4) (2014) 237–239.
[25] Abhishek Malhotra, Tobias S. Schmidt, Leonore Haelg, Oliver Waissbein, Scaling up finance for off-grid renewable energy: the role of aggregation and spatial diversification in derisking investments in mini-grids for rural electrification in india, Energy Policy 108 (2017) 657–672.
[26] Douglass C. North, Institutions, J. Econ. Perspect. 5 (1) (1991) 97–112.
[27] Stephen Knack, Philip Keefer, Institutions and economic performance: cross-country tests using alternative institutional measures, Econ. Politics 7 (3) (1995) 207–227.
[28] Rafael La Porta, Florencio Lopez de Silanes, Andrei Shleifer, The economic consequences of legal origins, J. Econ. Literature 46(2) (2008) 285–332.
[29] Andreas Goldthau, Rethinking the governance of energy infrastructure: scale, decentralization and polycentrism, Energy Res. Soc. Sci. 1 (2014) 134–140.
[30] Brian Sergi, Matthew Babcock, Nathaniel J. Williams, Jesse Thornburg, Aviva Loew, Rebecca E. Ciez, Institutional influence on power sector investments: a case study of on-and off-grid energy in kenya and tanzania, Energy Res. Soc. Sci. 41 (2018) 59–70.
[31] Yifan Cai, Yuko Aoyama, Fragmented authorities, institutional misalignments, and challenges to renewable energy transition: a case study of wind power curtailment in china, Energy Res. Soc. Sci. 41 (2018) 71–79.
[32] Lorenz Gollwitzer, David Ockwell, Ben Muok, Adrian Ely, Helene Ahlborg, Rethinking the sustainability and institutional governance of electricity access and mini-grids: electricity as a common pool resource, Energy Res. Soc. Sci. 39 (2018) 152–161.
[33] Bruce Bueno de Mesquita, Alastair Smith, Randolph M. Siverson, James D. Morrow, The Logic of Political Survival, MIT Press, Cambridge, 2003.
[34] GOGLA, Providing energy access through off-grid solar: guidance for governments. Report, 2017.
[35] Daron Acemoglu, James A. Robinson, Why Nations Fail: The Origins of Power, Prosperity, and Poverty, Crown, New York, 2012.
[36] Michaël Aklin, S.P. Patrick Bayer, Harish, and Johannes Urpelainen. Escaping the Energy Poverty Trap: When and How Governments Power the Lives of the Poor, MIT Press, Cambridge, MA, 2018.
[37] Hisham Zerriffi, Rural Electrification: Strategies for Distributed Generation, Springer, New York, 2011.
[38] IRENA, Renewable Capacity Statistics 2018. International Renewable Energy Agency, Abu Dhabi, 2018a.
[39] IRENA, Off-grid renewable energy solutions. Report, July 2018b.
[40] Douglass C. North, Barry R. Weingast, Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century england, J. Econ. Hist. 49 (4) (1989) 803–832.
[41] Daron Acemoglu, Simon Johnson, James A. Robinson, The colonial origins of comparative development: an empirical investigation, Am. Econ. Rev. 91 (5) (2001) 1369–1401.
[42] Avner Greif, Contract enforceability and economic institutions in early trade: the maghribi traders' coalition, Am. Econ. Rev. 83 (3) (1993) 525–548.
[43] Rafael La Porta, Florencio Lopez-De-Silanes, Andrei Shleifer, Robert Vishny, Investor protection and corporate valuation, J. Finance 57 (3) (2002) 1147–1170.
[44] Timothy Besley, Torsten Persson, The origins of state capacity: property rights, taxation, and politics, Am. Econ. Rev. 99 (4) (2009) 1218–1244.
[45] Benjamin A.T. Graham, Noel P. Johnston, Allison F. Kingsley, A unified model of political risk, Adv. Strategic Manage. 34 (2016) 119–160.
[46] Benjamin A.T. Graham, Noel P. Johnston, Allison F. Kingsley, Even constrained governments take: the domestic politics of transfer and expropriation risks, J. Conflict Resolut. 62 (8) (2018) 1784–1813.
[47] Michael M. Bechtel, The political sources of systematic investment risk: lessons from a consensus democracy, J. Polit. 71 (02) (2009) 661–677.
[48] Geert Bekaert, Campbell R. Harvey, Christian T. Lundblad, Stephan Siegel, Political risk spreads. NBER Working Paper, January 2014.
[49] Michaël Aklin, Johannes Urpelainen, Renewables: The Politics of a Global Energy Transition, MIT Press, Cambridge, MA, 2018.
[50] Martin Stadelmann, Paula Castro, Climate policy innovation in the south – domestic and international determinants of renewable energy policies in developing and emerging countries, Global Environ. Change 29 (2014) 413–423.
[51] Kavita Surana, Laura Diaz Anadon, Public policy and financial resource mobilization for wind energy in developing countries: a comparison of approaches and outcomes in china and india, Global Environ. Change 35 (2015) 340–359.
[52] Brian Min, Power and the Vote: Elections and Electricity in the Developing World, Cambridge University Press, New York, 2015.
[53] Xavier Lemaire, Off-grid electrification with solar home systems: the experience of a fee-for-serviceconcession in south africa, Energy Sustain. Develop. 15 (2011) 277–283.
[54] Michael Grimm, Luciane Lenz, Jörg Peters, Maximiliane Sievert, Demand for off-grid solar electricity: experimental evidence from rwanda, Ruhr Economic Papers 745 (2018).
[55] Thomas B. Smith, Electricity theft: a comparative analysis, Energy Policy 32 (18) (2004) 2067–2076.
[56] Northeast Group, Emerging Markets Smart Grid: Outlook 2015. Report, 2014.
[57] Climate Group, The business case for off-grid energy in india, The Clean Revolution, 2015.
[58] James R. Hollyer, B. Peter Rosendorff, James R. Vreeland, Democracy and transparency, J. Polit. 73 (4) (2011) 1191–1205.
[59] R. James, B. Hollyer, Peter Rosendorff, James Raymond Vreeland, Measuring transparency, Polit. Anal. 22 (4) (2014) 413–434.
[60] Torsten Persson, Gerard Roland, Guido Tabellini, Separation of powers and political accountability, Quart. J. Econ. 112 (4) (1997) 1163–1202.
[61] Barry R Weingast, The political foundations of democracy and the rule of the law, Am. Polit. Sci. Rev. 91 (2) (1997) 245–263.
[62] Timothy Besley, Robin Burgess, The political economy of government responsiveness: theory and evidence from india, Quart. J. Econ. 117 (4) (2002) 1415–1451.
[63] Scott Gehlbach, Philip Keefer, Investment without democracy: ruling-party institutionalization and credible commitment in autocracies, J. Comp. Econ. 39 (2) (2011) 123–139.
[64] A. Przeworski, M.E. Alvarez, J.A. Cheibub, F. Limongi, Democracy and Development, Cambridge University Press, Cambridge, 2000.
[65] Robin Harding, David Stasavage, What democracy does (and doesn't do) for basic services: school fees, school inputs, and african elections, J. Polit. 76 (1) (2013) 229–245.
[66] Daron Acemoglu, Suresh Naidu, Pascual Restrepo, James A. Robinson, Democracy does cause growth, J. Polit. Econ. 127 (1) (2019) 47–100.
[67] Brian Min, Miriam Golden, Electoral cycles in electricity losses in india, Energy Policy 65 (2014) 619–625.
[68] Stephan Haggard, Lydia Tiede, The rule of law and economic growth: where are we? World Dev. 39 (5) (2011) 673–685.
[69] Ronald H. Coase, The problem of social cost, J. Law Econ. 3 (1960) 1–44.

[70] Harold Demsetz, Toward a theory of property rights, Am. Econ. Rev. 57 (2) (1967) 347–359.
[71] Simeon Djankov, Rafael La Porta, Florencio Lopez-de Silanes, Andrei Shleifer, The regulation of entry, Q. J. Econ. 117(1) (2002) 1–37.
[72] Benjamin K. Sovacool, Jonn Axsen, Steve Sorrell, Promoting novelty, rigor, and style in energy social science: towards codes of practice for appropriate methods and research design, Energy Res. Soc. Sci. 45 (2018) 12–42.
[73] Monty G. Marshall, Polity iv project: political regime characteristics and transitions, 1800–2009. Technical report, University of Maryland, 2010.
[74] Michael Coppedge, John Gerring, David Altman, Michael Bernhard, Steven Fish, Allen Hicken, Matthew Kroenig, Staffan I. Lindberg, Kelly McMann, Pamela Paxton, et al., Conceptualizing and measuring democracy: a new approach, Perspect. Polit. (2011) 247–267.
[75] Michael Coppedge, John Gerring, Carl Henrik Knutsen, Staffan I. Lindberg, Jan Teorell, David Altman, Michael Bernhard, M. Steven Fish, Adam Glynn, Allen Hicken, et al., V-dem codebook v10. Varieties of Democracy (V-Dem) Project, 2020.
[76] Simeon Djankov, Rafael La Porta, Florencio Lopez-de Silanes, Andrei Shleifer, Courts, Q. J. Econ. 118 (2) (2003) 453–517.
[77] Matthias Busse, Carsten Hefeker, Political risk, institutions and foreign direct investment, Eur. J. Polit. Econ. 23 (2) (2007) 397–415.
[78] PRS, International country risk guide methodology. PRS Group, 2013.
[79] Thorsten Beck, Ross Levine, and Asli Demirgüç-Kunt, Law and finance: why does legal origin matter? World Bank Policy Research Working Paper 2904, 2002.
[80] Friedrich A. Hayek, The Constitution of Liberty, University of Chicago Press, Chicago, 1960.
[81] Rafael La Porta, Florencio Lopez-de Silanes, Andrei Shleifer, Robert Vishny, Investor protection and corporate governance, J. Financ. Econ. 58(1–2) (2000) 3–27.
[82] Michaël Aklin S.P. Harish, Johannes Urpelainen, A global analysis of progress in household electrification, Energy Policy 122 (2018) 421–428.
[83] Joshua Angrist, Steffan J. Pischke, Mostly Harmless Econometics, Princeton University Press, Princeton, 2008.
[84] Judea Pearl, Causality, Cambridge University Press, New York, second ed., 2009.
[85] Esther Duflo, Rema Hanna, Stephen P. Ryan, Incentives work: getting teachers to come to school, Am. Econ. Rev. 102 (4) (2012) 1241–1278.
[86] Karthik Muralidharan, Paul Niehaus, Sandip Sukhtankar, Building state capacity: evidence from biometric smartcards in India, Am. Econ. Rev. 106 (10) (2016) 2895–2929.
[87] Marco HD Van Leeuwen, Guilds and middle-class welfare, 1550–1800: provisions for burial, sickness, old age, and widowhood 1, Econ. History Rev. 65 (1) (2012) 61–90.
[88] Nicola U. Blum, Ratri Sryantoro Wakeling, Tobias S. Schmidt, Rural electrification through village grids: assessing the cost competitiveness of isolated renewable energy technologies in indonesia, Renew. Sustain. Energy Rev. 22 (2013) 482–496.