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Rural electrification, electrification inequality and democratic institutions in sub-Saharan Africa

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ABSTRACT

While it is commonly believed that democracy influences public service provision, comparably few studies have assessed how recent democratisation in developing countries has impacted tangible public service outcomes for economically deprived population shares. Using panel data from 46 sub-Saharan African countries between 1990 and 2010 as well as qualitative country case examples from Ghana, Swaziland, Uganda, Senegal and Rwanda, this paper examines considerable and growing rural electrification variations in terms of political, economic and demographic variables. The analyses suggest that democracy is strongly associated with rural electrification increases and rural versus urban electrification inequality decreases in sub-Saharan Africa. This result is robust to a variety of political, economic and demographic control variables as well as different econometric modelling assumptions. The paper further presents novel multi-variant evidence supporting that contested elections with strong oppositions as well as effective policy implementing institutions may act as intervening institutional mechanisms that explain a part of democracy's association with rural electricity provision. Higher income per capita, national savings and population densities may further foster rural electrification, while high foreign aid shares of GDP and rural population percentages may pose challenges to access equality.

Introduction

The UN 2030 Agenda for Sustainable Development adopted in September 2015 includes the goal to end global energy poverty by providing universal access to affordable, reliable, sustainable and modern energy for all. In the academic literature, rural electrification, defined as percentage of the rural population with access to electricity, has been found to be a crucial part of socio-economic development (Cook, 2011). An increase in rural electrification is associated with higher youth literacy rates by upgrading in-school and domestic learning facilities (Kanagawa and Nakata, 2008). It has been linked to improving ambulant and nursing care (Herrin, 1979). Furthermore, it has been found to enhance employment, especially among women (Dinkelman, 2011), enable additional agricultural and non-agricultural income generating activities, and advance rural productivity (Kirubi et al., 2009). Where complementary hard and soft infrastructure are present, access to electricity is generally accepted to result in such positive health, education and income consequences (Cook, 2011).

Electrification rates diverge substantially in different world regions. Fig. 1 shows rural and urban electrification rates for sub-Saharan Africa, South Asia, Latin America, Middle East and North Africa (MENA) and East Asia & Pacific. It exhibits two striking features. First, sub-Saharan Africa's rural electrification of 14% is significantly lower than in any other region of the world. Second, the evident urban bias in electrification measured as ratio between rural and urban electrification is 3.5 times greater in sub-Saharan Africa than anywhere else (cf. Mandelli et al., 2014; Ahlborg et al., 2015).

However, within sub-Saharan Africa unparalleled and growing cross-national variations exist in both rural electrification and rural versus urban electrification inequality. The standard deviation of rural electrification in the region has increased by almost 50% between 1990 and 2010. During this period, countries like Ghana and Senegal managed to increase rural electrification and decrease the urban electrification bias by an order of magnitude (World Bank, 2015). Yet they are contrasted by cases with more dubious trajectories. In Swaziland, electrification inequality has risen despite its middle-income status. In Rwanda, a strong urban bias exists in electrification. New rural electrification connections in Uganda have not managed to grow quicker than the rural population, resulting in a stagnation of rural electrification rates at less than 5% and a greater total number of rural residents without electricity despite consistent income growth rates (Bhattacharyya, 2013).

This paper contributes to a growing socio-politically orientated literature on electrification in developing countries (Ahlborg et al., 2015; Brown and Mobarak, 2009; Kroth et al., 2014; Min, 2015). It explicitly focuses on rural areas and the salient inequality between rural and urban electrification, aiming to analyse the importance of respective political, economic and demographic variables. It further intends to provide explicit multi-variant evidence for the existence of potential

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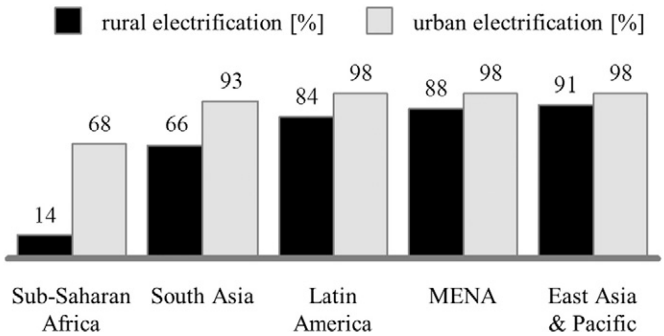

Fig. 1. Rural and urban electrification in 2010 (data source: World Bank, 2015).

political intervening mechanisms between democracy and the dependent variables.

In the early 1990s, most sub-Saharan African countries introduced multiparty elections, propelling the region's democratisation process (Bates et al., 2012). Democracies have been found to spend more money on public services such as education and health (Brown and Hunter, 2004; Kaufman and Segura-Ubiergo, 2001; Stasavage, 2005). A few studies have focused on tangible outcomes rather than budget allocations (Bueno de Mesquita et al., 2003; Diaz-Cayeros et al., 2013; Kroth et al., 2014; Lake and Baum, 2001). They similarly observe that democracies perform better at providing public services. Despite this suggested link, the fact that around 60% of the sub-Saharan electorate lives in rural areas, and the concurrence of increased cross-sectional rural electrification and electrification inequality variations with a salient democratisation process, no previous study has jointly analysed political, economic and demographic factors of rural electrification and electricity access inequality in sub-Saharan Africa over time.

Econometric panel data and ordinary least squares (OLS) models in this paper use electrification data from 46 sub-Saharan African countries between 1990 and 2010. The association between democracy and rural electrification is studied in panel data models controlling for a variety of political, economic and demographic variables. The multivariant approach then compares the democracy variable in econometric base models to those where additional political variables for oppositional strength in elections and institutional effectiveness are added to the same observation set. A decrease in the democracy variable coefficient, coupled with respective statistical significance levels, would constitute explicit evidence for contested elections or institutional effectiveness explaining parts of democracy's association with rural electrification. The model results are reinforced by a series of econometric robustness tests as well as by both factual and counterfactual case example evidence from Ghana, Swaziland, Uganda, Senegal and Rwanda, the latter two being provided in the Appendices B–C.

The Rural electrification in sub-Saharan Africa section of this paper deduces eight testable hypotheses regarding political, economic and demographic drivers of rural electrification in sub-Saharan Africa. The Data and descriptive statistics section discusses data sources and assumptions, followed by the econometric analyses entailing modelling approach, regression results and robustness tests in the Econometric analyses section. Qualitative evidence for three country cases is presented in the Case example analyses section, before the paper closes with a conclusion and policy implications.

Rural electrification in sub-Saharan Africa

Political drivers of rural electrification

Scholars have produced a range of studies showing a positive association between democracy and public service provision (see for instance Brown, 1999; Bueno de Mesquita et al., 2003; Kaufman and Segura-Ubiergo, 2001; Kudamatsu, 2012; Lake and Baum, 2001). Harding and Stasavage (2014) point out that whether the provision of a certain public good is attributable to politicians' actions is a crucial prerequisite for such a positive association to have potential implications. They argue that in a context of democratisation, politicians tend to prioritise actions on those public goods where their executive effort can be clearly connected to actual benefits on the ground. While to some extend dependent on context, following Harding's (2015) theory on road networks in Ghana, three factors render rural electrification attributable to executive efforts in sub-Saharan Africa. First, responsibility for national electricity infrastructure is highly centralised and bundled within the state apparatus (Barnes and Floor, 1996). To the best of the author's knowledge, there is no sub-Saharan African country where the state does not exercise a significant amount of control over its electricity infrastructure, often through state-owned enterprises, state-run electrification agencies and public grid ownership (Foster and Briceño-Garmendia, 2010; Karekezi and Kimani, 2002). The engineering problem of matching national electricity demand and supply via one interconnected national grid demands such centralised control. Electrification agencies tend to feature explicit and publically available planning criteria (Eberhard et al., 2011). Despite their significant untapped potential, decentralised electric capacity in sub-Saharan Africa, often installed by non-governmental actors (MacLean et al., 2015), are several orders of magnitude smaller than national grid extensions (International Renewable Energy Agency, 2012).[1] Second, somewhat contrary to popular belief, the power sector in sub-Saharan Africa is largely domestically financed, easing attribution of political electrification promises for its citizens. The World Bank in their 2010 Africa's Infrastructure report shows that between 2001 and 2006, 81% of the total electricity infrastructure spend in sub-Saharan Africa came from sub-Saharan African taxpayers and infrastructure users (Foster and Briceño-Garmendia, 2010). Only 6%, or $0.7 bn. annually, came from official development assistance (ODA) which includes concessional loans. Third, unlike other more qualitative public goods such as schooling quality, rural electrification is easily verifiable for the affected population as they have perfect information whether electric infrastructure is available to them or not (Mani and Mukand, 2007). As these factors generally suggest that rural electrification is attributable to political action in sub-Saharan Africa, it represents an intriguing variable to study across political systems in terms of its provision.

A small number of academic studies have addressed political drivers of electrification in developing countries. Brown and Mobarak (2009) argue that election-related incentives in low-income democracies increase the relative share of electricity provided to residential versus industrial consumers. Yet they neither address electricity access nor do they distinguish between rural and urban residential areas. Ahlborg et al. (2015) use data from 44 sub-Saharan African countries over a 13-year time period and find democracy and institutional quality to be positively associated with household electricity consumption. However, albeit acknowledging their significance, they do not examine rural versus urban electrification disparities or rural electrification *per se*. Min (2015) contends that electrification decisions in developing countries are influenced by electoral considerations. His cross-sectional econometric model for the year 2003 suggests a positive link between democratic history and country-wide electrification. Kroth et al. (2014) argue that added voter enfranchisement during South Africa's post-Apartheid democratisation increased rural electrification, mediated via citizenry participation and the liberalisation of political organisations. These findings corroborate the more general positive association between democracy and public service provision (Brown, 1999; Bueno de Mesquita et

[1] Harding and Stasavage (2014) furthermore express the general concern that when implementation agents are required to deliver a government's promise, a non-delivery of the promise is not directly attributable to the government but may be due to weak state capacity. However, if the delivery apparatus is centrally controlled under heavy state influence or run by the state itself, voters can attribute both a failure in delivery *per se* and the failure to deliver on the promise in general to the government (see Harding, 2015; Min, 2015).

al., 2003; Kaufman and Segura-Ubiergo, 2001; Lake and Baum, 2001), suggesting the below hypothesis.

H_{Pol1}. More democratic political systems should increase rural electrification and decrease rural versus urban electrification inequality in sub-Saharan Africa.

A mechanism often invoked regarding this argument is the presence of contested elections creating incentives for governments to target broad population shares. Electoral politics in democratising states have long been employed to challenge urban-bias arguments, such as those advocated by Bates (1981), as parties tend to ruralise over time (see for instance Varshney (1993) or Colburn (1993) for empirical evidence). Such a mechanism informs both the first and the second part of *HPol1*. As the median voter in sub-Saharan African countries usually lives in rural areas, rural public service demands rank higher on the political agenda (Meltzer and Richard, 1981) compared to authoritarian regimes where distributive mechanisms often follow more narrow patronage networks (Bratton and Van de Walle, 1997). In democracies, this implies higher political incentives to extend electricity infrastructure to previously unserved rural areas with miniscule per capita demand rather than improving existing grid infrastructure to improve reliability of the comparably few citizens already served. In Min's (2015) terms, the extension of rural infrastructure generates greater political externalities for politicians who wish to be re-elected. However, such a mechanism of creating incentives for politicians through contested elections is commonly not explicitly modelled as an intervening step between democracy and public service provision in econometric analyses. Rather, it is deduced from either a single regime type variable (Bates et al., 2012; Brown and Mobarak, 2009; Min, 2015) or a single contested election variable (Stasavage, 2005).

This paper explicitly analyses such a mechanism. LeBas (2011, p.7) in her book on party-building in Africa emphasises the role of oppositional parties for inducing popular mobilization through electoral contests, writing that "[s]trong party organizations are necessary to push reluctant incumbents toward reform. … Without strong opposition, elections in these contexts are unlikely to become competitive, and representative links between governments and citizens will remain weak." Usually, incumbents will have a rough idea of the main opposition's strength. A greater oppositional threat in a democracy could therefore increase the necessity for incumbents to scramble for votes and provide cost-intensive concessions to the rural population. Supporting evidence for this argument is provided by Min (2015) who shows that multipartism in India is associated with rural electrification increases. Successful bids of local Bahujan Samaj Party legislators in state assembly elections provided a mandate to further their mainly rural low-Caste voters' demands. His electrification example illustrates Varshney's (1998) wider explanation of India's relatively low levels of urban bias due to strong democratic and multiparty politics from below that advanced rural empowerment.

H_{Pol2}. Greater oppositional strength should be associated with higher rural electrification and lower rural versus urban electrification inequality in sub-Saharan Africa.

Furthermore, effective implementation institutions have been argued to be a *sine qua non* for electrification in developing countries (Cook, 2011). Policy implementation has been shown to greatly benefit from incorporating local communities in tactical and operational leadership (Bäck and Hadenius, 2008; Isham et al., 1997). As democracies generally enhance accountability and citizen participation, institutional implementation effectiveness is a second potential intervening variable between democracy and electrification. Nanka-Bruce (2010) and Onyeji et al. (2012) use cross-sectional socio-economic data to investigate rural and overall electrification access in sub-Saharan Africa, respectively. While neither study includes political regime type or electoral variables, both find institutional effectiveness to be positively and statistically significantly associated with electricity access. Similarly, Ahlborg et al. (2015) find their indicator for institutional quality to be positively associated with general average household electricity consumption in sub-Saharan Africa. As the argument applies equally to rural and total electrification, electrification inequality is unlikely to decrease by more than what is due to the convergence to a common natural upper bound (cf. Brown and Mobarak, 2009).

H_{Pol3}. More effective policy implementation institutions should increase rural electrification, but have no significant effect on electrification inequality.

There are a number of further interesting political variables regarding rural electrification in sub-Saharan Africa. A growing number of quantitative studies (Fenske, 2013; Gennaioli and Rainer, 2007; Larcom et al., 2016; Michalopoulos and Papaioannou, 2013) suggest the importance of pre-colonial political structures for a range of present-day economic and institutional variables. This literature is grounded in work such as by Herbst (2000) and Mamdani (1996) which analyses the prevalence of traditional political institutions in rural areas in-depth. All of these quantitative studies use data from Murdock's (1967) "Jurisdictional Hierarchy Beyond the Local Community Level" index to model pre-colonial ethnic political centralisation and map the data onto present-day political geography. The degree of pre-colonial centralisation has been positively associated with recent satellite light density at night as a proxy for economic activity (Michalopoulos and Papaioannou, 2013). As the vast majority of the economic activities proxied in this way occur in cities due to their considerably higher emittance of light at night, this result primarily suggests a positive association between pre-colonial political centralisation and urban electrification.[2] Yet the strength of the spatial results warrants the inclusion of pre-colonial political centralisation in the analysis.

Herbst (2000) argues that a fundamental problem of African state-building has been how to extend political power over vast and sparsely settled land, an issue he asserts pre-dates colonialism and continues to be highly salient. He separates sub-Saharan African countries by quality of political geography. States with difficult political geographies face greater centralisation challenges than do states with favourable geographies. This effect is controlled for in the analyses as favourable political geographies might foster national grid extensions which benefit a centralised approach and strong implementation institutions on the ground. Mamdani (1996) shows how British indirect rule during colonialization institutionalised decentralised despots in the form of traditional local ethnic authorities, exacerbating the challenges of centralised state consolidation. Following the above argument, such an effect should be accounted for in the analyses.

Economic drivers of rural electrification

Providing electricity is highly capital intensive. Cost-efficient coal, gas or nuclear power stations imply a high-cost construction and require continuous fuel supply. While oil-fired generation is practically absent in most developed countries, small-scale applicability and higher availability have offset generation efficiency and sustainability concerns in many low-income countries. However, related investment costs for extensive electrification remain high. Matching electricity demand and supply involves covering distances of several hundred kilometres. A high-voltage transmission grid infrastructure is required where decentralised systems are absent, and additional end-consumer distribution equipment. Consequently, Barnes and Floor (1996, 519) write that "no country … has ever completed rural electrification without the financial support of its public companies and government."

A variety of non-democratic countries have achieved broad rural electrification. Kromm (1970) explains in detail how the Soviet Union

[2] The centrality of largely state-controlled decision-making in electrification in sub-Saharan Africa, though curiously absent in Michalopoulos and Papaioannou's (2013) explanation of their findings, further strengthens such an expectation.

placed electrification at the centre of the re-organisation of its industry shortly after its founding. It managed to increase generation capacity by a factor of 40 between the 1930s and 1960s, electrifying significant portions of the population. Thailand electrified most of its rural population between the early 1970s and early 1990s during a spell of multiple coups and ensuing military rule, albeit some institutional democratisation. Its middle-income and steadily improving economic situation enabled a system of cross-subsidies from large to small customers as well as a well-planned continuous electricity generation expansion (Barnes and Floor, 1996). Van Gevelt (2014) shows how South Korea electrified the vast majority of its rural population between 1965 and 1979 during the military rule of Park Chung-hee. His government combined a top-down state-controlled approach of large-scale investments and cross-subsidy schemes with local participatory approaches to ensure effective implementation.

As such economically powered electrification has been achieved in a variety of different political regimes, political analyses of electrification typically include income variables to enable the assessment of political system effects at constant levels of overall economic performance. Several studies have found positive associations between both rural and urban electrification and GDP per capita (Mandelli et al., 2014; Ahlborg et al., 2015; Min, 2015). Brown and Mobarak (2009) find no distributive effect of different GDP per capita levels between residential and industrial consumers. In case of low electrification rates such as in sub-Saharan Africa, a potential catch-up effect of higher income levels by fostering both rural and urban electrification can be expected to be negligible in terms of affecting electrification inequality.

H*Econ1*. Higher GDP per capita should increase rural electrification, but should have no significant effect on rural versus urban electrification inequality in sub-Saharan Africa.

While urban electrification has been argued to have a positive GDP per capita effect, suggesting a two-way causality, this argument is much more disputed for rural electrification (Cook, 2011). Additionally, electrifying rural areas is more capital-intense than cities due to vast economies of scale differences, implying a much smaller business case. Herbst (2000) points to the numerous challenges of sparsely populated African states and explains that infrastructure investments commonly require sufficient domestic savings. As noted above, 81% of power sector infrastructure spend in sub-Saharan Africa between 2001 and 2006 came from domestic sources (Foster and Briceño-Garmendia, 2010). Quantitative research suggests a positive relationship between domestic savings and domestic investment in general in sub-Saharan Africa (Ndikumana, 2000). Onyeji et al. (2012) show that this association holds true for electricity access particularly and that national savings are the dominant financial resource for national infrastructure projects. This is especially true for infrastructure projects with small and insecure investment returns. The savings requirement is thus expected to be salient for rural electrification in sub-Saharan Africa and particularly salient for decreasing electrification inequality.

H*Econ2*. Higher domestic savings should be associated with higher rural electrification and lower rural versus urban electrification inequality in sub-Saharan Africa.

Official development assistance accounts for only 6% of sub-Saharan African infrastructure spend (Foster and Briceño-Garmendia, 2010). The effects of foreign aid in sub-Saharan Africa have been passionately debated with conflicting results (e.g. Burnside and Dollar, 2000; Easterly et al., 2003). While the Structural Adjustment Programs (SAPs) of the 1980s and 1990s saw conditional aid as a central tool for development, recent research has been considerably more critical (e.g. Moyo, 2009; Stein, 2008). Neoliberal SAPs are criticised for favouring the urban population and assuming that the rural poor would automatically gain through trickle-down effects. Recent poverty reduction orientation of foreign aid is marred by slow progress and a lack of structural change (Stein, 2008). Quantitative research shows no positive effect of repeated adjustment loans on economic growth or favourable policy change (Easterly, 2005). Chang (2002) in his book "Kicking Away the Ladder" argues that in the last 500 years, significant state interventions have been necessary for now-developed countries to catch up with more advanced economies at the time by developing their infant industries. Yet the conditions imposed by international donor agencies through SAPs in Africa have called for a significant reduction of state influence. Thus, these conditional aid programmes have been making previously successful rural electrification programmes in developing countries such as subsidy-oriented state-interventionist policies in Thailand or South Korea considerably more difficult.

Moreover, Knack (2001) and others have pointed out that states obtaining substantial shares of their revenue from international donors are less accountable to their citizens and under less pressure to maintain popular legitimacy. This mechanism directly opposes the effect of democracy on rural electrification argued above. Stasavage (2005) finds a statistically and substantially significant negative association between aid and primary education spending in sub-Saharan Africa. He similarly argues that aid enables governments to cultivate support through other channels than spending on education, reducing incentives for educational spending for this purpose *ceteris paribus*.

H*Econ3*. Higher aid levels should have an adverse effect on rural electrification and might increase rural versus urban electrification inequality in sub-Saharan Africa.

This paper controls for a number of additional economic variables. Following Brown and Mobarak (2009), agriculture as percentage of GDP as a potential driver of rural electrification is introduced in several econometric models. A higher relative income contribution of agriculture could imply additional incentives to electrify the rural population to increase productivity while low agricultural GDP contributions may lessen such incentives in favour of an often urbanised industry, *ceteris paribus* (Kirubi et al., 2009). A primary energy resources variable captures different availabilities of raw materials for electricity production, namely coal, oil, natural gas and uranium. If such raw materials are present in a given country, electricity generation is arguably eased. As these raw materials can be either used domestically or sold to generate natural resource rents, they furthermore constitute an interesting trade-off for national electrification planners. Min (2015) includes such a variable to control for the incentive to divert state resources towards resource extraction and the diminishing accountability of governments towards their population when natural resource rents are available. This indicates the potential presence of two contrary effects of natural resources. Industry as percentage of GDP is controlled for as higher values might suggest a focus on urban over rural electrification due to the mostly urban location of industry (see Brown and Mobarak, 2009). GDP per capita growth is further used to control for temporal fluctuations of income which could have an effect of short-term funding availabilities for infrastructure projects.

Demographic drivers of rural electrification

In any given country, the more people live in rural areas, the more people need access to electricity to reach the same rural electrification rate. Thus, higher rural population percentages impede increases of the national rural electrification rate. (Mandelli et al., 2014; Min, 2015; Nanka-Bruce, 2010; Onyeji et al., 2012). Similarly, low population densities are a considerable barrier for expanding infrastructure in sub-Saharan Africa. Marginal costs of penetrating large sparsely populated areas are usually significantly higher than in urban areas, and state-sponsored infrastructure projects are more difficult to implement when the state apparatus is not well represented in certain areas (Herbst, 2000). Several studies confirm a positive association between population density and electrification in developing countries

(Mandelli et al., 2014; Min, 2015; Onyeji et al., 2012). Both of these demographic factors can be expected to be particularly salient when rural and urban electrification are compared.

H*Demo1*. A lower percentage of rural population should increase rural electrification and decrease rural versus urban electrification inequality in sub-Saharan Africa.

H*Demo2*. Higher population density should increase rural electrification and decrease rural versus urban electrification inequality in sub-Saharan Africa.

Including both rural population share and population density in the same econometric model may further function as a proxy to control for Herbst's (2000) theory of favourable political geographies. His maps of African countries discuss the degree of dispersion of the population over the land to be governed by the state. Including both of these geographic variables enables an interpretation of the population density coefficient while holding the rural population share constant, which together may function as a measure of dispersion. Herbst's (2000) theory thus further supports *HDemo2* when a model also includes the rural population share as an explanatory variable.

As constructing electricity infrastructure takes several years, government decisions of future public service allocations may be influenced by urbanisation. A growing urban population shifts the median voter closer to urban areas, thereby potentially shifting political attention in the context of contested elections. Hence, a control variable measuring urban population growth is added to the econometric models. Furthermore, a population variable is controlled for to account for absolute scale effects.

Data and descriptive statistics

Dependent variables

Two different dependent variables are used in this paper. First, *Rural electrification* measures the fraction of the rural population with access to electricity, indicating a tangible rather than budgetary public good provision. Second, *Rural/urban electrification* as a ratio of rural versus urban electricity access describes electrification inequality. As no country in the sample has higher rural than urban electrification, this variable ranges from 0% to 100% equality. The World Bank reports rural and urban electrification rates most comprehensively (World Bank, 2015). Owed to its slow-moving nature, electrification data are available once a decade for 1990, 2000 and 2010 for all 48 sub-Saharan African countries. It coherently follows the above definition of electrification, uses three main data sources and applies an econometric modelling approach to smoothen any potentially remaining compatibility issues. More than half of the data points are taken from standardized large-scale surveys from the USAID Demographic and Health Survey Program, each sampling 5000–10,000 households. A further third of the data points are based on World Bank estimates backed by internal surveys and triangulation methods. National censuses provide the remaining data. Some surveys were not conducted in the reference year at the beginning of a decade, a negligible effect given electrification's slow and generally monotonous increase.

Some scholars have questioned the accuracy of electrification data (e.g. Kroth et al., 2014). While infrastructure data from developing countries should generally be handled with care, two independent sources appear to back World Bank data. First, the International Energy Agency (IEA) publishes rural and urban electrification rates in sub-Saharan Africa and 22 of its countries since 2009. Data points are gathered from industry, official government bodies and various surveys. For 2010, the IEA reports an overall electrification of 12.9%, similar to the World Bank figure of 14.1% (International Energy Agency, 2012). A country-by-country comparison reveals an overall deviation of 0.8 percentage points. Second, independent researchers and official government publications confirm several data points. Some of these accounts are used in the Case example analyses section. Recent literature has started to match night time satellite images with geocoded population data to proxy village electrification (Michalopoulos and Papaioannou, 2013; Min, 2015). While this method carries several merits, Min points out accuracy issues with electrification rates from satellite images deviating by up to 50% diversions from Indian census data. Especially in terms of rural electrification, he discusses problems regarding limited sensitivity of satellite sensors, measurement errors in rural areas close to big cities, bias due to measurement of non-electricity induced light sources, limited temporal data availability and the difficulties to infer specific household as opposed to merely streetlight presence. This paper therefore uses World Bank electrification data throughout.

Independent variables

Democracy models the degree of democracy in a specific country using the standard 21-point Polity IV scale (Marshall and Jaggers, 2014). One robustness test exchanges Polity IV for the 7-point Freedom House Political Rights scale (Puddington, 2013). To test hypothesis *HPol2*, *Opposition* denotes the fraction of votes the leading oppositional party or challenger of the incumbent received in national elections. It uses results from presidential elections in presidential, and parliamentary elections in parliamentary government systems.[3] Rather than dichotomously denoting if an election featured more than one candidate (cf. Stasavage, 2005), *Opposition* indicates to what degree the presence of electoral competition actually mattered. It quantifies the credibility of the threat for incumbents to lose power, thereby linking democracy to the need for incumbents to provide public services to voters. Data were taken from Lindberg (2009), updated until 2010 through National Election Agency (NEA) data where applicable. For those models that explicitly study the intervening effect of *Opposition* on *Democracy*, data points are missing when either no elections occurred during a specific decade or the opposition was banned from participating. However, as most sub-Saharan African countries have held elections between 1990 and 2010, 43 countries are still included in the analyses. Where elections have been argued to be fraudulent, this conceptualisation implicitly assumes that the threat to lose power is lower where governments successfully manipulated the vote such that the opposition received lower shares. To test *HPol3*, *Government effectiveness* measures how effective government policies are implemented. The World Bank publishes such a measure in its annual World Governance Indicators. Its continuous scale between −2.5 and 2.5 captures perceptions of the quality of public services and explicitly focuses on policy implementation.

In terms of the political control variables, *Centralisation* models the degree of pre-colonial political centralisation. The variable ranges between 0 (completely decentralised) and 1 (completely centralised) and is taken from Gennaioli and Rainer (2007). The data for *Political geography* is taken from Herbst (2000) and is modelled as an ordinal variable with three of Herbst's categories (favourable, neutral, difficult), excluding the four “Hinterland Countries” Chad, Mali, Mauritania and Niger. Small island states that Herbst does not include in his analysis fit his description of favourable geography best (they are small and have the largest concentration of people in and close to the capital) and are thus included in the favourable category. Ziltener and Künzler (2013) provide data for a binary *Indirect rule* variable to denote whether a country was subject to indirect rule.

Further economic and demographic variables included in the models are available from either the World Bank's World Development Indicators (World Bank, 2015) or the IEA. To avoid multicollinearity risks with

[3] Lindberg's (2009) data set shows that of the 45 countries with available data, 39 are governed by a presidential system, 5 by a parliamentary system, and 1 country has switched between the two between 1990 and 2010.

Table 1
Summary statistics and data sources.

Variable	Source	Obs.	Mean	SD	Range
Dependents					
Rural electrification	World Bank (WDI)	144	12.30	17.83	.10–.100
Rural/urban electrification	World Bank (WDI)	144	21.61	25.84	.13–100
Politics					
Democracy	Polity IV[a]	135	−1.26	5.75	−10–10
Opposition	Lindberg (2009), NEA	90	22.43	11.07	0–47.41
Gov't effectiveness	World Bank (WGI)	96	−.75	.62	−2.18–.72
Centralisation	Gennaioli and Rainer (2007)	126	53.73	31.85	0–100
Political geography	Herbst (2000)	123	1.66	.85	1–3
Indirect rule	Ziltener and Künzler (2013)	120	.63	.49	0–1
Economy					
GDP per capita (2013 10^3\$)	World Bank (WDI)	140	1.061	1.73	.117–11.44
Aid (% GNI)	World Bank (WDI)	137	13.36	11.56	.31–72.80
Fuel per capita (Gtoe)	IEA	141	.75	3.03	0–28.40
Agriculture (% GDP)	World Bank (WDI)	134	28.61	16.15	2.70–69.36
Savings (% GDP)	World Bank (WDI)	126	13.75	11.91	−26.58–61.84
GDP p.c. growth	World Bank (WDI)	138	1.16	3.98	−10.31–31.94
Industry (% GDP)	World Bank (WDI)	134	25.07	12.52	5.96–70.04
Demography					
Rural population (%)	World Bank (WDI)	144	64.58	15.91	14.30–94.58
Population density	World Bank (WDI)	144	76.47	108.14	1.71–631.00
Urbanisation (% growth)	World Bank (WDI)	144	4.34	1.91	.26–13.40
Population (log)	World Bank (WDI)	144	15.49	1.58	11.16–18.89

Notes: The summary statistics above refer to the models presented in all tables except Table 3. Please refer to Table 7 in the Appendix A for summary statistics of the models presented in Table 3.
All variables other than the dependents have been calculated as a 10-year average for each country between the three time periods (i.e. 1981–1990, 1991–2000 and 2001–2010). Missing values for particular years were omitted from decade averages.
[a] One robustness test uses Freedom House scores instead of Polity IV scores.

the rural population percentage variable, *Urbanisation* is modelled as absolute urban population growth. *Fuel per capita* is measured in annual gigatons of oil equivalent (Gtoe) and comprises domestic oil, coal, natural gas and uranium mining. *Fuel per capita* as well as *GDP per capita* are modelled as absolute values as the overall model fit was found to be slightly better compared to log-transformations. Interpretation is also more straight-forward for non-transformed variables. Log-transforming *Population* did slightly improve the model fit, in addition to decreasing the number of orders of magnitudes present in the model, which is why this variable is transformed in the analyses. Whether or not log-transformations were used had no significant effect on the main explanatory variables. Shapiro–Wilk tests indicated that such log-transformations did not markedly improve the normality of the variables. As dependent variable data are available for 1990, 2000 and 2010, all independent and control variables are calculated averages for three equally long time periods from 1981–1990, 1991–2000 and 2001–2010. This yields an average lag of 5 years for all independent variables, a suitable timeframe for changes in independent variables to materialise as infrastructural deltas. For each variable, years with missing data are omitted from calculating decade averages. Table 1 summarises the descriptive statistics for all variables.

Fig. 2 illustrates indexed variations of key variables between 1981 and 2010. *Rural electrification* has almost doubled in sub-Saharan Africa between 1990 and 2010, however starting from a low base of 7.7%. It grew slightly stronger than urban electrification, with higher growth in the 2000s than in the 1990s. Sub-Saharan Africa's GDP per capita declined in the 1980s and early 1990s amidst kick-started Structural Adjustment Programme interventions. This development has reversed towards the end of the decade, with a recent stronger growth period in the 2000s. The switch to multiparty elections in almost all sub-Saharan African countries in the early 1990s caused democracy scores to rise rapidly. Additional yet reduced growth occurred during the region's on-going democratisation process. The rural population percentage constantly declined from 77.4% in 1981 to 64.8% in 2010. While they do not establish causality, these overall patterns are broadly consistent with hypotheses *HPol1*, *HEcon1*, and *HDemo1*.

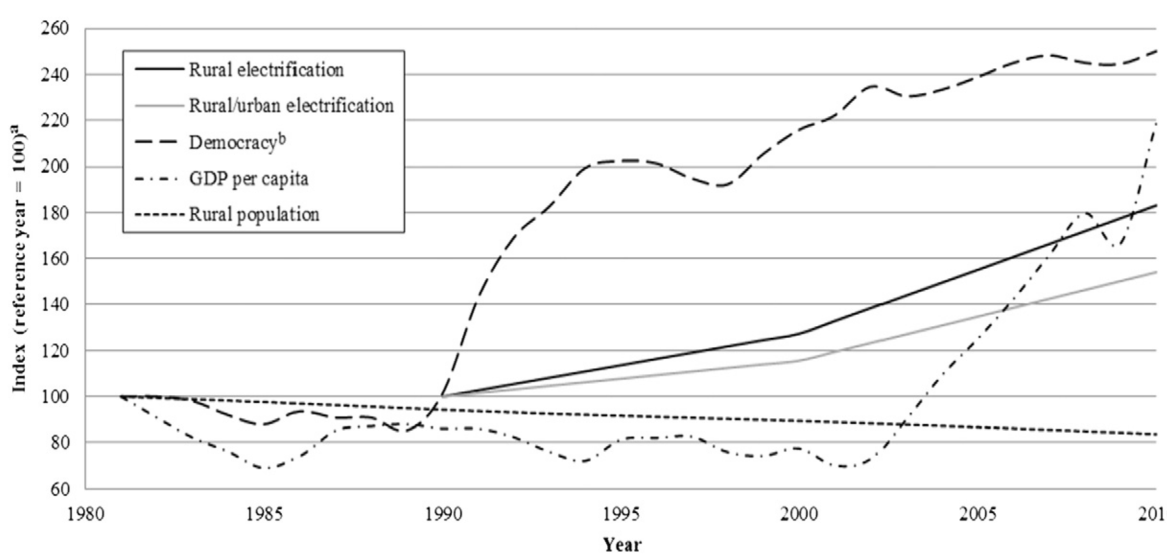

Fig. 2. Rural electrification, Rural/urban electrification, Democracy, GDP per capita and Rural Population against Time in sub-Saharan Africa [a] Reference year for *Democracy*, *GDP per capita* and *Rural population* is 1981, reference year values are −5.05, 694 (2013 USD), and 77.4%, respectively. Reference year for *Rural electrification* and *Rural/urban electrification* is 1990, reference year values are 7.7% and 13.5%, respectively. All variables have been normalised to 100 for their respective reference years. [b] The *Democracy* variable is modelled using the Polity IV scale from −10 to 10. An increase on the scale denotes an improvement in the level of democracy. The scale has been linearly transformed to 0–1 in the above figure to allow an index calculation. Therefore the reference value for 1981 is 0.2475, i.e. (−5.05 + 10)/20.

Econometric analyses

Modelling approach

This paper estimates a series of panel data and pooled OLS models, first using *Rural electrification* as the dependent variable, and later switching to *Rural/urban electrification*. Not surprisingly, the data exhibit country-level autocorrelation and heteroskedasticity, a Glejser's Test following Machado and Silva (2000) is significant beyond 99.9%. All models therefore estimate heteroskedasticity and autocorrelation consistent standard errors.

Models (1)–(5) present the main fixed-effects panel data models with country-clustered standard errors, utilising 135 observations from 46 sub-Saharan African countries. The country-decade data format renders the panel noticeably short. Model (1) analyses the main hypotheses, including *Democracy*, *GDP per capita* and *Rural population* as explanatory variables. Models (2)–(5) successively add several economic (*Aid*, *Fuel per capita* and *Agriculture*) as well as demographic (*Population density*, *Urbanisation* and *Population*) explanatory and control variables to demonstrate rigidity. A Variance Inflation Factor (VIF) test reveals that *Population density* and *Population* are highly multicollinear with the country fixed-effects.[4] Both sub-Saharan African population, and with it, population densities, have slowly and monotonously increased by at most a factor of 2 over the last 30 years, yet lie within a range of several orders of magnitude across countries. Therefore, they map relatively distinctively onto the country fixed-effects, causing the high degree of multicollinearity. Models (1)–(4) thus omit *Population density* and *Population* to allow direct inference of all variables, while model (5) analyses the robustness of the results in the presence of these two variables. In order to maximize the number of usable observations, the intervening political variables *Opposition* and *Government effectiveness*, as well as *Savings* are only included in later models. In addition to the fixed-effects, decade dummy variables for unobserved temporal effects were tested. While the *Democracy* variable remained statistically significant, the temporal dummy variables were neither independently nor jointly significant and were thus excluded.[5] This result is not surprising as the dependents have monotonically increased (i.e. stayed constant or strictly increased) for any 10-year time period in the sample, thus deeming marginal temporal effects close to constant and non-deterministic.

As models (1)–(5) include fixed-effects to allow within-country variation analyses, they account for all time-invariant country-level effects by definition. This also includes the pre-colonial and colonial political variables *Centralisation*, *Political geography* and *Indirect Rule* as they are constant between the scope of the study, i.e. sub-Saharan Africa's democratisation process between 1990 and 2010. In order to explicitly estimate the association between rural electrification and the pre-colonial and colonial political institutions, model (6) uses a Hausman–Taylor estimator with country clustered standard errors (Hausman and Taylor, 1981). This method employs a random effect transformation while using time-variant variables exogenous to the fixed effects as instrumental variables to remove the correlation of endogenous time-variant and time-invariant variables with the fixed effects. A Sargan–Hansen test confirms the validity of using *Rural Population* and *Democracy* as time-variant instrument variables to help to consistently estimate *Centralisation*, *Political geography* and *Indirect rule*.

To strengthen the results of the econometric analysis, the panel data models (7)–(12) repeat models (1)–(6) assuming piecewise interpolability of the dependent variable, thereby increasing the amount of usable observations to 468. As is common for infrastructure capacity with several decade-long lifespans in developing countries (see for instance Herbst (2000) with respect to road networks), rural electrification in sub-Saharan Africa has monotonically increased for any country in any 10-year period with available data as mentioned above. Large spikes in short timeframes are generally absent in such data as expanding the national grid infrastructure in vast territories is a gradual process. This supports the assumption that the dependent can be piecewise interpolated between two dates that are reasonably close to each other. For above reasons, the World Bank similarly makes such an assumption in its rural electrification data (World Bank, 2015). If piecewise interpolating in 2-year steps, four sets of observations each can be added between 1990 and 2000, and between 2000 and 2010 based on existing data. All independent and control variables are then calculated as a 2-year average preceding the *Rural electrification* observation, thereby shortening but maintaining their lag. The summary statistics for these models are available in Appendix A. Different methods of interpolation, i.e. piecewise linear, exponential and polynomial, as well as different lengths of interpolated time periods were tested. They have had no noteworthy effect on statistical significance levels in any model. Models (7)–(12) employ piecewise linear interpolation, robustness tests (25) and (26) change to a 3-year step interpolation and compare linear to exponential interpolation of the form $y = ax^b$.

Models (13a)–(15b) and (16a)–(18b) use *Rural electrification* and *Rural/urban electrification* as dependent variables, respectively. They subsequently introduce the two intervening institutional political variables *Opposition* and *Government effectiveness* to compare models with these intervening variables to base models that use the same observation set but include *Democracy* as sole political variable. A decreased *Democracy* coefficient coupled with respective statistical significance levels would suggest that parts of the *Democracy* association with the dependents may be explained by *Opposition* and *Government effectiveness*. Data availability is comparably scarce, the number of usable observations drops to 66 from 41 sub-Saharan African countries when all relevant variables are included. Models (15a) and (15b), as well as (18a) and (18b) re-run the previous models and exclude all insignificant variables. As several countries contribute only one observation, estimating country dummy fixed effects is not feasible, in addition to likely biasing standard errors due to high numbers of estimated coefficients.[6] Models (13a)–(18b) cluster standard errors by countries to account for country-level dependencies, *Population density* and *Population* are now included in the models. Robustness test (22) repeats model (4) to test the effect of running a pooled OLS model instead of fixed-effects and adding *Population density* and *Population*.

The robustness test section furthermore examines different modelling and error term assumptions. Model (19) uses a Prais–Winsten Generalized Least Squares (GLS) regression. This method adjusts for serial correlation without losing the first observation in order to fully utilize the short panel data. Model (20) deploys the Generalized Estimating Equation (GEE) approach, which in contrast to models (1)–(3) is based on quasilikelihood theory that assumes no particular response observations distribution. A random-effects formulation, although of secondary interest given the focus on within-country changes in this study, is provided in model (21). The robustness test section further addresses potential issues of multicollinearity, endogeneity, measurement errors, data source dependence, cross-sectional correlation as well as different interpolation assumptions to support the resilience of the results. While quantitative research on electrification in sub-Saharan Africa with small sample sizes has produced valuable insights before

[4] In the presence of country dummy variables, the VIFs for both variables are above 50. Hair et al. (2010) suggest that VIFs above 10 indicate severe multicollinearity risks.

[5] Stasavage (2005) finds the same insignificance of year effects in his models on public service provision in sub-Saharan Africa during a similar time frame and also excludes them from all his models.

[6] Estimates of error terms robust to heteroskedasticity and auto-correlation commonly need at least twice as many observations as variables (Varmuza and Filzmoser, 2009). High observation-to-variable ratios are generally preferable, with recommended minimum ratios starting around 2:1 and often higher (Arrindell and Van der Ende, 1985).

Table 2
Panel data models (dependent variable: rural electrification).

Model	(1)[a]	(2)[a]	(3)[a]	(4)[a]	(5)[a,b]	(6)[c]
Politics						
Democracy	.277***	.274***	.325***	.306***	.266**	.317***
	(2.96)	(2.83)	(3.12)	(2.90)	(2.15)	(2.77)
Centralisation						.0607
						(1.44)
Political geography						1.682
–favourable[d]						(.55)
–neutral[d]						4.891
						(1.22)
Indirect rule						−.0686
						(−.03)
Economy						
GDP per capita ($10^3$$)	.882*	.708*	2.326**	1.902*	1.810*	.511***
	(1.80)	(1.67)	(2.42)	(1.96)	(1.75)	(3.30)
Aid (% GNI)		−.0347	−.0453	−.0367	−.0431	
		(−.84)	(−1.10)	(−.90)	(−.95)	
Fuel per capita (Gtoe)			.00365	−.0204	−.0243	
			(.01)	(−.08)	(−.10)	
Agriculture (% GDP)			−.0280	−.0341	−.0279	
			(−.39)	(−.50)	(−.41)	
Demography						
Rural population (%)	−.536***	−.495***	−.344***	−.329***	−.303*	−.386***
	(−4.77)	(−4.73)	(−2.96)	(−3.09)	(−1.99)	(−4.54)
Population density					.00810	
					(.50)	
Urbanisation (%)				−.398	−.379	
				(−1.36)	(−1.29)	
Population (log)					1.054	
					(.31)	
N	135	133	125	125	125	115
R^2	.489	.492	.506	.518	.520	.539
Number of countries	46	46	44	44	44	39

Heteroskedasticity and autocorrelation consistent t-statistics in parentheses. *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively. All models include unreported constants.
[a] Models (1) – (5) are fixed-effects models with country-clustered standard errors to explore within-country variation. As the pre-colonial and colonial political variables *Centralisation*, *Political geography* and *Indirect Rule* are time-invariant for the examined time period, like all other constant country effects they are accounted for in the fixed-effects models.
[b] *Population density* and *Population* are highly multicollinear with country fixed effects. Model (4) is only included to demonstrate robustness with further demographic controls. It should not be used for inference for *Population density* and *Population*.
[c] To consistently estimate time-invariant variables in the panel data, model (6) uses an Hausman–Taylor estimator with country-clustered standard errors. *Rural population* and *Democracy* function as instrumental variables, a Sargan–Hansen test clearly confirms the validity of the related exogeneity assumptions.
[d] *Political geography* is an ordinal variable with "difficult political geographies" (Herbst, 2000) as reference category.

(Onyeji et al., 2012), it should be noted that small numbers of observations raise the risk of producing erroneous econometric results. Therefore, in addition to the various strategies in the econometric modelling to circumvent this problem discussed above, this paper complements the econometric analyses with in-depth qualitative robustness tests. It presents evidence from five country case-examples, three of which are presented in the main text, two further ones in Appendices B–C. These case studies further support the paper's overall arguments.

Econometric model results

Estimates for rural electrification

Table 2 presents the main panel data model results (1)–(6), Table 3 re-runs these models under the interpolability assumption (7)–(12). The statistical significance levels do not change markedly between the two approaches, if anything they become slightly stronger in models (7)–(12) as a greater portion of variability can be absorbed by the explanatory variables. All explanatory variable coefficients have the expected sign, *Democracy*, *GDP per capita* and *Rural population* are the only statistically significant variables throughout models (1)–(12).

Democracy is strongly positively associated with rural electrification in sub-Saharan Africa. It is its strongest predictor together with rural population percentages. This result supports the first half of *HPol1*. Holding all other variables constant, a one standard-deviation of the *Democracy* variable, i.e. 5.75 points or roughly a 25 percentage points jump on the −10–10 Polity IV scale, would increase rural electrification of a country at median electrification level by 31%, despite the constraining presence of an upper and a lower bound on the *Democracy* value. The median country-year rural electrification in the data is Djibouti in 2000 with 5.5% rural electrification, thus such a *Democracy* score increase in the country is associated with an increase to 7.2% rural electrification, *ceteris paribus*.[7] The result is statistically and substantially robust to the inclusion of different political, economic and demographic control variables as well as when interpolability of the dependent is assumed. The *Centralisation* variable coefficient, denoting the degree of pre-colonial political centralisation, is positive in both models (6) and (12), and slightly statistically significant in the latter. This finding is consistent with the results presented by Michalopoulos and Papaioannou (2013).[8] The other two political control variables have the expected sign, yet are not found to be statistically significant.

GDP per capita, a measure often used to proxy infrastructural development, is similarly positively associated with higher rural electrification, supporting the first part of *HEcon1*. It exhibits slightly

[7] In fact, Djibouti managed to increase its rural electrification from 5.5% in 2000 to 10.2% in 2010 while its average Polity IV score increased by 8 points.
[8] The comparably lower statistical significance levels could be expected as most of their results are based on the few, predominantly urban areas that appear lit in their data.

Table 3
Panel data models assuming piecewise interpolability of the dependent (dependent variable: rural electrification).

Model	(7)[a]	(8)[a]	(9)[a]	(10)[a]	(11)[a,b]	(12)[c]
Politics						
Democracy	.142***	.127***	.142***	.138***	.0813**	.162**
	(4.23)	(3.99)	(3.83)	(3.77)	(2.53)	(2.17)
Centralisation						.0809*
						(1.88)
Political geography						1.667
–favourable[d]						(.53)
–neutral[d]						4.220
						(1.12)
Indirect rule						.328
						(.12)
Economy						
GDP per capita ($10^3$$)	.541***	.521***	1.725***	1.665***	1.535***	.350***
	(6.16)	(6.07)	(7.04)	(7.85)	(8.61)	(3.81)
Aid (% GNI)		−.00361	−.00829	−.00513	−.00316	
		(−.53)	(−1.59)	(−.75)	(−.39)	
Fuel per capita (Gtoe)			.318**	.325**	.237**	
			(3.02)	(3.17)	(2.52)	
Agriculture (% GDP)			−.0131	−.00388	.00593	
			(−1.19)	(−.27)	(.42)	
Demography						
Rural population (%)	−.601***	−.583***	−.476***	−.464***	−.337***	−.470***
	(−17.89)	(−15.66)	(−8.91)	(−8.75)	(−12.48)	(−4.92)
Population density					.00217	
					(.45)	
Urbanisation (%)				−.252***	−.249***	
				(−3.74)	(−1.29)	
Population (log)					4.292***	
					(5.20)	
N	468	463	439	439	439	399
R^2	.454	.454	.478	.487	.503	.465
Number of countries	46	46	44	44	44	39

The above models assume that the dependent variable, *Rural electrification*, can be interpolated in 2-year steps based on observations from 1990, 2000 and 2010. This assumption stems from the monotonically increasing nature of rural electrification and the predominate absence of large spikes in short timeframes common to such infrastructure measures. This assumption is also used by the World Bank. All independent and control variables are now calculated as a 2-year average preceding the *Rural electrification* observation, thereby shortening but maintaining their lag. Different methods of interpolation have had no noteworthy effect on statistical significance levels in any model (see robustness tests). The above models employ piecewise linear interpolation, adding four sets of observations between 1990 and 2000, and between 2000 and 2010, respectively. Please refer to Table 7 in Appendix A for summary statistics.
Heteroskedasticity and autocorrelation consistent t-statistics in parentheses. *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively. All models include unreported constants.
[a] Models (7)–(11) are fixed-effects models to explore within-country variation. As the pre-colonial and colonial political variables *Centralisation*, *Political geography* and *Indirect Rule* are time-invariant for the examined time period, like all other constant country effects they are accounted for in the fixed-effects models.
[b] *Population density* and *Population* are highly multicollinear with the country fixed effects. Model (11) is only included to demonstrate robustness with further demographic controls. It should not be used for inference for *Population density* and *Population*.
[c] To consistently estimate time-invariant variables in the panel data, model (12) uses an Hausman–Taylor estimator with country-clustered standard errors. *Rural population* and *Democracy* function as instrumental variables, a Sargan–Hansen test clearly confirms the validity of the related exogeneity assumptions.
[d] *Political geography* is an ordinal variable with "difficult political geographies" (Herbst, 2000) as reference category.

weaker statistical evidence than for *Democracy*. A one standard deviation *GDP per capita* change would increase the median rural electrification by 53%. Djibouti in 2000 is thus estimated to increase its rural electrification from 5.5% to 7.8% if the per capita GDP were $1730 higher. The other economic independent and control variables examined in the panel data models are not consistently statistically significant.

Supporting *HDemo1*, *Rural population* is strongly negatively associated with rural electrification, suggesting its relative impeding effect for reaching a given rural electrification level. While models (5) and (11) should not be used for inference for the *Population density* variable due to the severe multicollinearity with the country fixed-effects discussed in the Modelling approach section, the models do find weak evidence that *Urbanisation* is associated with lower rural electrification. Only models (10) and (11) attribute statistical significance to the coefficient.

Table 4 shows models (13a)–(15b) to analyse the two intervening variables of oppositional strength and government effectiveness as well as additional economic controls. Model (13a) introduces *Opposition*, model (14a) adds *Government effectiveness*. Both variables decrease the number of usable observations considerably. Once the sparse intervening political variables are included, *Savings* does not greatly affect the number of usable observations. All explanatory variables have the expected sign. *Democracy*, *GDP per capita* and *Rural electrification* are again statistically significant throughout. As the available data points in models (13a)–(15b) are strongly clustered in the most recent 2001–2010 time period where rural electrification has generally been higher than in the 1980s and 1990s, the absolute value of all three coefficients increases compared to the earlier panel data models.

The significance of *Democracy* is stronger in the base models (13b), (14b) and (15b) compared to when the intervening variables are added to models (13a), (14a) and (15a), however the variable stays significant throughout even when both intervening variables are included. *Opposition* and *Government effectiveness* are both statistically significant in these models, the latter slightly stronger than the former. *Democracy* is the only significant variable where their introduction markedly affects the coefficient. The *Opposition* variable alone lowers the *Democracy* coefficient by 16.7%, when *Opposition* and *Government effectiveness* are added it decreases by 22.4%, suggesting that both oppositional strength and effective implementation institutions may explains parts of democracy's positive association with rural electrification. This effect

Table 4
Pooled-OLS analyses of intervening and additional economic control variables (dependent variable: rural electrification).

Model	(13a)	(13b)	(14a)	(14b)	(15a)	(15b)
Politics						
Democracy	.665*	.798**	.653**	.842***	.810***	1.134***
	(1.80)	(2.10)	(2.63)	(2.97)	(3.18)	(4.53)
Opposition	.242**		.149*		.195*	
	(2.09)		(1.74)		(1.89)	
Gov't effectiveness			5.726**		4.755**	
			(2.22)		(2.48)	
Economy						
GDP per capita ($10^3$$)	5.361**	5.337**	4.362**	5.731***	2.401**	2.247**
	(2.12)	(2.17)	(2.09)	(2.73)	(2.69)	(2.05)
Aid (% GNI)	−.358**	−.336*	−.237	−.238	−.291**	−.238***
	(−2.03)	(−1.85)	(−1.60)	(−1.47)	(−2.40)	(−2.91)
Fuel per capita (Gtoe)	−1.602**	−1.679**	−.723	−1.176		
	(−2.59)	(−2.40)	(−1.19)	(−1.66)		
Agriculture (% GDP)	.0991	.126	.198	.103		
	(.75)	(.85)	(1.42)	(.69)		
Savings (% GDP)	.218*	.170	.163	.199		
	(1.69)	(1.38)	(1.22)	(1.59)		
GDP per capita growth	−.130	−.339	−.435	−.649		
	(−.19)	(−.47)	(−.93)	(−1.22)		
Industry (% GDP)	.0932	.124	.153	.0887		
	(.66)	(.76)	(1.30)	(.67)		
Demography						
Rural population (%)	−.424***	−.450***	−.371***	−.365***	−.428***	−.463***
	(−3.14)	(−3.15)	(−3.71)	(−3.21)	(−4.75)	(−4.38)
Population density	.0944***	.0973***	.0826***	.0841***	.0876***	.0903***
	(4.63)	(4.56)	(6.10)	(5.60)	(5.12)	(4.87)
Urbanisation (%)	−.0312	−.229	−3.067**	−2.773*		
	(−.02)	(−.15)	(−2.20)	(−1.94)		
Population (log)	.353	.764	2.269**	2.972**		
	(.22)	(.52)	(2.11)	(2.66)		
N	73	73	66	66	78	78
R^2	.837	.826	.881	.863	.814	.786
Number of countries	41	41	40	40	43	43

Heteroskedasticity and autocorrelation consistent t-statistics in parentheses. *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively. All models include unreported constants.

is even stronger when all insignificant variables are dropped and the models are re-run with and without the two intervening variables. In model (15a), the presence of *Opposition* and *Government effectiveness* lower the Democracy coefficient by 28.6%. These results support the first parts of *HPol2* and *HPol3*, and furthermore suggest that due to the continued significance of *Democracy* there are additional, unobserved intervening mechanisms that positively associate democracy with rural electrification.

In terms of economic variables, models (13a) and (13b) find that apart from unchanged *GDP per capita* results, *Aid* and *Fuel per capita* are statistically significantly and negatively associated with rural electrification. This confirms the negative signs for the *Aid* variable coefficient present in models (2)–(5) and (8)–(11). The strength of this association decreases in models (14a) and (14b) where the number of observations is further reduced, however is salient again in models (15a) and (15b). Together, this provides positive, yet somewhat weak evidence for the first half of *HEcon3*. The similarity of Dutch disease effects of aid and natural resources on sub-Saharan African economies finds resemblance in their respective negative association with rural electrification. All other things being equal, the presence of such rents, which are subject to limited public scrutiny, enable governments to attract support differently than by making rural infrastructure concessions, thereby decreasing incentives to do so. As explained above, the conditionality of aid might additionally hinder successful electrification policies that have worked in other regions.

Both demographic independent variables *Rural population* and *Population density* are highly statistically and substantially significant, constituting further evidence for the first parts of *HDemo1* and *HDemo2*. Doubling the population density from its mean of 76 people per square kilometre to 152 more than doubles the median country's rural electrification, *ceteris paribus*. In this sample, the median country-year is Madagascar in 2000 with 6.6% rural electrification. Increasing its population density by 76 people per square kilometre is associated with a rural electrification rate of 13.4% instead of 6.6%. *Urbanisation* again is weakly negatively associated with rural electrification, while marginal scale effects of larger populations are also confirmed. As the data set becomes more skewed towards the most recent 2001–2010 period, overall and urban scale effects are more salient due to their exponential nature.

Estimates for rural versus urban electrification inequality

Models (16a)–(18b) in Table 5 use *Rural/urban electrification* as their dependent variable. Values closer to 100% indicate higher equality of electrification. The models use the same political, economic and demographic independent and control variables as above.

The *Democracy* variable is highly statistically and substantially significant in all models, again its statistical significance level decreases only slightly when the intervening variables are added. A one-standard *Democracy* deviation is estimated to increase the rural versus urban electrification ratio of the median country by 70%. In the sample, Benin in 2000 has the medium rural versus urban electrification ratio of 11%. Thus, a jump of 5.75 on the Polity IV *Democracy* scale is associated with a rural versus urban electrification rate of 18.7%. Similarly to models (13a)–(15b), its coefficient decreases when the intervening political variables are introduced. The addition of the *Opposition* again affects the *Democracy* coefficient most of all significant variables, decreasing it by 14.1%. There is little additional effect of introducing *Government effectiveness*, the *Democracy* coefficient is 16.9% smaller in (16a) compared to its base model (16b). While the *Opposition* variable is strongly significant in statistic and substantive terms, *Government*

Table 5
Pooled OLS analyses of electrification inequality (dependent variable: rural versus urban electrification).

Model	(16a)	(16b)	(17a)	(17b)	(18a)	(18b)
Politics						
Democracy	1.155**	1.344***	1.213***	1.461***	1.395***	1.508***
	(2.54)	(2.83)	(3.22)	(3.51)	(2.88)	(3.14)
Opposition	.343***		.234***		.299**	
	(2.80)		(2.70)		(2.40)	
Gov't effectiveness			6.382			
			(1.55)			
Economy						
GDP per capita (10^3\$)	6.473	6.439	4.671	6.194		
	(1.66)	(1.66)	(1.27)	(1.66)		
Aid (% GNI)	−.458**	−.427**	−.334**	−.328*	−.658***	−.637***
	(−2.52)	(−2.19)	(−2.05)	(−1.80)	(−3.04)	(−2.98)
Fuel per capita (Gtoe)	−3.470**	−3.580*	−2.230	−2.748		
	(−2.02)	(−1.94)	(−1.28)	(−1.41)		
Agriculture (% GDP)	.158	.196	.251	.152		
	(.93)	(1.03)	(1.44)	(0.81)		
Savings (% GDP)	.560***	.493**	.526***	.553***	.824**	.725**
	(2.98)	(2.60)	(2.83)	(2.87)	(2.26)	(2.03)
GDP per capita growth	−.512	−.810	−.821	−1.124		
	(−.59)	(−.89)	(−1.23)	(−1.57)		
Industry (% GDP)	.344	.388	.415*	.351		
	(1.47)	(1.55)	(1.86)	(1.51)		
Demography						
Rural population (%)	−.498***	−.536***	−.425***	−.425***	−.504***	−.524***
	(−3.01)	(−2.96)	(−3.38)	(−3.12)	(−3.69)	(−3.71)
Population density	.0773***	.0814***	.0670***	.0693***	.0848***	.0868***
	(3.86)	(3.70)	(4.04)	(3.91)	(4.54)	(4.46)
Urbanisation (%)	2.021	1.740	−2.068	−1.846		
	(1.28)	(1.05)	(−1.21)	(−1.04)		
Population (log)	−1.326	−.741	1.076	2.007		
	(−.62)	(−.36)	(.67)	(1.22)		
N	73	73	66	66	73	73
R^2	.792	.777	.829	.807	.727	.714
Number of countries	41	41	40	40	41	41

Country-clustered heteroskedasticity and autocorrelation consistent t-statistics in parentheses. *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively. All models include unreported constants.

effectiveness is not statistically significant and decreases substantively compared to the *Rural electrification* models. This supports that strong oppositions in democracies could pressure governments to shift their public service focus toward the rural majority electorate, while implementation effectiveness could influence both rural and urban service provision positively with limited effects on inequality. These findings are consistent with the second parts of *HPol1–HPol3*, and similarly to the results from models (13a)–(15b) suggest that additional unobserved intervening mechanisms between democracy and decreased electrification inequality exist.

Concurring with *HEcon1*, *GDP per capita* is no longer statistically significantly associated with rural electrification when the dependent changes to *Rural/urban electrification*, suggesting that high income levels may favour both rural and urban electrification rather than rural areas specifically. Two other economic variables are statistically significant throughout models (16a)–(18b). First, *Savings* is strongly associated with lower electrification inequality, providing evidence for the second part of *HEcon2*. A one-standard deviation increase in national savings as a GDP percentage is associated with increasing the rural versus urban electrification ratio of the median level country-year, Benin in 2000, from 11% to 18.3%. As 81% of funding for the power infrastructure in sub-Saharan Africa comes from domestic governments (Foster and Briceño-Garmendia, 2010), higher savings can be expected to benefit rural versus urban electrification as they make rural electrification more feasible, *ceteris paribus*. Second, in contrast to national savings, *Aid* again is negatively associated with the dependent, as hypothesised in *HEcon3*, at slightly higher significance levels compared to the rural electrification models. As argued in the Economic drivers of rural electrification section, direct aid payments in the form of official development assistance, while only constituting 6% of the financial resources for the power infrastructure in sub-Saharan Africa, have imposed heavy and at times counterproductive policy conditions on sub-Saharan African countries. Liberalisation as a guiding principle closes down options known to have helped countries like Thailand or South Korea to successfully electrify their rural citizens. Additionally, aid payments may relatively decrease government requirements to win elections through physical rural infrastructure provision with limited economic return.

Rural population and *Population density* are highly statistically significant, supporting the latter parts of *HDemo1* and *HDemo2*, respectively. Their significance indicates the importance of demographic disadvantages and barriers of rural residents for development. Control variables *Urbanisation* and *Population* are insignificant in all models.

Model robustness

There are multiple robustness concerns of the presented results that deserve attention. This section subsequently addresses potential issues regarding multicollinearity, cross-sectional dependence, endogeneity, adequacy of model choice, data source dependence, and the presence of short panel data.

All econometric models have been tested for variable multicollinearity. After accounting for the multicollinearity issue between country fixed-effects and both *Population density* and *Population*, the maximum VIF in any model was 5.5, all others were below 4, the average is 2.0. All of these values are considerably below the common critical value of 10 which would indicate multicollinearity risks. The individual VIFs for the three political variables in all models are below 3.

The degree of cross-sectional dependence was analysed using a Pesaran test to ensure independence of observations between countries. It was found to be highly insignificant for the panel data models in

Table 6
Additional robustness tests (dependent variable: rural electrification).

Model	GLS (19)[a]	GEE (20)[a]	RE (21)[b]	OLS (22)	OLS−FH (23)[c]	FE−lin. (24)[b]	FE−exp. (25)[d]
Politics							
Democracy	.325***	.320***	.406***	.412**	−2.970***	.169***	.162***
	(4.78)	(2.97)	(3.46)	(2.03)	(−2.88)	(3.85)	(3.80)
Economy							
GDP per capita	1.611***	1.694**	3.390***	7.476***	.468	1.630***	1.319***
(10^3\$)	(2.93)	(2.03)	(3.30)	(4.11)	(.20)	(10.87)	(9.13)
	−.0366	−.0365	−.0561	−.145	−.181	−.00590	−.000641
Aid (% GNI)	(−1.21)	(−.86)	(−1.43)	(−1.26)	(−1.35)	(−.68)	(−.06)
	−.0609	−.0516	−.111	−1.797***	.476	.212	.308**
Fuel per capita	(−.21)	(−.20)	(−.31)	(−2.95)	(.51)	(1.43)	(3.16)
Agriculture (% GDP)	−.0430	−.0406	−.0731	−.0114	−.0927	.00111	−.00103
	(−.92)	(−.57)	(−1.22)	(−.15)	(−.97)	(.06)	(−.07)
Demography							
Rural population (%)	−.315***	−.319***	−.203**	−.300**	−.379***	−.438***	−.393***
	(−4.68)	(−3.07)	(−2.30)	(−2.63)	(−3.16)	(−7.27)	(−10.12)
Population density				.00807***	.0927***		
				(3.52)	(3.40)		
Urbanisation (%)	−.461**	−.443	−.311	−.413	−.577	−.306***	−.320***
	(−2.43)	(−1.47)	(−.84)	(−.49)	(−.63)	(−4.39)	(−3.91)
Population (log)				1.054	1.097		
				(.15)	(.97)		
N	125	123	125	125	129	285	285
R^2	.983		.744	.780	.697	.486	.482
Number of countries	44	41	44	44	46	44	44

Heteroskedasticity and autocorrelation consistent z-/t-statistics in parentheses. *, **, and *** refer to significance at the 10%, 5%, and 1% levels, respectively. All models include unreported constants.
[a] Heteroskedasticity and autocorrelation consistent AR1 error term structure. Models include unreported country fixed effects.
[b] Random effects model.
[c] Democracy variable modelled using Freedom House data (lower scores indicate more democratic political system).
[d] Exponential interpolation of the dependent variable based on the data from 1990, 2000 and 2010.

Table 2, and slightly less insignificant for the interpolated models in Table 3. To ensure that the estimation is consistent even when cross-sectional correlation should be present, Driscoll-Kraay standard errors were used for the interpolated models which in addition to being heteroskedasticity and auto-correlation consistent also are cross-sectional correlation consistent (Driscoll and Kraay, 1998). The general insignificance of the Pesaran test confirms the presumption that rural electrification variations in the last 20 years are mainly driven by country-internal rather than external factors. Regional dependencies appear to be small. The dependent variable varies considerably between many neighbouring countries across sub-Saharan Africa. This also supports the idea that country-specific policies have considerable impact on electrification.

Furthermore, both a statistical and a substantive argument render the risk of endogeneity small in this study. First, all independent variables have been lagged by an average of 5 years to represent past decade averages. For the interpolated models, while the lag reduces, it still is positive. Unbounded variables that are modelled by past data are improbable to be caused by future occurrences. Second, rural electrification and electrification inequality arguably have limited impact on past assessments of the degree of democracy in a country, strengths of the opposition,[9] and continuous demographic developments. While rural electrification may introduce new opportunities of income generation, its measureable GDP contribution has been argued to be minor (Cook, 2011).

Robustness tests (19), (20) and (21) in Table 6 re-estimate panel data model (4) using different modelling approaches. The results are robust to a fixed-effects GLS approach as well as to a fixed-effects GEE approach. A random-effects formulation similarly does not affect the results markedly. The OLS-based models (13a)–(18b) have omitted country dummy variables. Robustness test (22) investigates the adequacy of choosing pooled OLS models for the analysis. It omits fixed-effects, allowing for the inclusion of *Population density* and *Population*, and estimates country-clustered standard errors. All statistically significant variables from the panel data models remain significant in model (22). Remarkably, its R^2 does not greatly decrease when 43 country dummy variables are excluded, remaining at 78% without dummy variables. The high R^2-value is thus achieved by modelling 125 observations with 9 instead of 52 variables. This indicates the relevance of the chosen political, economic and demographic variables for explaining the variations of rural electrification in sub-Saharan African countries. Consistent with *HDemo2*, *Population density* becomes highly significant in this and all other OLS specifications. Furthermore, several coefficients increase in model (22) compared to the panel data models. Brown and Mobarak (2009) find a similar effect in their electricity distribution study between FE and OLS models. This suggests that unobserved country effects account for some part of rural electrification.

To ensure that the positive association of democracy on rural electrification is not subject to measurement errors, model (23) changes the *Democracy* variable data source from Polity IV to Freedom House's Political Rights score. It uses the same data set as model (22) to maximize observations and ease comparability. *Democracy* remains highly statistically and substantially significant. Its negative coefficient is due to democracies receiving lower scores on the Freedom House scale. Notably, *GDP per capita* loses its significance and decreases in value in this specification. One possible explanation for this effect is that *GDP per capita* is stronger correlated to Freedom House than Polity IV scores in the data set, indicating that higher *GDP per capita* appear to induce lower Freedom House scores. A one standard deviation decrease on the Freedom House scale increases rural electrification by almost 5 percentage points.

[9] If there were any such association, it would likely be negative as voters choose oppositional parties because they anticipate that they will not be electrified in the future under the current government.

Models (24) and (25) change the interpolation approach, now interpolating *Rural electrification* in 3-year rather than 2-year steps. Model (24) employs piecewise linear interpolation, model (25) uses piecewise exponential interpolation instead. The significance of the main explanatory variables remains intact.

The longitudinal data used in this paper are not balanced and is considerably short. To examine the severity of using short panel data, a further unreported model was run using only observations from the most recent time period from 2001 to 2010. Such a purely cross-sectional specification avoids the dangers of serial correlation in short panel data models at the expense of a further decrease in observations. While the resulting sample size of 43 is prone to estimation errors, the results are consistent with the main findings.

Case example analyses

This section provides qualitative evidence from three sub-Saharan African countries to reinforce the plausibility of the econometric results. To examine some of the most salient cross-country variations, rural electrification success in Ghana, high electrification inequality in Swaziland and almost absent rural electrification in Uganda are analysed in turn. Two further case studies, namely Senegal's recent rural electrification success and Rwanda's low rural electrification and high electrification inequality, are analysed in Appendices B–C for further reference. They similarly support the econometric analyses.

Ghana

An increase from 6% rural electrification in 1990 to almost 50% in 2014 renders Ghana a notable rural electrification success story in sub-Saharan Africa. As urban electrification increased from 75% to 85%, electrification inequality was reversed from one of the most severe to one of the lowest in sub-Saharan Africa.

Political factors

The democratisation process in Ghana in the 1990s and 2000s has been highly salient in and beneficial to the country's approach to rural electrification. Jerry John Rawlings had been ruling Ghana since a military coup in 1981, and ran for president for his National Democratic Congress (NDC) party in the country's first multiparty elections in 1992. Starting in the late 1980s, he positioned himself to receive widespread support from Ghana's mainly rural electorate. Rural infrastructure endowments were a key strategy. Sandbrook (2000, p.105) writes that “Rawlings had targeted the rural areas as a major base of government support since 1988. He campaigned exclusively in the countryside in 1992 and dispensed patronage to local communities in the form of electricity extensions.” The National Electrification Scheme (NES) was launched in 1989, ambitiously aiming to provide universal electrification by 2020. This policy entailed a rural area focus entitled Self-Help Electrification Project (SHEP), where priority was given to communities with a population of 500 or more to maximise its reach (Bhattacharyya, 2013). Ghanaians have been argued to exhibit a relatively mature democratic voting behaviour in their first multiparty elections. Swing voters have been consciously evaluating government performance (Lindberg and Morrison, 2005). The NDC won the 1992 election in mainly free and fair elections, although some irregularities were recorded. Ensuring widespread publicity, rawlings intensified the NES ahead of the fiercely contested 1996 election, launching Phase 2 of SHEP in 1995. The policy integrated community leadership in its implementation and had a noticeable short-term goal of bringing electricity immediately to one thousand towns and villages (Sandbrook, 2000). Rural electrification skyrocketed by more than 350% in the 1990s to 21%. Briggs (2012) shows that constituencies targeted by the NES in the 1990s were significantly more likely to vote for the NDC than others. In turn, between 1992 and 1996 the NDC specifically targeted constituencies that had predominantly voted for the NDC in 1992. Briggs argues that this helped to retain high NDC vote shares in the 1996 elections won by the NDC against John Kufuor and his New Patriotic Party (NPP).

The NPP, benefiting from a severe economic crisis, narrowly defeated the NDC for Ghana's first ballot-box induced power transfer in 2000 and intensified rural electrification. In 2001, it re-launched SHEP to construct low voltage distribution poles in villages within a distance of 20 km from the grid. Crucially, this initiative manifested democratic institutions such as strong public participation and local leadership. Communities were encouraged to initiate own village electrification projects. To maximise dissemination and policy approval, the government required proof from communities that a minimum of one third of communal houses were being connected to the grid in order to receive SHEP funds for the project (Vanderpuye, 2010). Arguably, such a requirement has helped the government to achieve a maximum spread of its initiative to secure broad political backing. Throughout the decade, SHEP was the subject of intense electoral campaigning. It was instrumental in allowing the NES to electrify a total of 4800 communities by 2009 (Bhattacharyya, 2013). While a small regional bias exists towards the cocoa-rich Ashanti region, no region in Ghana had an overall electrification of below 49% in 2010. Remarkably, the economically least developed northern Ghanaian region ranks at national average levels of rural electrification (Ghana Statistical Service, 2012).

Economic and demographic factors

Since the 1990s, Ghana has united all positively associated variables of rural electrification evident from the econometric analyses above. Apart from apparent political incentives to provide rural electrification in the face of repeated fiercely contested elections and effective SHEP implementation institutions, economic and demographic factors additionally benefitted Ghana's rural electrification. Its per capita income level more than tripled between 1990 and 2010, closing the gap to the sub-Saharan average level which stood at 50% in 1990. It managed to amount close to double the region's average savings as GDP percentage. The financial source for the NES, the National Electrification Fund, was primarily being financed through national savings. In the 2000s, Ghana invested considerably in a diversified electricity generation infrastructure. Older large-scale power stations such as the Akosombo hydropower plant and the Takoradi oil plant were expanded, new facilities such as the 400 MW Bui hydropower plant and several smaller fossil fuel plants were added to the grid. As a consequence, Ghana imports less than 10% of its electricity. Aid dependency was halved to less than 10% of GDP albeit a decreasing amount of conditionalities especially since the 2000s. Instead, considerable shares of local financing are used in rural infrastructure projects.

Herbst (2000) classifies Ghana as a country with a neutral political geography. While not high initially, Ghana's population density has almost doubled to more than 100 people per square kilometre between 1990 and 2010. At the same time, its rural population percentage declined to close to 50%. Both of these factors have decreased the costs of reaching close to 50% rural electrification.

Together, these political, economic and demographic factors, evident from the econometric analyses above, suggest Ghana's remarkable rural electrification success.

Swaziland

Rural electrification in Swaziland increased from 13% in 1990 to 21% in 2010. While these electrification values are above the region's averages, they are considerably below average when controlling for Swaziland's relatively high GDP per capita. Of all sub-Saharan countries with a rural electrification of at least 10% in 1990, Swaziland has the lowest percentage point growth in rural electrification, and ranks among the lowest overall in terms of percent growth. Its urban electrification, however, escalated from 35% in 1990 to 63% in 2010, thereby outgrowing rural electrification by one third despite its higher base. It is thus one of only four countries in the sample where electrification inequality has grown between 1990 and 2010.[10]

Political factors

Swaziland's political structure between 1990 and 2010 has provided limited incentives to electrify the rural population. The country is governed by a modified absolute monarchy. King Mswati III has been ruling the country since age 18 in 1986. Despite constitutional reforms in 2005, all executive, legislative, and limited judicial powers are vested in the king. Oppositional movements have been violently broken up in the past, political parties remain prohibited unless they are proroyalist. Swaziland's Polity IV score of −9 in 2010 is the lowest in sub-Saharan Africa. The monarchy has executed tight control of the rural population using widespread intimidation, media control and surveillance. The successful depoliticisation of the rural population has helped to decrease governmental incentives to provide endowments to rural areas (Motsamai, 2011). Swaziland's urban–rural divide is highly salient. Its average GINI coefficient of 52.4 in the 2000s ranks it within the top 10% of most unequal countries in the world and in sub-Saharan Africa. Daniel (2007) asserts that the urban–rural bias is illustrated by Swaziland's dual land right system. A minority of mainly urban residents enjoys freehold rights under the Title Deed Land regime guaranteeing state-protected land ownership and trade. Yet the vast majority of the rural population is subject to the Swazi Nation Land leasehold system where permission to buy and sell land depends on local chiefs or companies administering the land on behalf of the monarchy (Levin, 1997).

The urban–rural bias is furthermore exemplified by Swaziland's continued uneven electrification. The state-owned utility company Swaziland Electricity Company (SEC) is controlled by the Ministry of Natural Resources and Energy (MNRE) and possesses de facto monopolies on import, production and distribution of electricity. Unlike Ghana, Swaziland does not have a designated rural electrification body. In 1997, the MNRE commissioned a detailed feasibility study to assess rural electrification in Swaziland. This study noticeably lists more negative than positive effects of rural electrification (cf. Jansen et al., 1997). While it acknowledges an improvement in the quality of life for the rural population, it repeatedly warns the government against overspending on rural electrification. The study (Jansen et al., 1997, p.11) states that "[e]conomic feasibility (i.e. feasibility from the national-economic point of view) should be a key pre-condition for government support to implementation of rural electrification." It presents unattested and peculiar concerns of rural electrification allegedly increasing socioeconomic disparities, exhibiting negative environmental effects and slowing the implementation of renewable energies. These beliefs, coupled with limited political incentives for rural endowments due to the political marginalisation of the rural population and the lack of a strong opposition, do not favour achieving electrification equality between urban and rural areas. The MNRE's 2003 National Energy Policy has thus almost exclusively focused on urban electrification. It grew from 43% to 63% between 2003 and 2010, compared to a modest increase from 18% to 21% in rural Swaziland.

Economic and demographic factors

In comparison to other sub-Saharan African countries, Swaziland's economic and demographic situation benefits rural electrification. It is a lower-middle income country with GDP per capita levels consistently between double and triple of the sub-Saharan African average between 1990 and 2010. It is one of the least aid dependent countries on the continent with a relatively diversified economy albeit a large governmental sector, and national savings of more than 20% of GDP. However, Swaziland has failed to use its income status to address rural electrification. An important aspect is its neglect of investment in domestic electricity production and distribution infrastructure. Consequently, it is forced to import 90% of its electricity and due to its unchanged high demand has the highest electricity tariffs in the region (African Development Bank, 2013). This has affected rural areas the most, both because of the considerable urban–rural income gap and the requirement of high voltage transmission lines to import the mainly South African produced electricity, which are mainly used to connect demand hubs in cities where per capita cost are lowest. Swaziland has committed to avoid overcharging industry at the expense of domestic users, instead intending to not cross-subsidise tariffs (Swazi Ministry of Natural Resources and Energy, 2003). This behaviour illustrates Brown and Mobarak's (2009) findings which suggest that authoritarian regimes in the presence of supply constraints tend to reduce residential provision of electricity in favour of industry through concomitant pricing mechanisms. They see a lack of political incentives as the main reason that prevents a differing intervention.

In terms of demographic factors, Herbst (2000) describes Swaziland as a country with a favourable geography. Its population density is above-median levels, with relatively short distances between highly populated areas. While the relatively high rural population percentage of 77% has made widespread rural electrification challenging, the ability to add 20 percentage points in urban electrification in just 7 years renders a lack of developmental and infrastructural capabilities to increase electrification an unlikely explanation.

Thus, consistent with the econometric analysis, the Swazi experience shows that comparably high income levels alone do not necessarily lead to greater electrification equality. Rather, the Swazi case can be argued to be a lucid counterfactual of the main argument of this paper. Had the rural Swazi population been able to politically participate and voice their concerns instead of being marginalised, government incentives for rural endowments may have been considerably greater, especially if a strong political opposition to channel rural grievances had existed. Favourable economic and demographic situations imply that implementing such rural endowments would have been possible at least to some extent. Thus, the absence of such a political mechanism and, instead, the presence of different incentives for the monarchy to favour urban electrification may have helped urban electrification to be prioritised and to outgrow its rural counterpart.

Uganda

With rural electrification at 2% in 1990 and 5% in 2010, Uganda has thus far been largely unable to provide access to electricity to its rural residents. Slightly more than half of its urban population is electrified, but urban electrification growth rates have similarly been small. The electrification inequality ratio in Uganda has therefore changed little and stood at roughly one to ten in 2010.

Political factors

Uganda's political development between 1990 and 2010 has created a system of non-democratic and individualised rule supported by a large patronage network which has made it difficult for a meaningful opposition to arise and represent the demands of large population shares left out by the regime. Since 1986, President Yoweri Museveni and his National Resistance Movement (NRM) have managed to advance a personalisation of the state, amidst widespread intimidation of the opposition. Museveni did not introduce multiparty elections until 2006, and then used the permission of political parties as part of a quid pro quo strategy to simultaneously increase presidential powers including the lifting of term limits (Tripp, 2010). Mwenda (2007, p.24) calls these constitutional amendments "a license for the creation of a presidential monarchy." Polity IV scores have remained negative throughout

[10] The other three countries are Burundi, Chad and Liberia, where rural electrification is all but absent.

the NRM's rule. Elections in Uganda, especially the no-party elections in 1996 and 2001 that secured Museveni above two-third majorities, have been corrupted by executive-orchestrated irregularities, including arresting and violently attacking opposition leaders. Consequently, there has been no strong opposition in either of these elections. While elections may have functioned as a source of legitimacy, the regime's source of power lies in Museveni's strong status and the extensive state-based network to distribute jobs, resources, contracts, licenses and permissions to political allies. Museveni used decentralisation to implement patronage distribution, the military leadership and the cabinet have drawn heavily from Museveni's home region in Western Uganda (Tripp, 2010).

Important nodes of the patronage network are close to 100 semi-autonomous government agencies, all with major officers and boards appointed by the government, overseeing different economic development initiatives. The Rural Electrification Agency (REA), established following the Electricity Act in 1999, is one of these organisations, and it combines two common features. First, many of the agencies have not had significant effects on their nominal tasks.[11] During the first 15 years of REA's existence, despite rising budgets, rural electrification did not materialise. In its recent 10-year strategy paper, Uganda's Ministry of Energy and Mineral Development (2012) acknowledged this shortcoming and publicised a goal of 22% rural electrification by 2022, requiring a total investment of $951 million without additional generation investment. Yet according to its official 2014 financial report, the government has only budgeted a combined $85.8 million for rural electrification between 2013 and 2016, merely 22% of what would be required to meet the target (Ugandan Ministry of Finance, 2014).

Second, the limited progress achieved has exhibited regional bias. The 2010 Ugandan National Household Survey shows that electricity as the primary source of lighting has increased by 48% from 4.2% in 2005 to 6.2% in 2009 in Western Uganda, while it has stagnated at around 1.5% in Northern, and even decreased by 30% to 3.5% in Eastern Uganda during this time (Ugandan Bureau of Statistics, 2010). Western Uganda possesses a greater absolute and relative amount of high and medium voltage electricity transmission lines. Furthermore, REA's proposed strategy to reach 22% rural electrification by 2022 plans to invest 46% of regional expansion funds in Western Uganda (Ugandan Ministry of Energy and Mineral Development, 2012), despite a relatively even population distribution between Western, Eastern, Northern and Central Uganda.

As a result of grossly missing the comparably modest goal of 10% rural electrification in 2012, the government further increased the influence of the REA. Under a "government must lead" (Ugandan Ministry of Energy and Mineral Development, 2012, p.2) maxim, it consolidated all private and public rural electrification initiatives and funding within the REA. Arguably, if Uganda possessed stronger democratic institutions that incorporated robust checks and balances on its government as well as public scrutiny, a further expansion of previously ineffective agencies like REA would be considerably more difficult to justify. If free and fair policy-oriented elections had been well-established, acting on demands of a neglected rural electorate to achieve tangible rural development would have most likely yielded higher political rewards than narrowly distributing favours to political allies.

Economic and demographic factors

Consistent with the econometric findings, Uganda's low income levels as well as challenging demographics have further exacerbated rural electrification. Uganda exemplifies that rapid GDP per capita growth alone is not decisive for rural electrification. While the country grew at close to 4% per capita annually between 1990 and 2000, it did so from a small base following the economic collapse under Idi Amin and the 1980s Bush War. In 2010, GDP per capita remained at one third of the sub-Saharan African average.

National savings have similarly been below average. More than half of the budget to achieve the electrification goals set out in 10-year strategy paper (Uganda's Ministry of Energy and Mineral Development, 2012) is financed directly by donor aid, bypassing both the civil service apparatus and the scrutiny of the Ugandan citizenry. Uganda is known for being among the top recipients of conditional structural adjustment loans in the world, leading to a considerable variety of neoliberal policy constraints imposed on its leadership (Easterly, 2005). As only 19% of the electrification budget comes from national funds, Uganda has effectively reversed the average ratio between national and foreign funds for power infrastructure in sub-Saharan Africa (Foster and Briceño-Garmendia, 2010). Strikingly, the Ugandan government approved to spend 18% more of its national power infrastructure funds on the Energy Ministry's "Policy, Planning and Support Services," which mainly comprises buying and equipping Energy Ministry and REA buildings, than on rural electrification for the whole country combined in 2013/14 (cf. Ugandan Ministry of Finance, 2014, p. 202–3, 211–2). Limited national savings have further impeded the capital-intensive construction of new electricity generation units in Uganda, making load shedding a common problem across the country. Plans for the two largest hydropower plants in north-western Uganda, the 600 MW units in Karuma and Ayago, have both been delayed by more than a decade and estimated costs have significantly increased.

Furthermore, 85% of Ugandans live in rural areas, constituting a socioeconomic obstacle of comparably high costs to achieve higher rural electrification rates. As Herbst (2000) shows, there are several areas with considerable distances from the capital Kampala with sizeable population densities, exacerbating a centralised electrification approach. Thus, Uganda's poor track record can be understood in light of significant political, economic and demographic barriers for rural electrification salient in the econometric findings.

Conclusion and policy implications

This paper has presented both quantitative and qualitative evidence to support its theoretically developed hypotheses. Its central argument comprises two main points. First, the econometric and case-example analyses show a strong positive association between democracy and rural electrification in sub-Saharan Africa between 1990 and 2010. Rural electrification appears to be attributable to politicians' actions, a crucial prerequisite for such an association to be meaningful. While electrification has been possible in the absence of democratic institutions, the analyses suggest that rural electrification has been more successful in sub-Saharan African states with more democratic institutions, thereby challenging classical work on democracy and development such as by Huntington and Nelson (1976). The positive association is robust against a number of pre-colonial, colonial and post-colonial political control variables as well as per capita GDP and a variety of other economic and demographic variables. Democracy was also found to be positively associated with reducing rural versus urban electrification inequality markedly quicker in sub-Saharan Africa. Second, using an intervening variable modelling approach, this paper has provided novel multi-variant evidence which suggests that heavily contested elections featuring an influential opposition as well as an enhanced effectiveness of policy implementation may constitute institutional explanations of parts of democracy's association with rural electrification. The case studies further support this argument. Countries like Ghana have been able to achieve impressive electrification gains, where election-induced concessions delivered through well

[11] Mwenda (2007) estimates that semi-autonomous agencies are funded with more than 3% of GDP, most of these funds from international donors, yet attests them a greater meaning for distributing individual endowments than achieving impact in their respective fields.

executed policies have combined with manageable economic and demographic circumstances. Where such political incentives have been largely absent, like in Swaziland, or may have helped to establish patronage networks with narrowly defined endowment recipients, like in Uganda, rural versus urban electrification inequality and rural electrification, respectively, have suffered.

Additional findings include that, not surprisingly, higher income levels and favourable demographic factors were found to be positively associated with rural electrification. Consistent with World Bank data supporting that over 80% of sub-Saharan Africa's power infrastructure is financed through domestic funds (Foster and Briceño-Garmendia, 2010), national savings were found to be positively associated with rural electrification. Direct aid payments, constituting only 6% of funds for sub-Saharan Africa's electricity infrastructure, were found to be slightly negatively correlated with rural electrification and more strongly negatively correlated with rural versus urban electrification equality.

A number of different policy implications result from this study.

Political systems appear to matter for rural electrification and electrification inequality in sub-Saharan Africa. Fostering democratisation may create important windfall effects via more inclusive institutional frameworks and providing incentives for governments to improve living standards of the poor in the form of infrastructure endowments. As the econometric analysis have suggested, such gains can be substantive. The example of Ghana shows how participatory approaches in rural electrification policies can significantly benefit their success, a result which resembles Van Gevelt's (2014) finding for South Korea. Strengthening institutional ties between the government and rural constituencies eases the usually centrally planned approach to rural electrification, a measure that carries further political incentives in democracies with contested elections.

The negative association between the rural and urban electrification gap and foreign aid has two potential implications. First, while countries like Thailand and South Korea have successfully used heavy state-interventionist policies to electrify its rural population built on cross-subsidies from large to small customers, such policies are considerably more difficult to implement for African governments subject to conditional adjustment loans informed by neoliberal theories. Yet, as the business case for rural over urban electrification is usually negative, state interventions seem necessary to compensate for such effects as historic examples have shown (cf. Chang, 2002). Senegal's successful approach of using cross-subsidy schemes illustrates this implication. Second, a re-evaluation of how aid money is spent may prove fruitful. Non-monetary aid such as technical and educational assistance may be more suitable for targeted infrastructure interventions as opposed to continued funding of parastatal agencies with little track record of success.

Furthermore, there are considerable national and sub-national variations in both electrification and the presence or absence of related drivers and challenges across sub-Saharan Africa. As there is no quick fix to the rural electrification problem, policies should be conscious of these variations and should iteratively tailor solutions to the complexity of particular contexts, rather than applying broad brush dogmatic approaches with universalistic targets and timelines.

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Appendix A. Summary statistics for interpolation model

Table 7
Summary statistics and data sources for models with interpolated dependent.

Variable	Source	Obs.	Mean	SD	Range
Dependents					
Rural electrification	World Bank (WDI)	528	12.22	17.52	.10–.100
Politics					
Democracy	Polity IV	468	.20	5.83	−10–10
Centralisation	Gennaioli and Rainer (2007)	462	53.73	31.76	0–100
Political geography	Herbst (2000)	451	1.66	.85	0–1
Indirect Rule	Ziltener and Künzler (2013)	440	.63	.48	1–3
Economy					
GDP per capita (2013 10^3\$)	World Bank (WDI)	512	1.21	2.08	.07–19.71
Aid (% GNI)	World Bank (WDI)	489	13.12	13.20	.14–150.56
Fuel per capita (Gtoe)	IEA	524	.96	3.83	0–35.96
Agriculture (% GDP)	World Bank (WDI)	489	28.10	16.56	2.14–87.90
Demography					
Rural population (%)	World Bank (WDI)	528	64.59	15.72	14.30–94.58
Population density	World Bank (WDI)	528	75.47	105.80	1.72–631.00
Urbanisation (% growth)	World Bank (WDI)	528	3.97	1.97	−5.87–18.66
Population (log)	World Bank (WDI)	528	15.49	1.57	11.16–18.89

Notes: The summary statistics above refer to models where the dependent variable has been interpolated based on existing data. All variables other than the dependents have been calculated as an average for each country in the two years preceding the 11 years with available or interpolated data (1990, 92, 94, 96, 98, 2000, 02, 04, 06, 08, 2010). Missing values for particular years were omitted from the averages.

Appendix B. The Senegalese Case

Senegal's rural electrification stood at 3% in 1990, and only slightly increased to 5% by 1997. Both figures were significantly below the sub-Saharan African average. Yet between 1998 and 2010, Senegal managed to catapult rural electrification to around 30%, double the sub-continent's average. Its urban electrification has steadily grown from 60% to close to 90%. While still considerable, the rural versus urban electrification ratio thereby improved from one to twenty to one to three.

B.1. Political factors

Senegal's democratisation process with peaceful election-induced transition of power in 2000 created incentives for the government to electrify considerable shares of the rural population. The country was ruled by Abdou Diouf and his Parti Socialiste du Sénégal (PS) between 1981 and 2000. Diouf took various democratisation steps in the second half of his rule, including widespread political reforms that granted oppositional parties more rights, levelled the electoral playing field and improved freedom of speech (Vengroff and Magala, 2001). However, Diouf's poor economic track record since 1981 forced him into a runoff with Abdoulaye Wade of the main oppositional party Parti Démocratique Sénégalais (PDS) in the 2000 general elections. While rural voters in Senegal have been found to generally favour the incumbent (Koter, 2013), Vengroff and Magala (2001) argue that rural opposition was fundamental in securing Wade's win in the runoff. It constituted Senegal's first peaceful transition of power from one party to another in elections judged free and fair by the international community.

To solidify rural support, the PDS government was quick to greatly expand the dedicated rural electrification agency, the Agence Sénégalaise d'Électrification Rurale (ASER), created in 1998 by the PS under growing political pressure of the main oppositional. The PDS increased funding for ASER and introduced a variety of rural electrification initiatives. It set out an ambitious rural electrification target of 30% by 2015 in 2002. Among the newly introduced initiatives were innovative policies such as the Senegalese Rural Electrification Action Plan (Plan d'Action Sénégalais d'Électrification Rurale, PASER) in 2002 (Mawhood and Gross, 2014). PASER focuses on establishing concessions via private sector participation, dividing Senegal into 18 concessions available for competitive bidding. Private concessionaires individually develop specific local and cost-effective electrification plans and are required to bear at least 20% of the investment cost. Similarly to the Ghanaian case, the Senegalese government needs to centrally approve all decentral rural electrification projects, a policy design that helps it to ensure that broad population shares benefit from electrification rather than concentrating the infrastructure to support a few. Despite the remarkable gains achieved, Mawhood and Gross (2014) point out that the PASER policy in particular would have been more successful if governmental effectiveness had been higher, evident in poor project management, protracted consultations and limited capacities. Despite such criticism, success stories such as the considerable increase of rural electrification manifested the rural support for the PDS government, the latter helped secured a clear victory in the 2007 elections, albeit oppositional allegations of electoral fraud.

B.2. Economic and demographic factors

The newly elected PDS government's move to re-nationalise the energy utility in 2000 enabled a cross-subsidy scheme financed mainly by the positive economic development of the country and domestic savings which greatly benefited rural electrification. World Bank and IMF conditionalities required the previous Diouf government to embark on a privatisation-focused electricity sector reform in the late 1990s (Gökgür and Jones, 2006). Shares of the state-owned utility SENELEC were sold to a Canadian-French consortium which started to manage the utility in 1999. Measures included rises in tariffs to close financial gaps of electricity provision, posing risks for the rural population to afford electricity. After its election in 2000, the Wade government, much to the surprise of the World Bank, was quick to buy back all SENELEC shares to fully reverse privatisation of the utility (Gökgür and Jones, 2006). As a second push for privatisation with improved conditions for the Senegalese governments failed, SENELEC has remained fully state-owned. Working against World Bank and IMF loan conditions, the government introduced a tariff-system based on a large-scale cross-subsidising scheme to cover the deficits of electrification (Boccanfuso et al., 2008) which enabled considerably broader electrification. Consistent with the econometric results in this paper, it greatly benefitted from a threefold increase of Senegalese GDP per capita levels in the 2000s and above sub-Saharan African mean national per GDP savings, averaging 16% during the 2000s instead of relying heavily on conditional aid. ASER's designated Rural Electrification Fund, much in line for figures for the sub-Saharan African sub-continent, is mainly financed through a tax on electricity usage, functioning itself as a re-distributive mechanism (Mawhood and Gross, 2014).

Demographic factors have posed both challenges and opportunities for Senegal. While a quickly growing population density and a rural population of only 55% relatively ease rural electrification, Herbst (2000) notes that Senegal has a difficult political geography where the Southern part of the country is separated from the rest by The Gambia. During Wade's government, a secessionist movement erupted in the southern Casamance area.

The success of the rural electrification programme in Senegal is thus not solely due to demographically favourable conditions and an improving economic situation, but has furthermore benefited from political incentives for the PDS government to increase rural electrification. Cross-subsidising policies together with private funds attracted through PASER have helped to finance the significant broadening of electricity access to rural areas, reaching the ambitious 30% target in 2010, five years earlier than planned (Bhattacharyya, 2013).

Appendix C. The Rwandan case

Rural electrification in Rwanda has consistently been in the bottom quartile of sub-Saharan African countries between 1990 and 2010, remaining markedly under 5%.[12] At the same time, urban electrification has slightly increased to connect around half of urban households to the grid, resulting in a rural versus urban electrification inequality ratio that lies in the top quartile of sub-Saharan African countries.

C.1. Political factors

The political development in Rwanda after the 1994 genocide formed an autocratic regime built on narrow urban elites, providing political incentives for urban over broad rural electrification. Despite a rhetoric of democracy and national reconciliation after the genocide which gained widespread support, the ruling Rwanda Patriotic Front (RPF) implemented a de-facto dictatorship and widespread political exclusion (Reyntjens, 2004, 2011). After assuming a military victory to end the genocide committed by extremist Hutus in July 1994, the RPF under its leader Paul Kagame quickly consolidated power. In the following decade, the RPF exiled, imprisoned and killed Hutu elites from early 1995, reversed previous attempts of inclusion inside the RPF, which replaced the largely ceremonial Hutu president Pasteur Bizimungu with Kagame, and banned the main opposition party, the Mouvement Démocratique Républicain (MDR). Desrosiers and Thomson (2011) point out that while the regime was grounded in contrary ideological narratives, the RPF greatly favoured Tutsi, especially those who were anglophone, with regards to access to power, income and education. While the population was mainly Hutu, by 1996 the vast majority of MPs, Supreme Court judges, mayors, university students and professors, the army and the intelligence service was Tutsi.

At the same time, "the Tutsization of urban Rwanda … had become the sociological and economic foundation of the RPF" (Reyntjens, 2004, p.188). The Rwandan government made consistently weak budgetary commitments for rural development, instead favouring the urban elite. Ansoms (2008, p.6-8) shows in-depth how "the Rwandan government presents spending targeted at the urban elite as pro-poor priority expenditure," a tactic that resonates well with Desrosiers and Thomson's (2011) analysis of the differences between benevolent leadership narratives of the RPF regime elites and actual socio-political realities. The banning of any meaningful opposition (Kagame won the 2003 presidential elections with 95.1% of the vote and an alleged turnout of 96.6%) made challenges to such urban–rural biases close to impossible and provided no considerable incentives for rural endowments. Rural electrification serves as a vivid example.

Studying a number of seminal government policy documents reveals a lack of political push for rural electrification. The government's "Rwanda Vision 2020" issued in 2000 does not feature rural electrification as a priority area (Republic of Rwanda, 2000). The document does not include a rural electrification goal. It only states that it aims to electrify 25% of its population by 2010 (a goal the government has missed by more than 50%), and 35% of the population by 2020. However, as electrification in urban areas is considerably more cost effective, reaching a such broadly defined goal implies an almost automatic focus on urban over rural electrification. Similarly, the Ministry of Infrastructure's Electricity Access Rollout Programme (EARP) started in 2009 does not distinguish between urban and rural electrification targets either but implicitly favours urban centres for electrification. The government's 2013 IMF Poverty Reduction Strategy Paper (PRSP) repeats the de-prioritisation of rural electrification in a more lucid way. It asserts that electrification, at the time still at only 14% of the total

[12] The World Bank reports a rural electrification rate of 4.0% for 2010, the IEA does not provide rural electrification data for Rwanda in 2010 and instead reports 4.7% for 2012.

population, "will focus initially on viable clients, i.e. those who can make productive use of energy and those who can afford to pay for the cost-covering connection fee" (Republic of Rwanda, 2013, p.51–52), and that "the levels of consumption for some are too low to justify a grid connection" (Republic of Rwanda, 2013, p.40). Its vague claims to use decentralised technologies on a large scale for rural areas is not based on any significant experience with the technology in Rwanda or the greater region and would require enormous technological leapfrogging within a few years to become a reality.[13] It is thus not surprising that the electrification gains achieved by the EARP by 2013, an increase to 16% of overall electricity access, are largely limited to urban areas (Republic of Rwanda, 2013). Yet the Rwandan government chose to increase its overall electricity access target to 70% by 2017, a magnitude which may again be best understood in light of Desrosiers and Thomson's (2011) work on the high importance of maintaining benevolent leadership narratives for the RPF regime elites towards the international community (the IMF in this case) and its own population, regardless of how meaningful they are on the ground.

C.2. Economic and demographic factors

While favourable demographics have aided the rapid consolidation of power, income declines have forced the Rwandan regime to trade-off different options where to spend its energy infrastructure budget. GDP per capita has been considerably below the sub-Saharan African average. Income per capita levels fell in the 1990s, mainly driven by the halving of GDP in a single year during the 1994 Rwandan genocide. National savings in Rwanda are well below sub-Saharan African averages, exacerbating the usage of the usually domestic chancel to finance electrification infrastructure. With increasing industrialisation in urban areas, Rwanda has experienced severe electricity supply shortages due to failure to invest in new generation capacity (Safari, 2010). The cost of electricity increased by 900% between 1995 and 2006, deeming electricity largely economically inaccessible for the majority of the poor population, especially where flexible payment schemes are absent (Van Gevelt et al., 2016). Resource allocation for electrification infrastructure has favoured urban over rural areas, keeping the urban versus rural electrification high.

At the same time, the donor community has regarded Rwanda as a 'donor darling' and ensured greatly above regional average aid payments despite the country's significant human rights abuses (Reyntjens, 2011). Up to 50% of the national budget were aid financed, thereby bypassing the scrutiny of the Rwandan people, a situation exacerbated by the absence of political opposition which could have exercised potential checks and balances.

The favourable geographic conditions have helped the RPF to effectively concentrate power, yet have not furthered rural electrification challenges. Rwanda has the highest population density of all continental sub-Saharan African countries at 439 people per square kilometre in 2010. Its rural population share, while still high at around 75% in 2010, has decreased at the fastest absolute rate of all sub-Saharan African countries, apparent in its considerable urbanisation rates. Herbst (2000) classifies Rwanda as a country with favourable political geography. Centralised control over the country, a beneficial factor for state-driven electrification programmes, is greatly eased by its demographic conditions. It allowed Kagame and his regime to consolidate political power relatively quickly after the genocide and aided the regime in building a pervasive bureaucratic apparatus. Gennaioli and Rainer (2007) calculate a pre-colonial political centralisation index of close to 1, indicating that state control in Rwanda has traditionally been centralised.

[13] In fact, such decentralised renewable technologies, despite their significant potential in sub-Saharan Africa, continue to play a miniscule role for the electricity generation mix on the sub-continent.

While these geographic conditions favour large-scale state-driven electrification programmes in general, such initiatives tend to require political commitment to be extended to the rural population. Yet, in the context of considerable economic constraints, the well-consolidated Rwandan regime's urban-based elite system of patronage (Green, 2011) has worked to substantially de-prioritise rural electrification over elite endowments in the absence of democracy and a strong opposition. This provides a lucid political counterfactual case to the econometric analysis in this paper, as arguably a context of contested elections in a strong democracy would have forced the RPF to lend more credibility to its fictional claims to inclusion by reversing its salient urban and elite bias in endowment allocation.

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