Rural Electrification and Domestic Violence in Sub Saharan Africa

Abstract

Electrification is frequently said to foster women's development and contribute to a modernization of gender roles. Using Demographic and Health Survey data from rural areas in 22 Sub-Saharan countries collected between 1999 and 2014, this paper examines the role of electricity access in reducing Intimate Partner Violence by means of region difference-in-difference and propensity score matching approaches. Women in households with electricity report significantly lower acceptance of IPV. This relationship seems to be largely driven by endogeneity, though, and applying matching and difference-in-difference approaches cast doubts on the causality of electricity for changes in IPV.

DRAFT VERSION JANUARY 2017

JEL: J12, J16, O13, O18

Keywords: rural electrification, domestic violence, intimate partner violence, region difference-in-difference, propensity score matching

1. Introduction

One third of all women experience violence within their lifetime, most frequently perpetrated by their intimate partner. Since the 1993 World Conference on Human Rights and the Declaration on the Elimination of Violence against Women it is officially recognized as a violation of human rights. Intimate partner violence (IPV) impacts women's sexual, reproductive, and mental health, and increases the risk of chronic diseases (WHO 2013). It is the leading cause of homicide death in women globally and is associated with increased levels of depression and suicidal behaviour (DEVRIES et al. 2013). Ways to reduce IPV are less obvious, though. Evidence suggests that socio-economic factors that reinforce a culture of violence against women need to be addressed. This includes challenging social norms that support male authority over women as well as strengthening women's economic position and legal rights (KLUGMAN et al. 2014).

Especially in rural areas, electrification is frequently said to foster women's development and contribute to a modernization of gender roles (KÖHLIN et al. 2011). Better access and exposure to information, especially through increased availability of television, has been shown to influence attitudes and behaviour. Most prominently, JENSEN AND OSTER (2009) show that women's attitudes and behaviour are influenced through the introduction of cable TV in rural India even over a very short time-frame. Amongst others, acceptance of IPV is reduced. Moreover, access to electricity is often expected to change women's relative status in the household due to higher female labour participation. Some evidence from South Africa and Nicaragua exists that income generation opportunities for women are improved by electrification (DINKELMAN 2011, GROGAN AND SADANAND 2012).

Against this background, the present paper analyses patterns of IPV in relation to electricity access in rural Africa. Using Demographic and Health Survey (DHS) data from rural areas in 22 Sub-Saharan countries collected between 1999 and 2014, it examines determinants of attitudes toward IPV, the correlation between attitudes and

occurrence of IPV, and differences in IPV cross-country prevalence. For analysing the role of electricity access, the identification strategy relies on region difference-in-difference and propensity score matching approaches. I furthermore probe into the two potential underlying transmission channels, increased media access and higher female labour participation.

According to the definition of the WHO "World report on violence and health", IPV is behaviour within an intimate relationship that causes physical, psychological or sexual harm (KRUG et al. 2002). The paper concentrates on acts of physical aggressions – such as slapping, hitting, kicking, and beating. The DHS data is the largest source for nationally representative data about violence at home in developing countries. It provides information both on attitudes toward IPV and its occurrence. The focus of the analysis is on attitudes as the main outcome indicator. While the DHS has information on attitudes toward IPV for almost all survey waves collected since 1999, data of effective experience of physical aggressions is available only for a subset of countries and survey waves. Furthermore, the indicator for occurrence of IPV that is elicited in the DHS only captures whether a woman has ever experienced IPV in her live. The indicator hence is not very sensitive to a decrease in IPV occurrence since it can only change through cohort replacement. It can be seen in those data sets that have information both on attitudes and occurrence of IPV that women who believe that IPV is justified are more prone to being physically abused by their partner. The literature confirms this finding based on other data sets (ALIO et al. 2011, UTHMAN 2011). Hence, changes in attitudes can be assumed to induce changes in prevalence of IPV.

Existing research has pointed out that levels of IPV largely vary across regions and countries. In Sub-Saharan Africa, 40 percent of women have experienced physical or sexual violence by an intimate partner. It is the region with the second-highest prevalence worldwide, only exceeded by South Asia with a prevalence rate of 43 percent (KLUGMAN et al. 2014). At the same time, the region is where most of the

remaining non-electrified people live. Around 590 million of the total 1.1 billion non-electrified people live in Africa (SE4ALL 2015).

The remainder of this paper is organized as follows. Section 2 elaborates the theory of change on how electricity access might influence attitudes toward IPV. Section 3 presents the data. Section 4 provides descriptive statistics on IPV prevalence and attitudes toward IPV, cross-country differences, and individual risk and protection factors for IPV. Section 5 specifies the empirical strategy and Section 6 presents the results of multivariate regressions to estimate the relationship of electricity and attitudes toward IPV. Section 7 concludes.

2. Theoretical background and literature

This section presents the potential underlying mechanisms how rural electrification might lead to changes in IPV prevalence. In particular, rural electrification enables changes at the household and the enterprise level that ultimately might affect attitudes toward IPV (see Figure 1). Once households in rural areas connect to the electricity grid, they acquire primarily electric lighting, information, and entertainment devices. To a lower extent, households also invest into appliances that facilitate housework like electric irons and refrigerators. Electric stoves are rarely used in rural Sub-Sahara Africa.[1] This leads to better access and thus higher exposure to information.

Moreover, it gives household members higher flexibility to exercise their daily duties, and housework can be done more efficiently. Women released from housework can use the additional time for productive purposes and hence increase their labour supply. At the same time, electricity can drive enterprise creation and cause productivity gains in existing enterprises. A resulting increase in labour demand

[1] South-Africa is an exception as can be seen in DINKELMAN 2011.

might lead to higher female labour participation, which might improve women's economic situation and change traditional gender roles.

While some of these effects only accrue to households that have electricity at home, attitudes of non-electrified households in electrified areas might also change. First, they can also benefit from the labour demand effect. Second, information spill-overs might occur: information access might also improve for non-electrified households by mouth-to-mouth communication and usage of information technology at electrified neighbours, especially TV watching.

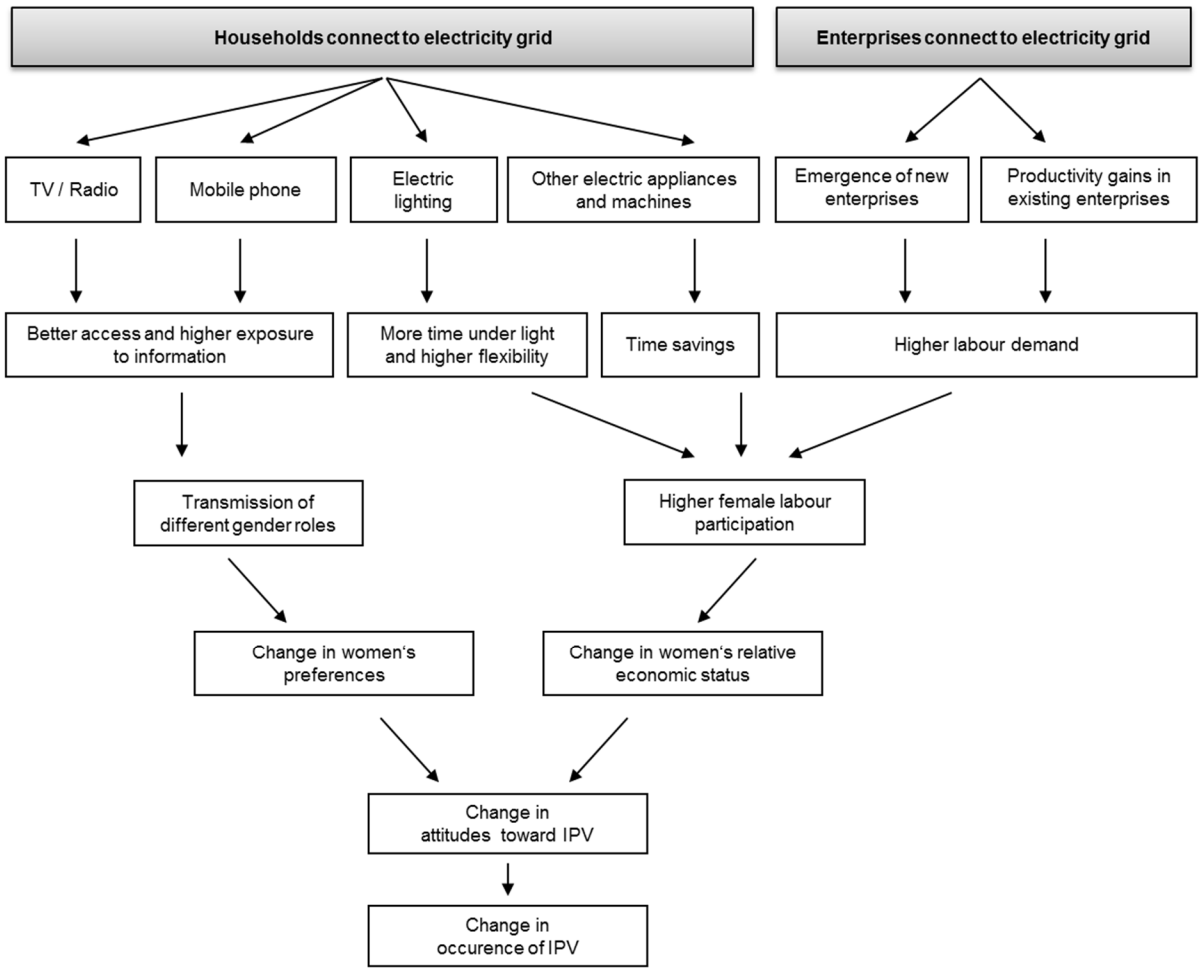
Several studies show empirically that household effectively gain better access to information through electrification (see for example IEG 2008, KHANDKER, BARNES AND SAMAD 2012, LENZ et al. 2016). A change in female labour participation following electrification has most prominently been shown by DINKELMAN 2011 in South Africa and GROGAN AND SADANAND 2012 in Nicaragua, while evidence from Africa is more pessimistic (BERNARD 2012; PETERS, VANCE AND HARSDORFF 2011; NEELSEN AND PETERS 2011).

Traditional economic models of domestic violence suggest that educational, economic and social empowerment is protecting women against violence (FARMER AND TIEFENTHALER 1997, TAUCHEN, WITTE AND LONG 1991). Domestic violence is assumed to be driven either because of a direct gratification of the perpetrator (e.g. direct enjoyment of the pain of another or release of frustration) or in order to execute control. In most Sub-Saharan countries, where IPV is often socially accepted, the latter reason seems to be the dominant.[2] According to the models, a woman accepts IPV as long as the utility she gains from being in a violent relationship is at least as high as her utility when leaving the relationship. Greater economic independence increases the possibility of a woman to leave a relationship without losing utility. Knowledge on

[2] In developed countries, the earlier reason seems to be dominant. See for example CARD AND DAHL (2011) who explain domestic violence in the US by emotional cues.

different gender roles might shift her preferences whereby the utility she obtains from a violent relationship might decrease. Accordingly, since electricity might affect both the economic opportunities outside the relationship and knowledge on different gender roles, one would expect that women with electricity access are less likely to accept IPV.

Figure 1: Theory of Change



Source: own illustration

The empirical evidence is not that clear, though. Analysing the effect of mass media on several indicators for women's status, JENSEN AND OSTER (2009) show that acceptance of IPV is reduced through the introduction of cable TV in rural India. This study uses very similar outcome indicators for attitudes toward IPV as the ones used in this paper. It furthermore observes changes in son preference, increases in women's

autonomy and decreases in fertility.[3] Also PIEROTI (2013) shows that women who are in regular contact with mass media, i.e. newspaper, radio, or television, are less likely to accept IPV. WAKUNUMA (2012), by contrast, observes an increase in social conflict and violence in relationships induced by mobile phone ownership.

Also for the relationship between women's employment and IPV, empirical studies show both positive and negative effects. KRISHNAN et al. (2010) look at the effect of spousal employment status and physical domestic violence in Bangalore, India. Using panel data, they detect that the risk of violence increases for women who become employed in comparison to women who stay unemployed. Similarly, HEATH (2012) finds a positive correlation between work and domestic violence in Dhaka, Bangladesh. Yet, this correlation is only present among women with less education or who were younger at first marriage. With data from the US, AIZER (2010) shows that an increase in relative female wages decreases domestic violence.

One attempt to explain these conflicting results is that effects differ depending on the bargaining power of a woman. This relationship is often described as an inverted U-shaped relation with women at higher levels of empowerment challenging traditional sex roles, which increases the risk of violence. Only if a woman has realistic opportunities to leave the relationship, protective effects predominate. The bargaining power of a woman is determined both by individual factors such as the relative economic position or cultural expectations regarding male and female gender roles. (ESWARAN AND MALHOTRA 2011, GOODE 1971, HEISE 2012, JEWKES 2002, LEVINSON 1989).

In cross-country comparisons, two factors for differences in IPV stand out: cultural expectations and economic development. Cultural expectations refer to institutions like patrilocality and patrilineality, dowry systems, or "collectivist" cultures compared

[3] These findings have been challenged by a replication study that finds some of the results to be sensitive to index construction and that observes heterogeneous effects by age and social identity, as well as spillover effects (see IVERSEN AND PALMER-JONES 2013).

to "individualist" cultures (see for example ARCHER 2006, JAYACHANDRAN 2015, ALMOND AND EDLUND 2008; ABREVAYA 2009; FERNÁNDEZ AND FOGLI 2009; and FERNÁNDEZ et al. 2004). With regard to economic development, studies highlight the bidirectional relationship between a country's GDP and levels of IPV (see for example JAYACHANDRAN (2015) and DUFLO 2012).

3. Data

This paper uses data from the Demographic and Health Surveys (DHS).

Table 1: DHS data used

	First wave			Second Wave		
		Sample size for			Sample size for	
	year	attitudes toward IPV	experience of IPV	year	attitudes toward IPV	experience of IPV
Benin	2001	3,170	n.a.	2011-12	7,757	n.a.
Burkina Faso	2003	7,994	n.a.	2010	10,179	7,274
Cameroon	2004	4,171	1,346	2011	5,787	2,087
DRC Congo	2007	4,241	1,717	2013-14	9,680	4,038
Ethiopia	2005	7,766	n.a.	2011	8,677	n.a.
Ghana	2003	2,680	n.a.	2008	2,029	1,112
Guinea	2005	4,840	n.a.	2012	4,786	n.a.
Kenya	2003	3,835	2,976	2008-9	4,127	3,457
Lesotho	2004	3,492	n.a.	2009	3,674	n.a.
Liberia	2007	3,122	2,541	2013	4,289	n.a.
Malawi	2004	8,456	7,255	2010	16,007	4,685
Mali	2006	7,034	4,885	2012-13	6,504	2,247
Mozambique	2003	6,135	n.a.	2011	6,732	3,801
Namibia	2006-07	2,270	n.a.	2013	2,246	669
Niger	2006	5,490	n.a.	2012	7,372	n.a.
Nigeria	2008	18,119	13,589	2013	18,665	14,057
Rwanda	2000	5,190	n.a.	2005	5,561	2,118
Senegal	2005	6,559	n.a.	2010-11	7,521	n.a.
Tanzania	2004-05	5,856	n.a.	2010	5,511	4,318
Uganda	2000-01	3,805	n.a.	2011	4,686	1,269
Zambia	2001-02	3,908	n.a.	2007	3,099	2,676
Zimbabwe	2005	4,290	3,413	2010-11	4,374	3,521
Total		123,866	38,942		149,263	57,329

Source: DHS all country data set.

DHS data is nationally representative data on population, health, and nutrition from over 90 developing countries.[4] It is the largest source of nationally representative data on domestic violence and provides up to six nationally representative cross-sectional survey waves per country, collected since 1984. Individuals are not tracked over time.

The surveys collect basic socio-economic household information and elicit information on health aspects among all female household members of reproductive age (15 and 49). Since 1999, these woman interviews have collected information on attitudes toward IPV.

I use all Sub-Saharan country data sets since 1999 in which information on attitude toward IPV is available for at least two waves.[5] In some of these surveys, a sub-sample of women were asked in detail about domestic violence experiences. I restrict the sample to households in rural areas and women who have ever been married or lived in a partnership. Countries, survey waves, and sample sizes used in this paper are displayed in Table 1. In some households, more than one woman is interviewed. I account for this fact in the following by clustering standard errors on the household level.

Attitudes

For eliciting attitudes toward domestic violence, women are asked about acceptability of IPV in five different situations.

They are asked whether they think it is acceptable that a husband beats his wife if

i) she goes out without telling him

ii) she neglects the children

iii) she argues with him

[4] For more information, see http://www.dhsprogram.com

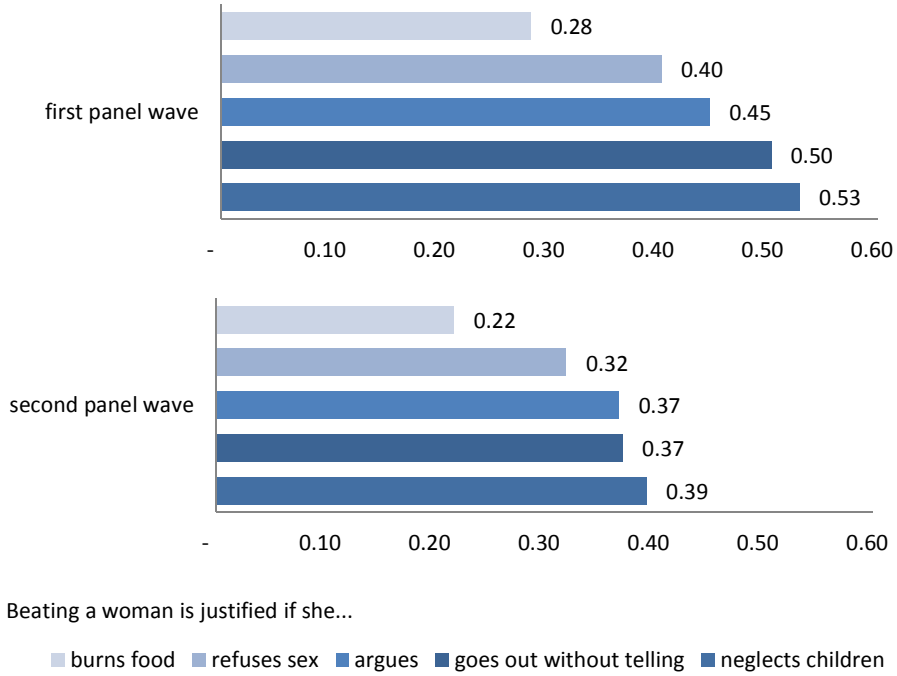
[5] For Ethiopia, Mali, Nigeria, and Zimbabwe three waves with information on attitudes exist. I only use the most recent two.

iv) she refuses to have sex with him or

v) she burns the food.

My dependent variable for measuring acceptance of domestic violence in the following analysis aggregates this information into a binary variable indicating whether the woman accepts being beaten in any of these five situations.[6]

Figure 2: Justification of IPV, by situation



Source: DHS all country data set

Female consent to IPV depends on the reason for beating a woman. The DHS data from all Sub-Saharan countries shows that it is most accepted to beat a woman if she neglects her children and it is less accepted if she burns food (see Figure 2). Over time, we can see a general decrease in acceptability of IPV, no matter for what reason. The decrease is strongest for a wife going out without telling her husband and lowest if a wife argues with the husband. Almost 60 percent of all women accept IPV in at least one situation. 15 percent accept it in all five situations. The intermediate steps of accepting four,

[6] Results are largely robust to alternative ways of constructing the outcome indicator. Annex 3 shows results for each of the five questions separately and three alternative ways of summing up the five questions, including multiple correspondence analysis (mca).

three, two, or one situation are almost evenly distributed with around 10 percent at each step.

Occurrence

For measuring occurrence of domestic violence, DHS asks about a set of behaviourally specific acts that women have ever experienced. Two forms of physical violence are distinguished: less severe violence and severe violence. Each of the two are elicited by asking women whether they have ever experienced any of the following situations: For less severe violence women are asked whether they have ever been slapped, have been punched with fist or hit with something harmful, or have been pushed or shook or have had something thrown by the husband/partner. For severe violence, women are asked whether they have ever been kicked or dragged, have been strangled or burnt, or have been threatened with a weapon. These questions are adapted from the *Conflict Tactics Scale* that has widely been used also in industrialized countries. The instrument is considered a valid and reliable measure of intimate partner violence (WHO 2013).

In order to establish an indicator on experience of domestic violence in my analysis, I aggregate all questions into two binary variables indicating whether the woman has ever experienced any less severe violence or any severe violence. Unfortunately, I do not have the information for all data sets when exactly this experience of IPV has occurred. In most countries it is only recorded whether a woman has ever experienced IPV in her lifetime. The indicator hence is not very sensitive to a decrease in IPV occurrence since it can only change through cohort replacement. For this reason, I use changes in attitudes toward domestic violence as my main outcome indicator. This information is available for all 22 countries, can be expected to change also over a short period of time and is relevant, since it can be expected to be positively correlated with effective experience of domestic violence.

As also suggested by the literature (e.g. ALIO et al. 2011, UTHMAN 2011), attitudes toward IPV are effectively correlated with its occurrence. In the sub-sample of countries where information on occurrence of IPV exists, a total of almost 26 percent has ever experienced any severe or less severe form of violence through her husband. 18 percent of all women have experienced a less severe form of violence. Seven percent have additionally also experienced severe violence.

The correlation coefficients for accepting IPV and experiencing less severe violence is 0.09 when controlling for country dummies and is significant at the 1 percent level. The corresponding correlation coefficient for severe violence is 0.03, also significant at the 1 percent level. Among women who have ever experienced violence, the share of women accepting violence is with 62 percent clearly higher as compared to 48 percent among women who have not experienced violence.

Electricity access

Finally, access to electricity is measured by a binary variable that indicates whether the household has an electricity source. In most cases it is plausible to assume this electricity source to be a connection to the national electricity grid. It cannot be completely ruled out that in some countries also decentralized sources (Solar Home Systems, generators, etc.) are subsumed under this question.

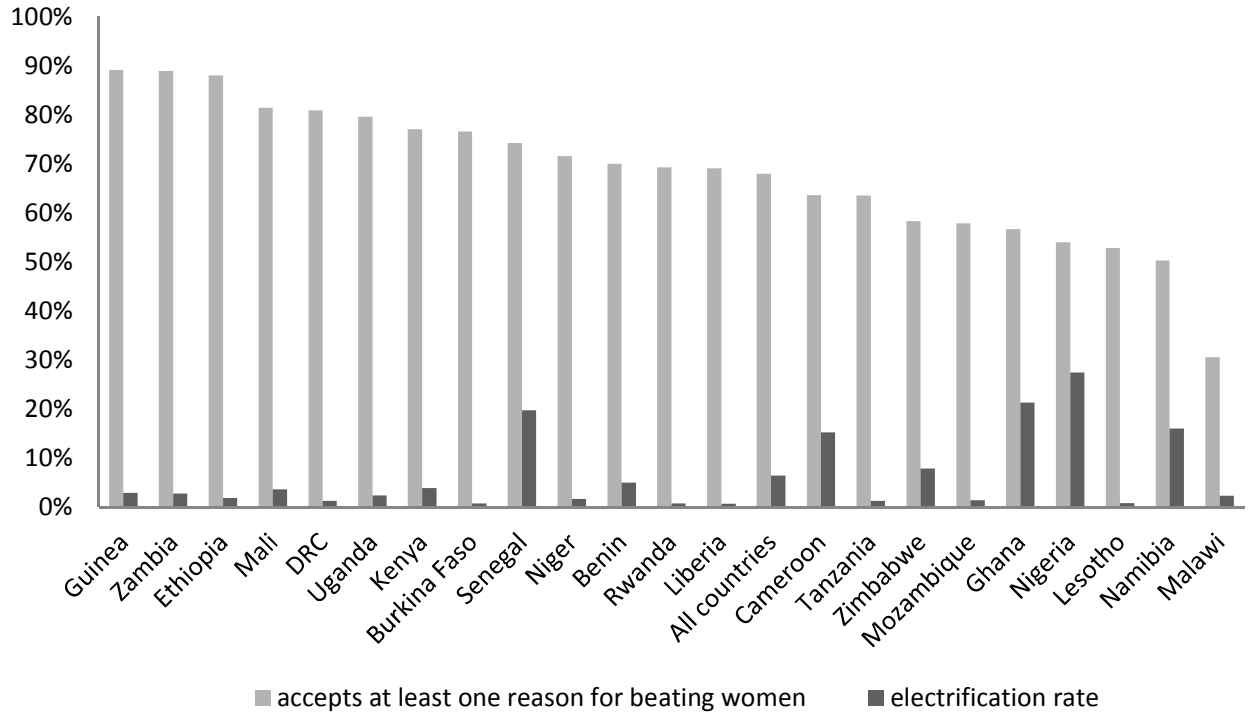
4. Prevalence and determinants of domestic violence

4.1 Cross-country differences

The degree of consent to IPV varies strongly between countries of Sub-Saharan Africa, from less than 30 percent in Malawi to almost 90 percent in Guinea. At country level, no clear correlation with national rural electrification rates exists (see Figure 3).[7]

[7] The correlation coefficient is -0.3142 but statistically not significant.

Figure 3: Acceptance of IPV and electrification rates, by country



Source: DHS country data sets, first panel wave

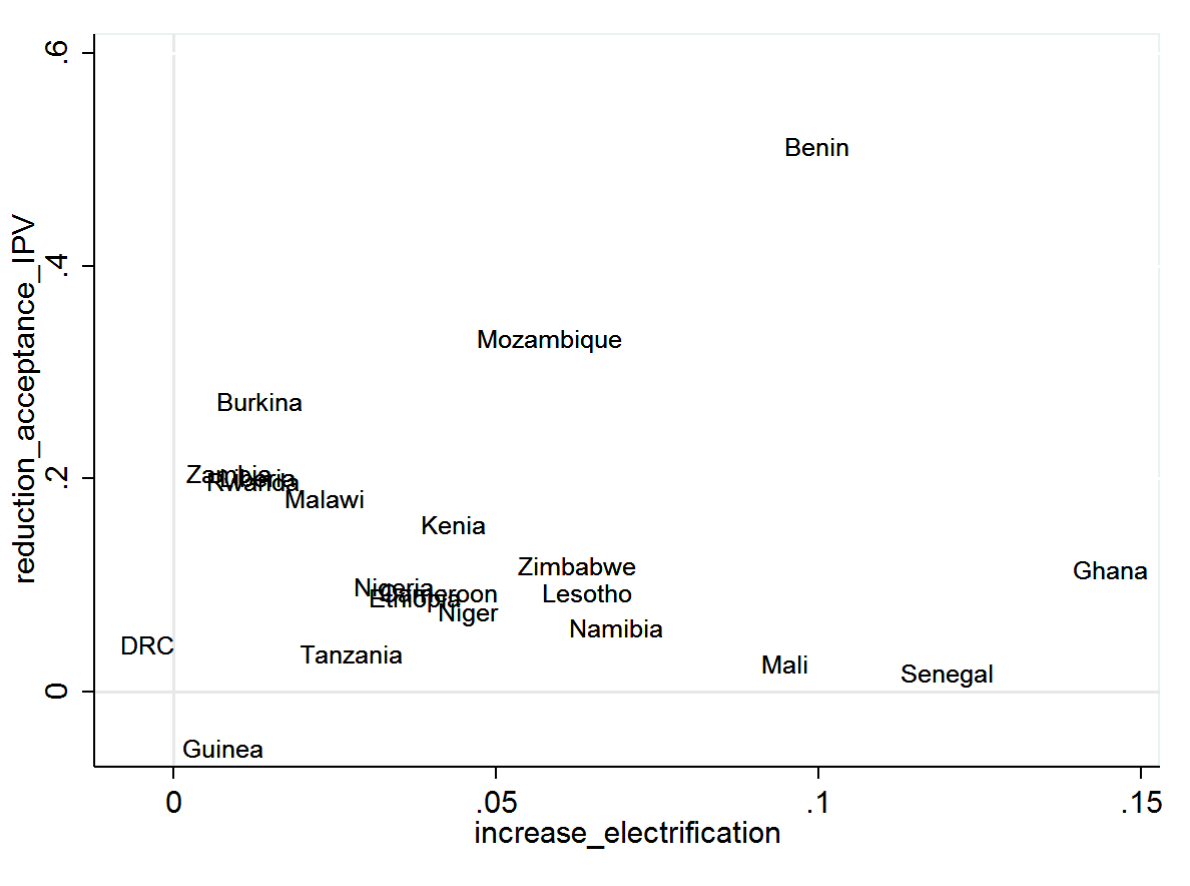
Rural electrification rates vary considerably between countries as well. While in countries like Liberia, Burkina Faso, Rwanda, or Lesotho only around one percent of the respondents lived in households connected to the electricity grid in the first panel wave, more than 15 percent of respondents in Cameroon, Namibia, Senegal, Ghana, and Nigeria did.

Comparing changes in electrification rates and acceptability of IPV between the first and the second survey wave two important observations can be made (see Figure 4). First, large differences between countries stand out. With regard to progress on rural electrification, Ghana, Senegal, Benin, and Mali performed best with increases of around 10 percentage points. DRC performed worst with even a decrease of the electrification rate which had already been extraordinarily low in the first wave. With

regard to the acceptability of IPV, some countries like Senegal, Mali, or Tanzania register only minimum progress, while acceptability of IPV went down by 51 percentage points in Benin.

Second, at the country level, no clear correlation between changes in electrification and IPV acceptance can be observed.

Figure 4: Changes in IPV acceptance over changes in electrification rates by country



Source: DHS all country data.

4.2 Characteristics of women who accept IPV

Comparing characteristics of women who accept IPV with those who do not (see Table 2, column 2) the following patterns stand out:

(i) Women who accept IPV live farer away from urban areas and have less modern infrastructure in their clusters.

(ii) They generally live in poorer households. These households possess less high-value assets (i.e. a car) and have poorer infrastructure (no piped water).

(iii) Higher education decreases the likelihood of accepting IPV. Respondents who accept IPV attended secondary school less often than women who do not accept IPV. The difference for primary school attendance is less pronounced. Moreover, women who accept IPV have less educated partners.

(iv) Accepting IPV is more common among younger women, and among women in more traditional partnerships who marry earlier and have a higher age difference with her partner.

(v) Women living in larger households are more likely to accept IPV. Also the respondents' number of children increases the likelihood of accepting violence.

(vi) Muslim women are more likely to accept IPV as well as women living in a polygamous relationship, which is most frequent in Muslim relationships.

(vii) Among a smaller sample of women for whom we have more details concerning domestic violence, we see that women who witnessed her father beating her mother in childhood are more likely to accept violence.

Table 2: Descriptives on sample (only first wave)

	(1) all respondents, all countries		(2) Respondents who accept IPV	(3) Respondents with electricity
	N	mean (sd)	difference* (p-value)	difference** (p-value)
Cluster characteristics				
Distance to nearest urban cluster	103,520	27.8 (22.9)	1.78 (0.000)	-9.133 (0.000)
Cluster has electricity	122,371	0.23 (0.42)	-0.028 (0.000)	1
Share of HH in cluster with water tap	122,371	0.16 (0.07)	-0.001 (0.045)	0.013 (0.000)
Share of HH in cluster went to hospital last 12 month	122,371	0.4 (0.067)	-0.001 (0.007)	0.007 (0.000)
Share of HH visited by family planning worker last 12 month	122,371	0.07(0.03)	0 (0.086)	0.006 (0.000)
HH characteristics				
Respondents per HH	122,371	1.43 (0.86)	0.047 (0.000)	0.03 (0.003)
HH has electricity	122,151	0.059 (0.24)	-0.023 (0.000)	1
HH uses tap water	122,313	0.127 (0.33)	- 0.02 (0.000)	0.16(0.000)
Age head of HH	122,233	42.6 (13.8)	-0.08 (0.416)	0.164 (0.302)
Head of HH is female	122,371	0.18 (0.38)	-0.014 (0.000)	0.041 (0.000)
Number of HH members	122,371	6.96 (4.45)	0.251 (0.000)	0.419 (0.000)
HH owns bike	122,121	0.35 (0.48)	0.01 (0.001)	-0.033 (0.000)
HH owns motorcycle	122,055	0.098 (0.3)	-0.002 (0.194)	0.055 (0.000)
HH owns car	121,981	0.015 (0.12)	-0.01 (0.000)	0.037 (0.000)
Respondent characteristics				
Respondent is muslim	121,002	0.42 (0.49)	0.033 (0.000)	-0.075 (0.000)
Age of respondent	122,371	30.9 (8.95)	-0.681 (0.000)	0.571 (0.000)
Respondent attended secondary school	122,368	0.078 (0.27)	-0.041 (0.000)	0.121 (0.000)
Respondent attended primary school	122,368	0.4 (0.49)	-0.028 (0.000)	0.215 (0.000)
Respondent is married	122,371	0.8 (0.4)	0.013 (0.000)	-0.036 (0.000)
Number of children	122,371	4.17 (2.91)	0.01 (0.637)	-0.422 (0.000)
Age at first cohabitation	122,371	17 (3.61)	-0.356 (0.000)	1.309 (0.000)
Exposed to violence in childhood	30,178	0.22 (0.41)	0.041 (0.000)	0.019 (0.015)
Characteristics current partnership				
Age difference between partners	108,537	9.97 (8.56)	0.344 (0.000)	-0.605 (0.000)
Partner attended secondary school	119,378	0.16 (0.37)	-0.04 (0.000)	0.167 (0.000)
Relationship is polygamous	105,734	0.34 (0.47)	0.032 (0.000)	-0.05 (0.000)
Partner drinks alcohol	35,488	0.26 (0.44)	0.001 (0.819)	0.051 (0.000)

Source: DHS all country data set, first wave. * difference in means between women who accept IPV and those who do not. Country dummies included. **difference in means between women in HHs with and without electricity connection. Country dummies included.

Women who live in households with electricity are generally better off than women in non-connected households (Table 2, Column 3). For example, they own more assets and have better education. They seem to be more modern, as indicated by the age of first cohabitation or the age difference between partners.

5. Empirical strategy

The aim of this paper is to analyse the relationship between having electricity at home and attitudes toward IPV. The main difficulty in interpreting this relationship causally lies in the household's connection status not being exogenous but rather a result of a twofold selection process:

First, to connect to the grid the household has to be located in an area that is served by the electricity grid. Electrification rates are normally highest in the countries' capital and urban centres and rapidly decrease with the distance to urban centres. Out of economic considerations, rural areas with an above-average demand for electricity are the priority for rural electrification in order to make investments into rural electrification as profitable as possible. Rural areas with electricity can hence be expected to be the livelier places with comparably high economic activity. Furthermore, rural electrification is often a highly politicised process. Rural electrification is a means to secure electoral support and regions selected for electrification might be politically privileged regions in other regards too.

Second, a household in a grid connected area decides whether to connect or not. Since electricity has very high priority for rural households, the decision to connect is mainly driven by affordability considerations and connected households can be expected to be the economically better off households. Furthermore, other household characteristics like educational level or modernity drive the households' decision to connect.[8] These regional and household characteristics are likely to be correlated with attitudes toward IPV and thereby make a causal interpretation of an observed correlation difficult.

[8] See Section 5.3 for characteristics of connected vs. non-connected households.

5.1 Linear Probability Estimation

As a first attempt to address the endogeneity problem, I estimate a simple multivariate linear probability model (LPM), regressing the binary attitudes indicator on electrification status and further control variables.[9] The included variables can capture a substantial number of potential confounding factors. Since the DHS data is not a panel, I assume in a first step that no unobserved heterogeneity exists and pool all observations across the two waves of data. Country dummies are included and standard errors clustered at the household and cluster level.

At the regional level, I control for the distance of the sampled cluster to the nearest urban cluster that has also been surveyed by DHS. This information is obtained from GPS data provided by DHS.[10] In order to control for general infrastructure availability in the neighbourhood, I control for the availability of piped water and health services in the cluster.[11] At the household level, I include a set of household characteristics like the age and sex of the head of household and number of household members. Also indicators for the economic situation of the household like ownership of bikes, motorcycles, cars, and usage of tapped water are included.

At the individual level, I control for the respondent's religion, age, education, marital status, and number of children, and the partner's education. Moreover, the age at first cohabitation serve as an approximation for whether the respondent comes from

[9] Despite the binary character of the attitudes indicator, an LPM seems to give good estimates, since the explanatory variable of interest, electrification status, is discrete as well (see WOOLDRIDGE 2002, p.456). Results of a probit estimation of the simple multivariate model confirm the results from the LPM estimation.

[10] In order to guarantee respondent confidentiality, DHS displaces randomly the GPS data coordinates of interviewed clusters. Urban clusters are displaced up to 2 kilometres. Rural clusters are displaced up to 5 kilometres, with 1% of the rural clusters displaced up to 10 kilometres. Accordingly, the calculated distances to urban areas are only approximations.

[11] Since DHS does not provide information on infrastructure in the cluster, I calculate the share of interviewed households in each cluster that uses water from a tap, that has visited a hospital in the last 12 month, and that has been visited by a family planning worker in the last 12 month.

a rather traditional or modern background. More formally, I estimate the following equation for all women *i* in household *j* in cluster *k* in country *l.*

$$y_{ijkl} = \beta E_j + t + \alpha_l + X_{ijk} + \varepsilon_{ij}$$

where y_{ijkl} is the outcome variable of interest. *E* denotes the households' electrification status that equals unity for those connected and *t* denotes a dummy variable for the second period. α_l describes country dummies and *X* denotes sets of respondent, household, and cluster characteristics.

5.2 Propensity Score Matching

In this approach, I restrict the analysis to households connected to the grid and non-connected household that are as similar as possible to the connected household by means of a Propensity Score Matching (PSM) approach. Matching builds on the Conditional Independence Assumption (CIA) that dictates that the outcome variables must be independent of the treatment, conditional on the observed covariates. The treatment in the present case is whether the household has connected to the grid. The CIA requires that the covariates are non-responsive to the connection status (ROSENBAUM 1984). The covariates to be included should only be those that affect the decision to connect and the outcome variable (SCHMIDT AND AUGURZKY 2001, CALIENDO AND KOPEINIG 2008).

Finding variables that fulfil this requirement is somewhat challenging, since I do not have pre-electrification information for households connected to the grid. This is why I have to rely on variables that I assume to be non-responsive to the electricity connection. I use the distance to the nearest urban cluster, sex of the head of the household, availability of tapped water in the cluster, and whether the head of household attended at least secondary school as covariates. One might argue that these

variables as well are influenced by electrification. However, the influence seems to be very subtle and only perceivable in the very long run. For example, the educational level of the household could be influenced by electrification, as investments into education might be affected by electrification in the longer run. The educational decision, though, is too long ago to have been influenced by electrification since on average the head of household is 43 years old and school attendance already around 30 years ago. It is plausible that very few rural areas in my sample had already been electrified 30 years ago.

I use a nearest neighbour matching algorithm[12] without replacement and restrict possible matching partners to households living in clusters where no household has electricity. Households in grid access areas that have deliberately decided not to connect are thereby excluded. First, these households can be expected to be substantially different from connected households. Second, spill-over effects from connected to non-connected households that might bias the estimation are avoided. The PSM approach is able to increase the comparability of the treatment and control group substantially, although balance of covariates cannot be completely achieved. Balancing tests are displayed in the Annex. I test sensitivity of the results to bias as suggested by ROSENBAUM (2002).

[12] The decision for a matching algorithm involves a trade-off between bias and efficiency (see CALIENDO AND KOPEINIG 2008). The nearest neighbour algorithm reduces bias at the cost of higher variance compared to algorithms that use multiple neighbours. Restricting replacement has the opposite effect. Robustness tests show that applying algorithms with replacement and using multiple neighbours does not alter the results.

5.3 Region difference-in-difference

In a third attempt to reduce the endogeneity problem, I estimate a region difference-in-difference model. A region is defined as the lowest administrative entity that is representatively covered by DHS over two waves. Between three and 15 of these geographical areas exist per country. On average, each country is divided into nine regions.

The model has the following structure:

$$y_{imt} = \alpha_j + t + \beta E_{mt} + X_{it} + \varepsilon_{ijt}$$

where y_{imt} is the acceptance of IPV of woman *i* residing in region *m* in period *t*. *E* denotes the share of households that have electricity at home within each region *m*. α_j describes region fixed effects. *t* denotes a dummy variable for the second period and *X* denotes sets of respondent, household, and cluster characteristics. The main difference in comparison to the earlier models is the inclusion of region fixed effects and the treatment definition as the share of connected households within the region rather than the individual households' connection status.

The region difference-in-difference approach allows for controlling for time-invariant, unobservable characteristics of a region that might be correlated with the electrification status and attitudes toward IPV that otherwise would induce distortions. These might be for example cultural traits like attitudes with regards to technological innovations and gender roles. Obviously, the region difference-in-difference is not able to control for time-variant, unobservable characteristics. In the present case, the risk that regions might be on different secular trends cannot be fully ruled out. The approach might be furthermore threatened, if people with high entrepreneurial spirit or aspirations moved to electrified areas. I argue that this happens only to a very low extent since the vast majority of people in rural areas are

subsistence farmers and therefore depend on arable land. Even rural dwellers who work in non-agricultural jobs depend additionally on subsistence farming and hence are fairly immobile. Moreover, this kind of migration would normally occur within the geographical area defined here as one cohort and therefore does not bias my results. In my dataset, a total of 201 regions exist across all countries with on average 675 observations.

6. Estimation results

6.1 Electricity and intimate partner violence

Table 3 displays the results from four different regression models. Column 1 and 2 show results from a simple Linear Probability Model with and without controlling for the cluster, household, respondent, and partnership characteristics discussed in Section 5.1.[13] Mozambique, Niger, Rwanda, and Zambia are excluded since GPS data is not available for all waves.[14] Column 3 displays results of the matching approach and Column 4 shows the results of the region difference-in-difference approach.[15]

While the first three models show a negative and significant effect of electricity access on attitudes toward IPV, the coefficient turns positive and insignificant in the region difference-in-difference approach. The simple Linear Probability Model indicates that households with electricity have a six percentage point lower probability of accepting IPV. This corresponds to a reduction in accepting IPV of 9 percent and accounts for around half of the overall reduction in IPV acceptance between the first and the second panel wave. The slightly smaller coefficient for electricity access in the matching approach indicates that the simple Linear Probability Model is suffering from

[13] Unfortunately, it is not possible to control for ethnicity, since only a small subset of country data sets provides this information. However, the general tendency of the results can be confirmed among the subset of countries and controlling for ethnicity.

[14] The general tendency of the result does not change if the GPS variable is dropped and more countries included instead.

[15] Individual country analyses are displayed in Annex 4.

endogeneity that can at least partially be reduced through the matching. The matching results have to be interpreted with some care, though, since it cannot be fully ruled out that results may still suffer from endogeneity. Applying a sensitivity analysis following ROSENBAUM (2002) shows that the results of the matching approach are rather sensitive to bias: A hidden bias of the magnitude of 1.3 would explain away the observed effect. This means that results are robust as long as two households with the same observed covariates differ in their odds of being connected to electricity by at most 1.3. Together with the results of the region difference-in-difference this suggests that - at least over the observed time frame – electricity access does not have reduce acceptance of IPV. The descriptively observed correlation seems to be driven by endogeneity.

Table 3: Effect of electricity access on attitudes toward IPV (P-values in parentheses)

	(1) all observations	(2) all observations	(3) matching	(4) region diff-in-diff
HH has electricity	-0. 094 (0.000)***	-0.057 (0.000)***	-0.036 (0.000)***	
Share of households with electricity in region				0.067 (0.680)
Cluster characteristics	No	Yes	Yes	Yes
HH characteristics	No	Yes	Yes	Yes
Respondent characteristics	No	Yes	Yes	Yes
Partnership characteristics	No	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	-
Region dummies	No	No	No	Yes
Year of data collection	No	Yes	Yes	Yes
Mean value outcome at baseline	0.66	0.66	0.57	0.66
Adj. R-Squared	0.13	0.17	0.12	0.03
Number of observations	219,834	219,834	36,315	219,834

Source: DHS all country data set. *Notes:* Coefficients are estimated by a Linear Probability Model with robust standard errors clustered at the household and cluster level. For the region difference-in-difference approach, standard errors are clustered at the region level. Detailed results can be found in the Annex.

6.2 Transmission channels

According to the theory of change, a change in attitudes toward IPV after electrification can either be induced through better media access or via higher female labour participation. In the following, I analyse in the DHS data set whether women in connected households indeed show differing patterns regarding these characteristics and include interaction terms in the multivariate regression models.

Table 4: Media access of connected and non-connected households (p-values in parentheses)

Indicator	N Whole sample	(1) Mean non-connec. HH	(2) Difference connect. vs. non-connect. HH*
Has TV at home	213,185	0.07	0.177 (0.000)
watches TV	213,017	0.19	0.234 (0.000)
watches TV at least weekly	213,017	0.08	0.165 (0.000)
watches TV at least daily	213,017	0.02	0.065 (0.000)
Has radio at home	213,302	0.57	0.131 (0.000)
Listens to radio	213,105	0.57	0.125 (0.000)
Listens to radio at least weekly	213,105	0.39	0.127 (0.000)
Listens to radio at least daily	213,105	0.17	0.053 (0.000)
Has mobile phone at home	160,633	0.38	0.206 (0.000)

Source: DHS all country data set.
Notes: *difference between households with and without electricity estimated by means of a probit estimation, controlling for all cluster, household, and respondent characteristics presented above.

As displayed in Table 4, column 1, also non-electrified household watch TV, listen to the radio, and have mobile phones. They either operate these appliances on dry-cell batteries (radios) or have a generator or solar panel to power a TV set. Households without electricity source at home visit neighbours, bars, or shops to watch TV or listen to the radio. They charge their mobile phone at neighbours', schools, health stations or in shops where phones can be charged for a fee. Yet, connected households have significantly better access to these information and entertainment sources (see Table 4,

column 2). They own more TV sets and watch TV more frequently, own more radios and have more mobile phones.

Regarding female labour participation, it can be observed that virtually all women pursue some kind of work apart from housework (see Table 5). These activities comprise working on the family's fields, selling things, helping in the family business, and salaried work. Of course, not all of these activities can be expected to influence attitudes toward IPV. The strongest effect can be expected from non-agricultural jobs outside the household. Earning money with the job can furthermore be expected to influence attitudes toward IPV.

Table 5: Female labour participation in connected and non-connected households (p-values in parentheses)

Indicator	N whole sample	(1) Mean non-connec. HH	(2) Difference connect. vs. non-connect. HH[a]
Woman works	221,839	0.99	0.017 (0.000)
Woman works in non-agricultural job	221,839	0.29	0.106 (0.000)
Works at home	141,993	0.33	0.018 (0.000)
Works self-employed	159,408	0.53	0.015 (0.001)
Earns money	225,816	0.67	0.072 (0.000)

Source: DHS all country data set.

Notes: [a]difference between households with and without electricity estimated by means of a probit model, controlling for all cluster, household, and respondent characteristics presented above.

A quarter of all women in non-connected households work in non-agricultural jobs, which are above all sales jobs (60 percent – not displayed in the table). Around 16 percent are skilled manual workers, six percent work as unskilled manual workers. The service sector employs further nine percent and six percent work in professional, technical or managerial occupations. Around one third of all women exercise the work at home, almost half of the jobs are self-employment and 70 percent earn money with their work. Women in grid connected households work significantly more often in non-agricultural jobs (see Table 5, column 2). Compared to women in non-connected

households, these non-agricultural jobs are more frequently in the services sector and professional activities. They are less often sales activities or skilled manual activities. Moreover, they are more likely to have a paid job.

Table 6: Results - Transmission channels (p-values in parentheses)

	(1) matching	(2) region diff-in-diff
HH has electricity	-0.024 (0.000)***	-0.109 (0.823)
Interactions		
TV & electricity	-0.032 (0.000)***	0.990 (0.139)
radio & electricity	-0.000 (0.984)	0.371 (0.606)
Non-agricultural job & electricity	-0.002 (0.790)	-0.032 (0.974)
Earns money & electricity	0.019 (0.005)***	-0.982 (0.102)
TV	-0.002 (0.749)	-0.036 (0.903)
Radio	-0.027 (0.000)***	-0.280 (0.092)*
Non-agricultural job	0.000 (0.981)	0.031 (0.823)
Earns money	-0.028 (0.000)***	-0.106 (0.197)
Cluster characteristics	Yes	Yes
HH characteristics	Yes	Yes
Respondent characteristics	Yes	Yes
Partnership characteristics	Yes	Yes
Country dummies	Yes	-
Year of data collection	Yes	Yes
Adj. R-Squared	0.12	0.04
Number of observations	35,465	220,083

Source: DHS all country data set. *Notes:* Coefficients are estimated by a Linear Probability Model with robust standard errors clustered at the household level. For the region difference-in-difference approach, standard errors are clustered at the region level. Detailed results can be found in the Annex.

In order to analyse the identified transmission channels in the regression analysis, I include corresponding interaction terms for all characteristics that are available in all waves and countries (see Table 6). In general, the results do not show a very clear picture. It seems that access to information is an important driver of changes in attitudes, even though results differ somehow in the matching and region difference-

in-difference estimation. The matching approach shows that having electricity and a TV at home decreases the probability of accepting IPV by three percentage points. Radio ownership induces a significantly negative effect. In the region difference-in-difference, the effect of TV points rather into the opposite direction.

Earning money is overall associated with lower acceptance of IPV even though not necessarily driven my better income possibilities due to electricity. The matching approach shows even an increase in acceptance of IPV when earning money and having electricity and earning money. Working in non-agricultural jobs seems not to make any difference.

7. Conclusion

This paper analysed the relationship between rural electrification and domestic violence in 22 Sub-Saharan countries. As an indicator for occurrence of domestic violence, it focussed on attitudes toward IPV among women between 15 and 49 years elicited by the Demographic and Health Surveys between 1999 and 2014. Descriptive analyses showed that the level of domestic violence varies substantially between countries and over time. In all but one country, levels of consent to IPV decreased over the last 15 years, but to very differing degrees. Differences in prevalence can be explained by individual and community and macro-level factors. Among individual factors, especially education and the woman's age stand out as the main protecting factor against IPV. Risk factors are associated with being Muslim and having been exposed to domestic violence during childhood. Furthermore, women in larger households and more traditional relationships with a higher age difference between the partners and who entered cohabitation at younger ages are more likely to accept IPV.

Women in households with electricity report significantly lower acceptance of IPV. However, this relationship can be assumed to be substantially driven by

unobservables. Matching and region difference-in-difference approaches are able to control for parts of this endogeneity and reduce the effect of electricity on IPV acceptance substantially. In the region difference-in-difference approach, the effect even turns positive and insignificant. Moreover, the matching results are sensitive to bias. Following Rosenbaum (2002), a sensitivity analysis shows that a hidden bias of the magnitude of 1.3 would explain away the observed effect.

These results do not come as a surprise since changes in gender roles are usually understood to be rather slow processes and this analysis only covers a time period of between 5 and 10 years. Also, large cross-country differences in attitudes towards IPV suggest that societal institutions and cultural expectations play an important role in shaping attitudes towards IPV. For these to change, it probably takes more than a decade.

Accordingly, data covering longer time periods and stronger identification strategies are needed to definitely assess the impact of electricity on IPV. If it could be confirmed that access to electricity effectively decreases IPV, it would also have huge implications on social cost. Violence against women and girls are often estimated to generate costs amounting to billions of dollars and go up to more than 4,000 billion USD, which is equivalent to 5% of the world's GDP in 2013 (DAY et al. 2005 and HOEFFLER AND FEARON 2014). If these numbers are true, even the high investment costs of rural electrification appear to be acceptable. Also the Sustainable Development Goal 5 on gender equality asks to "eliminate all forms of violence against all women and girls in the public and private spheres". The goal is clear, the way to reach it is not. In the short run, rural electrification seems not to be the panacea.

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Annex 1: Details on Propensity Score Matching Approach

Since the decision to connect to the electricity grid is a household decision, I use households rather than women as the matching unit. In the first step I estimate a probit model and regress the connection status of a household on a number of covariates for all countries separately. Results are displayed in the first column of Figure A1_1 below. In a second step, I use the coefficients from this regression to predict the probability to connect among all households that live in clusters without electricity access. A cluster is considered to have no electricity access if none of the households surveyed within the cluster has a grid connection. I thereby exclude as matching partners households in electricity access areas that have deliberately decided not to connect since they might be affected by the treatment through spill-overs and can be assumed to be substantially different from connected households. The estimated probabilities, also known as the propensity scores, are then used to identify matching partners using a nearest neighbor algorithm without replacement.

Figure A1_1: Probit estimations before and after matching (p-values in parentheses)

	Before matching	After matching
distance_nearesturban	-0.001	-0.001
	(0.000)	(0.000)
water_piped_vill	0.098	0.120
	(0.000)	(0.000)
hoh_higher_edu	0.090	0.080
	(0.000)	(0.000)
head_hh_female	0.017	0.042
	(0.000)	(0.000)
age_firstcohabitation	0.003	0.004
	(0.000)	(0.000)
Pseudo R-Squared	0.26	0.04
Wald test	20,333.76	1,393.59
p value	0.00	0.00
Number of observations	224,598	43,151

Note: Country dummies included. *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

The distribution of the propensity scores among connected households and non-connected household in non-electrified areas is displayed in Figure A1_2.

In order to assess whether the comparability of the groups has improved through the matching approach I look at differences in means of the covariates between the connected households and the control households. As can be seen in Figure A1_3, the difference between the groups to be compared becomes substantially smaller if we only use the matched sample. However, differences stay statistically significant. As a second way to test the quality of the matching process, we look at the pseudo-R^2 of the probit model, regressing the connection status on covariates used for the matching. First, we use all non-connected HH as counterfactual (see Figure A1_1, column 1) and then we use only the matched non-connected ones (Figure A1_1, column 2). The pseudo-R^2 is expected to fall if a balance improvement is achieved. This is what

we see in our data: the pseudo-R^2 falls from 0.26 to 0.04. However, the respective Wald test shows a joint significant influence of the covariates in the non-matched and matched case. Accordingly, the matching approach is able to increase the comparability substantially. Differences between the two groups still exist, though.

Figure A1_2: Distribution of propensity scores among connected households (1. Yes) and non-connected households in non-electrified areas (0. No)

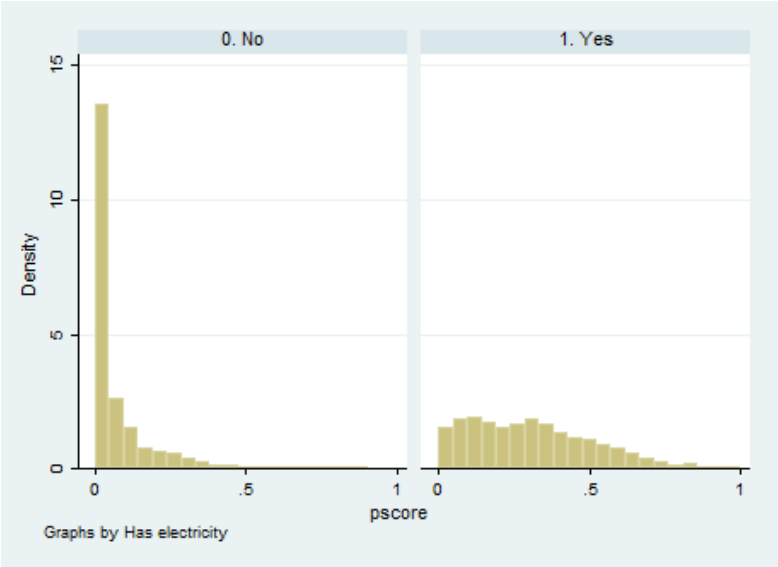

Figure A1_3: Balancing of covariates between treatment and control group

Difference in means of covariates	Before matching	After matching
distance_nearesturban	-8.09***	-2.19***
water_piped_vill	0.21***	0.08***
hoh_higher_edu	0.23***	0.08***
head_hh_female	0.03***	0.02***
age_firstcohabitation	1.22***	0.54***

Note: difference in means between connected and non-connected households. Country dummies included. *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

Annex 2: Details on results in Section 6

Annex 3: Robustness of index construction

Coefficient of electricity connection; no control variables

Annex 4: Individual country regressions