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A global analysis of progress in household electrification

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ABSTRACT

Universal electricity access is an important element of the United Nations Sustainable Development Goals, and global efforts to monitor progress in electrification have recently escalated. To inform these efforts, we describe a new database of total, rural, and urban electrification rates across the world. Using transparent coding criteria and decades of data, going back to the 1960s for many countries, from nationally representative surveys and official reports from 124 non-OECD countries, we uncover evidence for rapid progress in household electrification relative to earlier estimates. Our comprehensive and freely available database offers a solid baseline for tracking progress in household electrification across the world. We confirm a robust association between per capita income and household electrification, and identify population density and urbanization as additional key drivers.

1. Introduction

The United Nations Sustainable Development Goal (SDG) #7 strives to "ensure access to affordable, reliable, sustainable and modern energy for all," as a large body of literature suggests that access to a reliable an affordable supply of electricity and clean cooking fuels can contribute to healthier, more convenient, and more productive lives (Dinkelman, 2011; Barnes, 2014; Greenstone, 2014; Aklin et al., 2016). To support progress toward the energy access SDG, the World Bank has established a Global Tracking Framework (GTF) that measures progress in energy access over time (World Bank, 2017). The GTF is a unified set of metrics toward meeting the clean energy access SDG, with progress in electrification playing a central role.

While the GTF itself is a major achievement in measuring progress toward universal electricity access, it does not solve the problem of establishing a reliable historical baseline for national electrification rates around the world. The fundamental barrier to the robust tracking of progress in electrification is the lack of a good baseline, as the quality of historical data on rural electrification remains poor. Existing datasets on national electricity rates by the World Bank and the International Energy Agency (IEA) (World Bank, 2017; IEA, 2016) are not only incomplete, but are only available for the post-1990 period and include values that are based on simulation or interpolation (see Section 2). Assessing progress toward universal electricity access is greatly complicated by the lack of high-quality data on historical rates of progress by different countries. Historical data on changes in total and urban electrification would allow policymakers to compare their progress with previous rural electrification efforts and learn from past successes and failures.

To address this challenge, we describe a new database of total, rural, and urban electrification rates across the world.[1] With decades of data based on nationally representative surveys and official reports from 124 countries outside the OECD and post-communist world, we present the largest and most detailed dataset on electrification to this date. The dataset is based on transparent coding criteria, does not contain any information that relies on simulations or interpolations, and includes observations for the pre–1990 period (our dataset covers the period 1949-2015; see Section 2). We use the database to offer updated estimates on progress in electrification across the world and link this progress to country characteristics from income per capita to population density, urbanization, and natural resource rents. The fully documented data are freely available for non-commercial use to any interested users, and the sources for every data point are described in full in the replication archive.

We find evidence of rapid progress in total and rural electrification across the world. Our estimates suggest that past numbers, such as the

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[1] Collecting data on both urban and rural electrification rates are necessary since the urban rate alone does not always convey the correct picture. For instance, the total electrification rate for Chile in 1960 was 70.6%, a fairly high rate for this period. But this was achieved mainly through urban electrification (86.3%) while rural electrification still languished (23.9%).

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GTF estimates, have substantially underestimated progress in electrification over the past decades. This result is robust to excluding our pre-1990 observations, excluding outliers, and various estimation strategies, including fractional logistic regressions. Indeed, nation-level trends in electrification rates are mostly linear over time. Even Sub-Saharan Africa, where electrification rates are usually much worse than any other region, performs better than previous estimates. These results show that the World Bank's interpolation approach understates nation-level progress in household electrification.

We also confirm the robust link between electrification rates and per capita income, and show that high population densities and urbanization go a long way toward explaining why some countries have achieved high electrification rates even under low incomes per capita. In contrast, democratic political institutions and natural resource rents do not explain overperformance in progress toward universal electrification.

2. Methodology and data

Our sample includes non-OECD countries with a population of at least 300,000 and that have reliable electrification data. This means that wealthy western European nations and post-Soviet countries with a universal electrification rate early on are not part of our sample. That also applies to conflict-ridden or completely closed political systems like Afghanistan, Iraq, and North Korea. In effect, our sample comprises of 124 countries spanning 15 regions (see Table S1, which contains the coverage for our data and the World Bank's).

We followed three different rules when compiling the data. First, we defined national/urban/rural electrification rates with respect to households, i.e., the proportion of total/rural/urban households within a country that had access to electricity. This was the easiest way to ensure consistency across the sample. However, in some cases we could not find the household electrification rates and instead used the proportion of the population. Second, we focused on access to grid electricity. So when there were electrification rates provided by different access types, we favored the numbers connected to the main grid. However, sometimes sources did not make such clear distinctions and in these cases we relied on the number provided. We ensured to exclude households whose primary source of electricity is solar power; this makes sense since these households are likely not connected to the grid. Third, in cases where we had two of three (total/rural/urban) electrification data points for a given year, we used the population data from the World Bank Development Indicators for that year and calculated the third value. This calculation is superior to trend-based simulations since it takes the population levels into account.

We used many different sources to collect the electrification data. First, we used the national census where available. We thought this to be the most reliable source of electrification data. These data were generally obtained either from the country-specific national statistical offices or from hard-copy reports. Second, we used nationally representative household surveys that included questions on electricity access. As with the census, we sometimes used survey reports that were published by the national statistical office or downloaded the actual survey data and calculated the electrification rate using the appropriate variable. When neither the census nor national representative surveys were available, we used other reliable government agency statistics and published journal articles. We used data from the Demographic & Health Survey only when its rates were in line with the trend. In cases where multiple sources listed different electrification rates for a given year, we used the more credible and nationally representative source. The dataset is accompanied by a reference document that lists the source used for each separate observation.

2.1. Data coverage

In total, we have 1065 observations for 124 countries across 15 different regions in Asia, Africa, Latin America, Middle East, Eastern Europe and the Caribbean between years 1949–2015. The number of data points for total electrification rate is 1008; the numbers for rural and urban electrification are 723 and 666, respectively. All numbers used in the analysis are based on the data we have collected. Unlike World Bank (2017), we do not simulate any data points.

Table S1 shows data coverage by region. There is considerable variation in the data collected across different regions. Some countries (e.g. in Latin America) had representative surveys conducted every few years (or sometimes every year) allowing us to collect rich electrification data. Governments in some others (e.g. in the Middle East) put out reliable electrification data at less regular intervals. Eastern and Western Africa have the most number of countries in the dataset (16 each), whereas Eastern Europe and East Asia have the least number of countries (2 each). South America with 12 countries has the most comprehensive for total, urban, and rural electrification rates. Along with South America, both East and West Africa represent the regions with the most electrification data available. On the other hand, Southern and Eastern Europe have among the least available data, in part because the electrification rates in these countries reached 100% early on.

Fig. S1 shows variation in data coverage over time. It shows that the available data increased over time, a trend that is consistent with more nationally representative household surveys over time. It is also possible that national governments were more better at collecting electrification data for both rural and urban areas and more open at releasing them to the wider public over time. To compare the coverage of World Bank (2017) and the new database, see Fig. S14.

2.2. World Bank: global tracking framework data

The World Bank GTF for the United Nations Sustainable Energy For All (SE4ALL) initiative contains electrification data (total, rural, urban) based on nationally representative household surveys (World Bank, 2017). The data are based on about five hundred surveys, and missing values are then imputed with results from statistical simulations. The dataset contains observations for the years 1990–2012 for 198 countries. The total electrification rate is available for 24.7 years for the average country, though the vast majority of observations are simulated. The key difference between the GTF and our data is thus that we only use actual observations based on reliable, nationally representative data. Fig. S11 compares our data with the GTF data.

There are multiple differences between our data and the GTF. For instance, GTF used survey sources to document that Namibia had achieved 37% electrification in 2001. However, the census for the same year lists a 32% electrification rate. The discrepancies are more prevalent, however, when GTF uses simulations: Nigeria and Yemen are listed as having a 43% and 51% electrification rate in 2006 and 2004 respectively, whereas we find an electrification rate of 21% and 42% when we use a nationally representative survey and census information. The disparities are not limited to Africa or an overestimation of electrification rates. For example, the GTF lists Thailand as having an electrification rate of 82% in 1996 but we use census sources and find that the country had already achieved 96% electrification.

To ensure that the results below were not driven by ceiling effects, we removed countries from the regression analysis after they reached a 99% electrification rate. To see why leaving them in the dataset would be problematic, visualize a figure that has time on the x-axis, and electrification on the y-axis. A long series of values above 99% would gradually flatten the effect of time. Thus, we set observations to missing once they reach 99%, which in practice means that the country has achieved full electrification. We do so separately for total, urban, and rural electrification in both the GTF and our dataset. For an analysis of time effects without the removal of fully electrified countries, see Tables S6–S8.