EEG Theme 3, Paper 2 Overview

Electricity Reliability and Urbanization: A Microeconomic Research Agenda

Paul Gertler, University of California, Berkeley
Ken Lee, University of California, Berkeley
A. Mushfiq Mobarak, Yale University

November 4, 2016

In rural areas, electricity access is the priority

1.2 billion people lack access to electricity (IEA 2015).

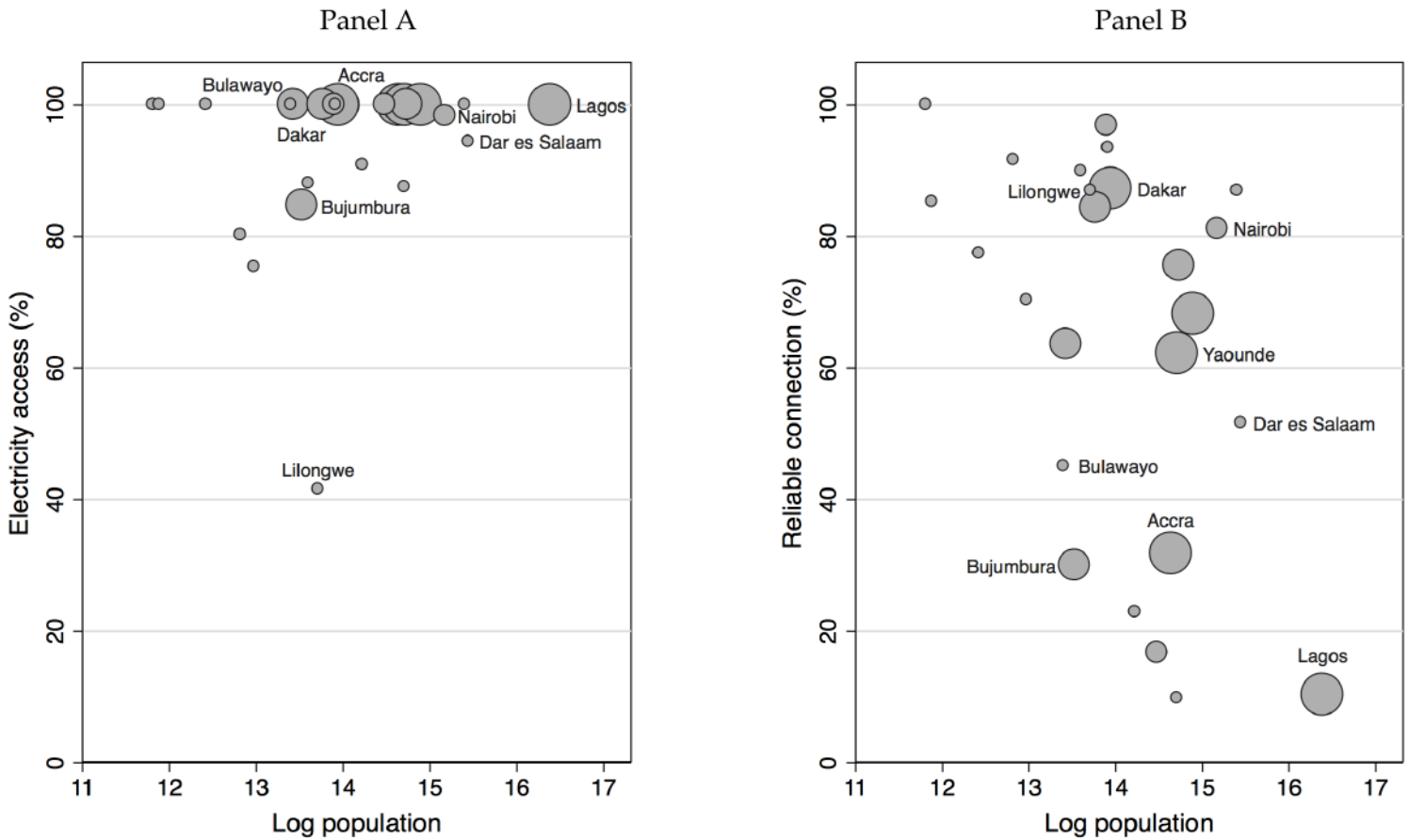
Micro studies focus on rural settings: low access rates, agricultural workforces.

What happens to rural households and villages when they are electrified for the first time?

- Dinkelman (2011) (South Africa)
- Lipscomb, Mobarak, Barham (2013) (Brazil)
- van de Walle et al. (2015) (India)
- Barron and Torero (2016) (El Salvador)
- Chakravorty, Emerick, and Ravago (2016) (Philippines)
- Burlig and Preonas (2016) (India)
- Lee, Miguel, and Wolfram (2016)

But in cities, reliability is the problem

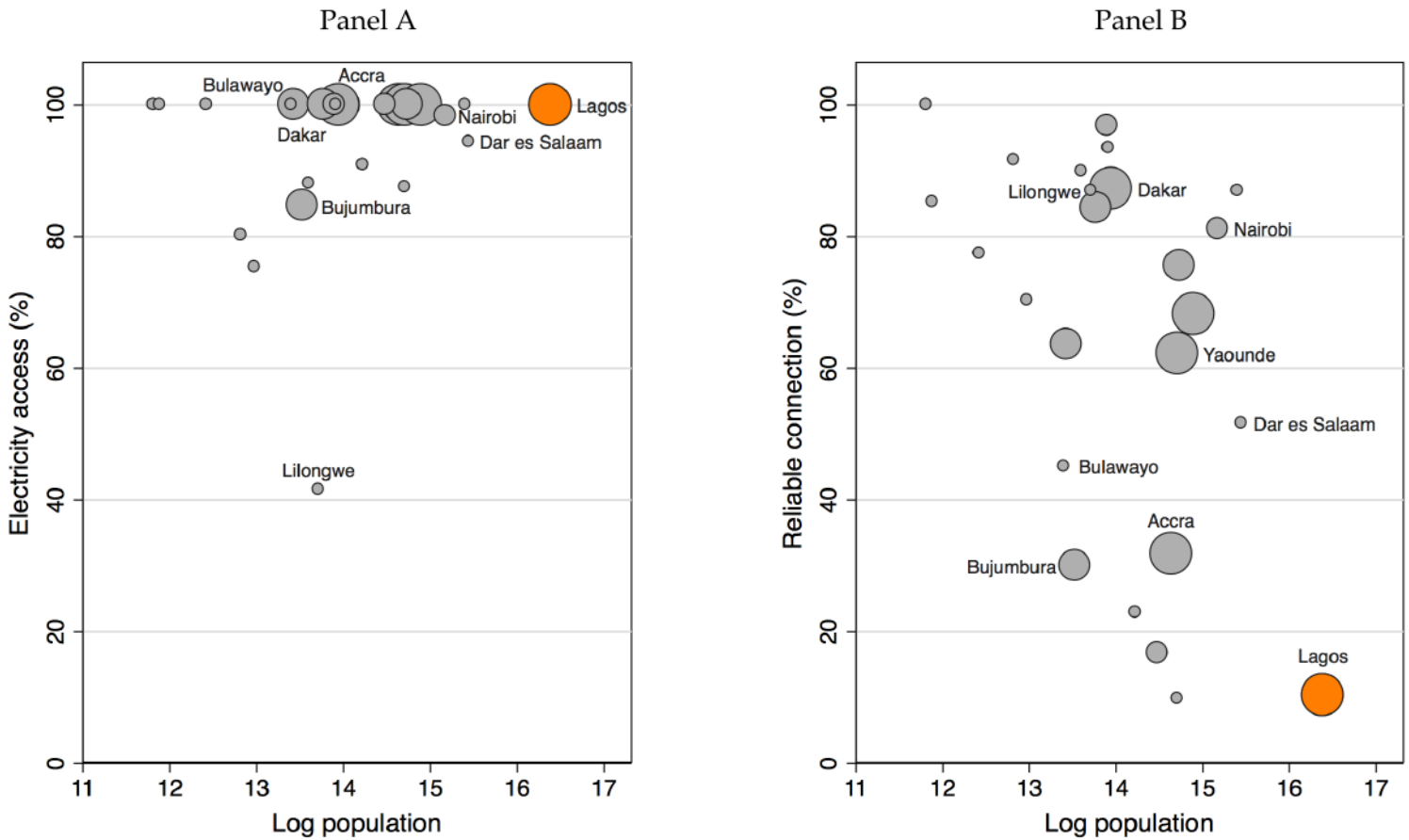
Figure 1—Electricity access and reliability in major cities in Sub-Saharan Africa



Notes: Markers are scaled to reflect the estimated population density for each city. Electricity access is defined as being located in an area with an electricity line nearby. Reliable connection is defined as an electricity connection that works "most of the time" or "all of the time". Based on Afrobarometer survey data (Round 6).

But in cities, reliability is the problem

Figure 1—Electricity access and reliability in major cities in Sub-Saharan Africa



Notes: Markers are scaled to reflect the estimated population density for each city. Electricity access is defined as being located in an area with an electricity line nearby. Reliable connection is defined as an electricity connection that works "most of the time" or "all of the time". Based on Afrobarometer survey data (Round 6).

The New York Times

AFRICA

Weak Power Grids in Africa Stunt Economies and Fire Up Tempers

By NORIMITSU ONISHI JULY 2, 2015

Nigeria's electrical grid churns out so little power that the country mostly runs on private generators. So when a fuel shortage struck this spring, a national crisis quickly followed, disrupting cellphone service, temporarily closing bank branches and grounding airplanes.

"With the advent of democracy, we were promised constant power, or at least improved power," he added. "But much to our surprise, things have only gotten worse. In some middle-class parts of Lagos, people are lucky if they now get 30 minutes of power a day."

Outline

What are the causes and consequences of electricity outages in urban centers?

In our framework, existing and future work is organized around three questions:

1. What are the causes of outages and what can be done about them?
2. How are suppliers and consumers responding to outages?
3. What are the impacts of outages on productivity and growth in cities?

Causes of outages

Causes

Outages may be planned or unplanned, and caused by supply, demand, and political factors.

Set of factors is likely to the same in cities and rural areas.

A. Supply side factors

1. Insufficient generation — Alam (2013), Allcott, Collard-Wexler, and O'Connell (2016)
2. Fuel mix diversity — Allcott, Collard-Wexler, and O'Connell (2016)
3. Network fragility — Anderson and Dalgaard (2013), Burlando (2014), Lee, Miguel, and Wolfram (2016b)
4. Scheduled maintenance

Causes

Outages may be planned or unplanned, and caused by supply, demand, and political factors.

Set of factors is likely to the same in cities and rural areas.

A. Supply side factors

1. Insufficient generation	Alam (2013), Allcott, Collard-Wexler, and O'Connell (2016)
2. Fuel mix diversity	Allcott, Collard-Wexler, and O'Connell (2016)
3. Network fragility	Anderson and Dalgaard (2013), Burlando (2014), Lee, Miguel, and Wolfram (2016b)
4. Scheduled maintenance	

B. Demand side factors

1. Capacity overloads	Carranza and Meeks (2016)
2. Unexpected shocks	Fisher-Vanden, Mansur, and Wang (2015)
3. Illegal connections	Jamil (2013)

Causes

C. Political economy considerations

1. Subsidy "trap"	McRae (2015) (Colombia)
2. Cross-subsidies	Alam (2013) (India), Harish and Tongia (2014) (India)
3. Political motives	Min and Golden (2013) (India), Baskaran, Min, and Uppal (2015) (India)
4. Bribes, corruption	Olukoju (2004) (Nigeria), Kojima, Bacon, and Trimble (2014) (SSA), Pless, Bazilian, and Fell (2014), Lee, Miguel, and Wolfram (2016) (Kenya)
5. Vandalism, theft	

Solutions

Identifying appropriate solutions will depend on understanding the causes of the outages.

e.g., energy efficient appliances to address local overloads (Carranza and Meeks 2016)

But there is very limited data on even the most basic patterns and causes of outages in cities.

Solutions

Identifying appropriate solutions will depend on understanding the causes of the outages.

e.g., energy efficient appliances to address local overloads (Carranza and Meeks 2016)

But there is very limited data on even the most basic patterns and causes of outages in cities.

EEG research areas:

We need basic high frequency spatial data on patterns of outages in cities.

What is driving these outages? For example, how do political economy considerations exacerbate the frequency of outages, or result in variations in the quality of supply for different groups of users? What can be done about outages?

Supplier and consumer responses to electricity outages

Supplier responses

Long run options:

- Invest in new capacity
- Improve network quality

Short run options:

- Dynamic pricing to smooth demand (e.g., peak pricing)
- Design tariffs to incentivize consumption in certain sectors
- Load shedding (i.e., rolling blackouts)

Load shedding

When demand exceeds available supply, utilities may ration power through load shedding.

Consumers in different regions may experience different levels of load shedding. In Karnataka, rural users experience more blackouts.

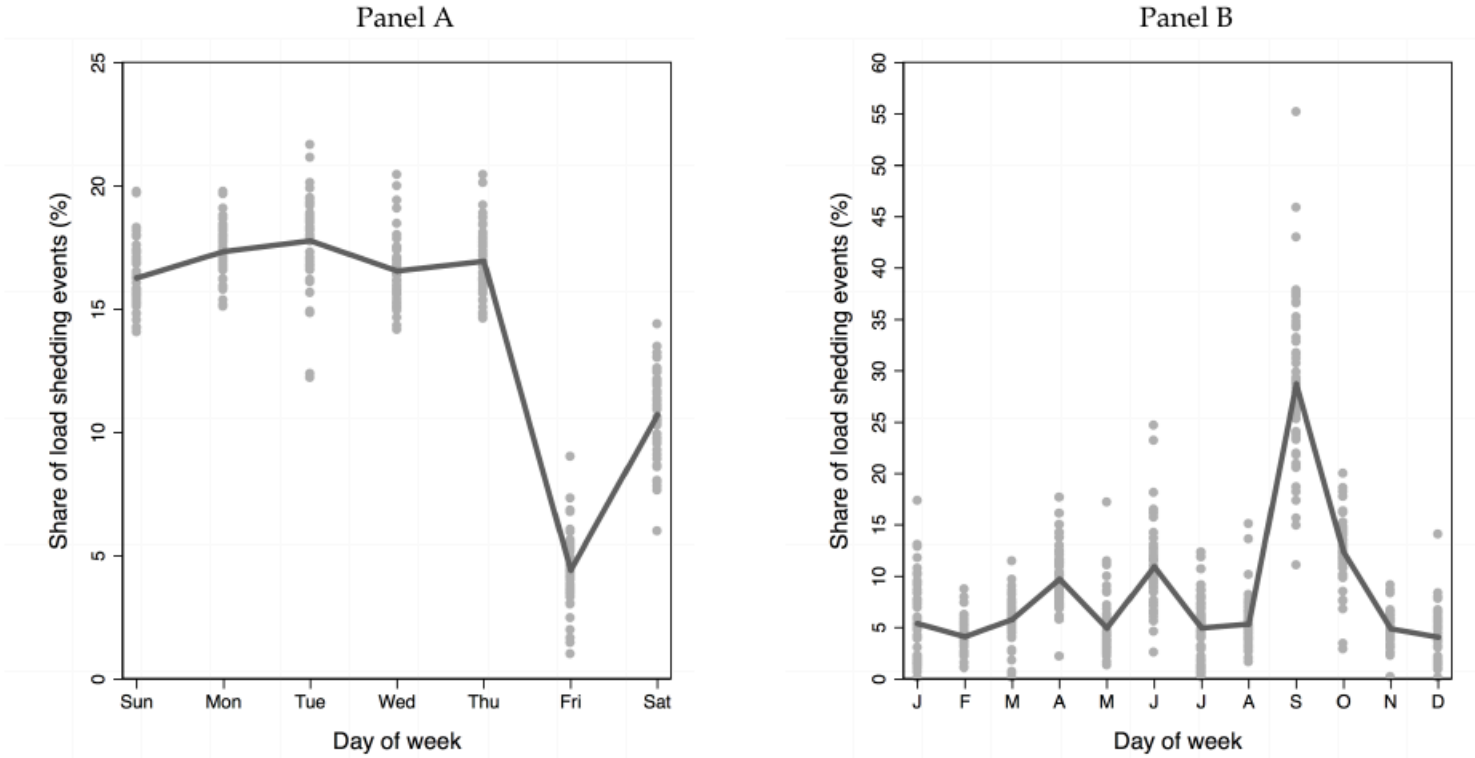
Harish and Tongia (2014) (India)

How might load shedding vary within a city?

We examine data on nearly 180,000 load shedding events in Dhaka, Bangladesh, between 9-2012 to 9-2014.

Patterns of load shedding in Dhaka, Bangladesh

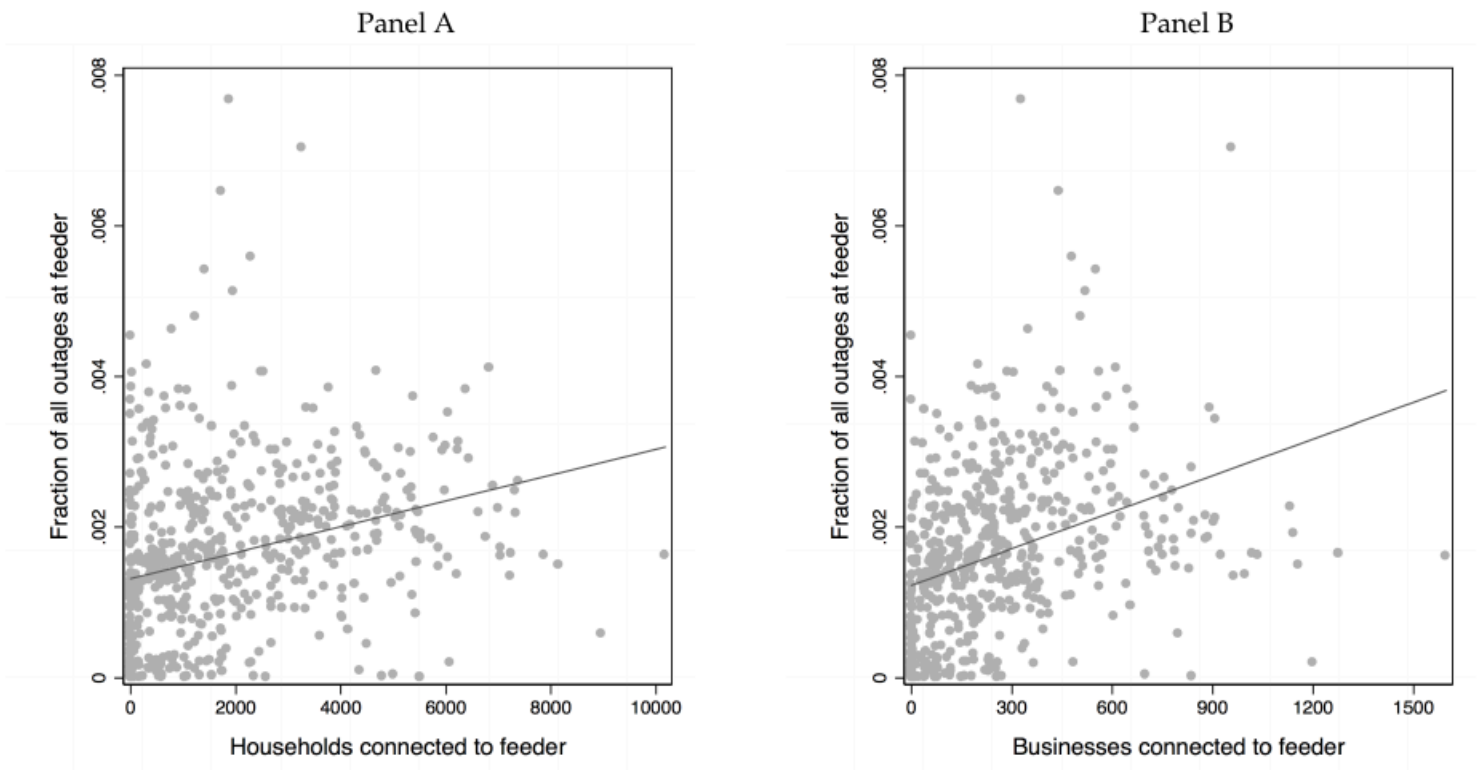
Figure 2A—Weekly and seasonal variation in load shedding in Dhaka



Notes: Each point represents the fraction of all substation load shedding events to occur either on a specific day of the week or during a specific month. The dataset covers all load shedding events in Dhaka between September 2012 and September 2014. In total, there are 52 substations and 648 feeder lines. The number of feeder lines attached to each substation ranges from 4 to 35, with a median of 13. Over the course of the 25 months covered by the dataset, there were nearly 180,000 load shedding outages in total, or 7,157 outages per month on average. The median duration of each outage in our dataset is 60 minutes.

Patterns of load shedding in Dhaka, Bangladesh

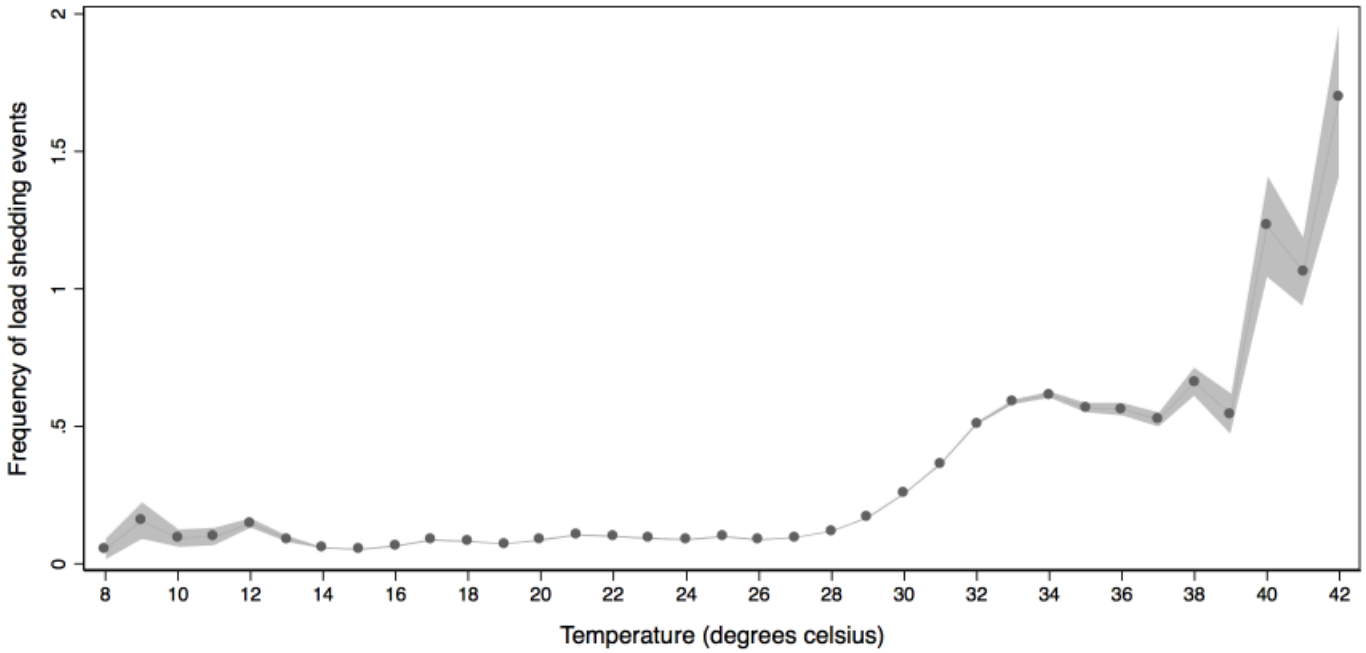
Figure 2B—Household and business density variation in load shedding in Dhaka



Notes: Each point represents the fraction of all outages (between September 2012 and September 2014) that occurred on a specific feeder line.

Patterns of load shedding in Dhaka, Bangladesh

Figure 2C—Temperature variation in load shedding in Dhaka



Notes: The vertical axis indicates the frequency of load shedding events at the level of the substation.

Consumer responses

Firms adapt to electricity shortages.

- Invest in back-up generators, substituting grid electricity with diesel power.

  Steinbuks and Foster (2010) (SSA), Reinikka and Svensson (2002) (Uganda), Adenikinju (2003) (Nigeria), Allcott, Collard-Wexler, and O'Connell (2016) (India)

- Outsource, substituting electricity inputs with other intermediate inputs.

  Fisher-Vanden, Mansur, and Wang (2015) (China)

- Adjust their production technology and/or production schedule.

  Alam (2013) (India)

Consumer responses

Firms adapt to electricity shortages.

- Invest in back-up generators, substituting grid electricity with diesel power.

  Steinbuks and Foster (2010) (SSA), Reinikka and Svensson (2002) (Uganda), Adenikinju (2003) (Nigeria), Allcott, Collard-Wexler, and O'Connell (2016) (India)

- Outsource, substituting electricity inputs with other intermediate inputs.

  Fisher-Vanden, Mansur, and Wang (2015) (China)

- Adjust their production technology and/or production schedule.

  Alam (2013) (India)

EEG research area:

How do households, firms, and public facilities adapt to outages?

Impacts of electricity outages on productivity and growth in cities

How large are the impacts?

Studying outages is difficult because of limited data and outages are not random.

Macro impacts are potentially large (2 to 3% of GDP in SSA).

World Bank (2015) (SSA), Anderson and Dalgaard (2013) (SSA), Fried and Lagakos (2016) (SSA)

Limited evidence of household impacts on labor and health.

Burlando (2014) (Tanzania)

Evidence that adaptation reduces negative impacts for firms.

Fisher-Vanden, Mansur, Wang (2015) (China), Allcott, Collard-Wexler, and O'Connell (2016) (India)

Suggestive evidence that shortages impact industry structure in the long-run.

Alby, Dethier, and Straub (2012), Alam (2013), Allcott, Collard-Wexler, and O'Connell (2016)

Supply quality and urban agglomeration

At city-level, few studies address linkages between power quality, productivity, and growth.

Like other place-based policies, rural electrification can induce migration responses resulting in the overcrowding of inelastically-supplied local public goods.

- Dinkelman and Schulhofer-Wohl (2015)

Competing effects of improving the quality of electricity supply in cities.

- Enhances agglomeration forces; local businesses become more productive, generating positive spillovers.
- Overcrowding and congestion of complementary infrastructure, such as roads and sanitation.

Supply quality and urban agglomeration

At city-level, few studies address linkages between power quality, productivity, and growth.

Like other place-based policies, rural electrification can induce migration responses resulting in the overcrowding of inelastically-supplied local public goods.

- Dinkelman and Schulhofer-Wohl (2015)

Competing effects of improving the quality of electricity supply in cities.

- Enhances agglomeration forces; local businesses become more productive, generating positive spillovers.
- Overcrowding and congestion of complementary infrastructure, such as roads and sanitation.

EEG research area:

What are the short and long run impacts of outages on productivity, industry structure, and urban agglomeration?

Future directions

Research agenda

EEG #1: We need basic high frequency spatial data on patterns of outages in cities.

EEG #2: What is driving these outages? For example, how do political economy considerations exacerbate the frequency of outages, or result in variations in the quality of supply for different groups of users? What can be done about outages?

EEG #3: How do households, firms, and public facilities adapt to outages?

EEG #4: What are the short and long run impacts of outages on productivity, industry structure, and urban agglomeration?

EEG #5: How major cities in the newly industrialized countries have historically addressed constraints to electricity supply. What mix of technological and economic solutions have been utilized and to what extent are these solutions relevant today?