Exploring the Relationship Between Load Shedding and Crime in Gauteng

Bhavesh Ram
University of San Francisco, bhavesh.ram@gmail.com

Follow this and additional works at: https://repository.usfca.edu/thes

Recommended Citation
https://repository.usfca.edu/thes/1572

This Thesis is brought to you for free and open access by the All Theses, Dissertations, Capstones and Projects at USF Scholarship: a digital repository @ Gleeson Library | Geschke Center. It has been accepted for inclusion in Master's Theses by an authorized administrator of USF Scholarship: a digital repository @ Gleeson Library | Geschke Center. For more information, please contact repository@usfca.edu.
Exploring the Relationship Between Load Shedding and Crime in Gauteng

May, 2024

Bhavesh Ram
MS Applied Economics Student

Arman Khachiyan
Faculty Advisor

Department of Economics

University of San Francisco

Abstract
This study investigates the impact of load shedding, a recurring power outage phenomenon in South Africa, on crime rates in the densely populated Gauteng province. Using a novel dataset that combines Eskom's load shedding schedules with detailed crime statistics from 2015 to 2022, a fixed-effects regression model is employed to examine the relationship between blackout hours and various crime categories.

Findings reveal that while load shedding does not significantly affect overall crime rates, it significantly increases the incidence of contact crimes and sexual offenses, particularly during daylight hours. Additionally, our results provide evidence that load shedding diminishes the ability of Police to detect crimes, whether through reducing effectiveness or lowering levels of policing.

This study contributes to the literature by providing a nuanced understanding of how load shedding influences specific crime types and by highlighting the differential impact of blackouts based on the time of day. The results could have important implications for policymakers and law enforcement agencies seeking to mitigate the adverse effects of load shedding on public safety in South Africa.
Acknowledgements and Dedication

Always in my heart, I deeply appreciate the support and encouragement of my dear friends and family. You know who you are. Special thanks to my inspiring, selfless parents, Val and Rabin. None of this would have been possible without you. Thank you to Diksha and Ricky, for being so contagiously excited about research! (nerds), and being my cheerleaders all the way.

My deepest thanks to my advisor, Dr Arman Khachiyan, for having me as your student. Your unwavering patience, brilliant insight and generosity of knowledge were my guiding light in this process (load shedding or not!), and pursuit of my degree.

To the USF community, Economics department, Graduate Student Senate, my cohort and peers, thank you for your continuous support and keeping me sane. Thank you to Chaitanya, Shiv, Devin, Lucie and Yan for your sage advice on this work.

To SFMG and SRF – my spiritual family, my deepest gratitude for guarding and guiding my every step.

Herman, Dan and the team at EskomSePush – besides the incredibly useful app, thank you for your diligence in collecting, verifying and maintaining load shedding data, and making this resource freely available. Thank you to Michael Howe-Ely for guiding me on data collection. To all my teachers, and everyone that’s helped me on the way, dankie.

This work is dedicated to the people of South Africa. Your resilience, fortitude, diversity, creativity, tenacity and inexhaustible humour are the true light of our nation, and an indomitable beacon for this world. Morena boloka setjhaba sa heso.

All errors are my own.
Introduction & Literature Review

A Brief History of Eskom

The transition to democracy in South Africa in 1994 ushered in an era of profound transformation, marked by the dismantling of apartheid and the pursuit of social and economic equality. This transition, while liberating, also exposed the stark realities of decades of systemic inequality and underdevelopment. Nelson Mandela’s newly elected ANC government faced the daunting task of addressing pervasive disparities across all sectors, with a particular emphasis on expanding essential services and infrastructure which had previously been privy to a minority of South Africans.

One of the most pressing challenges in this endeavor was the need to drastically expand access to electricity. In the early 1990s, only 30% of the population, primarily concentrated in urban areas, had access to reliable electricity. The government, recognizing electricity as a fundamental enabler of economic development and social progress, embarked on ambitious electrification programs. These initiatives aimed to extend the reach of the national grid, with the goal of providing electricity to over 80% of the population by the mid-2000s (Eskom Heritage, 2024).

Eskom, the state-owned power utility founded in 1923, is a central role player in the story of the electrification of South Africa. During the apartheid era, between the 1950s and the early 1990s, Eskom’s capacity increased from 1,500 MW to approximately 40,000 MW. This expansion included the construction of several large coal-fired power stations, which helped South Africa achieve some of the lowest electricity costs globally during that period (A Short History of ESKOM, Part 1 (1923-2001), 2022).
Load Shedding: Eskom’s Infrastructure Inadequacy

State of the art until the 1970’s, Eskom’s infrastructure was not accessible to most of the population and therefore did not have the capacity to support true electricity demand in South Africa. This infrastructure remained largely unchanged until the inception of democracy, and, the rapid expansion of electricity access, coupled with growing demand from a burgeoning population and expanding economy, placed immense strain on Eskom’s infrastructure and operational capabilities. The legacy of apartheid-era underinvestment in generation capacity, and post-democracy dearth of maintenance and upgrades had left Eskom with ageing power plants and an outdated grid. Moreover, the construction of new power stations, such as Medupi and Kusile, faced significant delays and cost overruns, exacerbated by allegations of corruption and mismanagement (De Ruyter, 2023). In the 30 years between 1994 and 2024, only approximately 9,200 additional MW of dispatchable power were added to Eskom’s generation capacity, including imports and emergency generation resources (Busisipho & Mischka, 2022) (Eskom, 2024).

These supply-side constraints, combined with the escalating demand for electricity, has created a precarious situation for South Africa’s energy supply. By 2007, Eskom was struggling to meet peak demand, leading to the implementation of “load shedding” (Loadshedding Explained, 2024).

Load shedding is a controlled and systematic process of reducing electricity demand on a power grid. It involves the intentional and temporary interruption of power supply to pre-selected areas, typically based on predetermined schedules and priorities. The primary goal of load shedding is to maintain the stability and integrity of the electrical grid by preventing a total blackout, which could have severe and widespread consequences for the entire country.

When first implemented in South Africa in late 2007, the timing, distribution and duration of load shedding blackouts were erratic and poorly communicated. This initial bout of load shedding
directly impacted production of the minerals and mining sector, a large consumer of electricity and the largest contributor to South Africa’s GDP. This led to a local recession in the last half of 2007. South Africans were granted a reprieve from rolling blackouts in the ensuing months, with sporadic blackouts in the first few months of 2008.

The collapse of a large coal storage silo at Majuba Power Plant, and abnormally inclement weather caused significant power generation issues stemming from coal shortages, resulting in sporadic load shedding being reintroduced in late 2014 and 2015. There was no load shedding for the period 2016-2017 reported by Eskom. Effectively suspended until 2018, when production issues began to surface at the new Medupi and Kusile power plants, load shedding was then implemented at an exponentially increasing scale. The level and intensity of load shedding blackouts implemented reached its peak in 2023, with 335 days in which there was at least one blackout and a total of 6,947 hours of load shedding nationwide.

Changes in Blackouts: Exponential Growth in Load Shedding over time. There were 335 days with at least one blackout in 2023 (Data: EskomSePush 2024)
Existing Literature and the Impact of Load Shedding

Load shedding has thus become a common occurrence in South Africa, with far-reaching impacts on various sectors including education (Kgarose, Makhubele, & Setaise, 2024), healthcare (Ngaduba, 2018), socioeconomics (Inglesi-Lotz, 2023), and potentially, crime (Lambongang, 2023).

The impact of load shedding extends beyond mere inconvenience, exerting a profound influence on the South African economy (Naidoo, 2023). Studies have consistently shown that load shedding negatively affects GDP growth and disrupts business operations, with some sectors being more adversely affected than others (Naidoo, 2023) (Zwelithini & Dumsile, 2022). Estimates place the economic cost of load shedding between ZAR 1.5 billion and ZAR 2.4 billion per day of load shedding (USD 80m – USD 130m¹) (Chamber, 2023). The uncertainty and disruptions caused by load shedding also deter investment and affect labor market dynamics (Owen, 2023). Further, the impacts of load shedding are not uniformly distributed spatially. Certain regions and demographic groups may bear a heavier burden, with disparities arising due to factors such as geographic location, income, employment status, and industry (Inglesi-Lotz, 2023).

The World’s Biggest Polluter?

In an environmental context, South Africa’s reliance on coal-fired power plants and the consequent load shedding episodes underscores the pressing need for a transition to more sustainable energy sources. The environmental cost of load shedding is far reaching. Ageing and poorly maintained generation units are responsible for releasing massive amounts of pollutants into the local environment. Eskom, South Africa’s primary power utility, generating 90% of South Africa’s electricity in 2024, is a significant contributor to pollution. It is the largest emitter of sulfur dioxide (SO₂) per capita globally, surpassing the power sectors of the EU, US,

¹ At an exchange rate of 18.60 at the time of writing
and China combined ((EDGAR), 2023). A study by Greenpeace rated Eskom as the lead polluter of nitrogen dioxide globally, operating six of the world’s ten worst polluting sites, and nine of the ten highest polluting sites in Africa (Greenpeace, 2023). Eskom's poor emissions record is primarily due to its reliance on power generation from coal. Its coal-fired power plants, also release large quantities of carbon dioxide (CO₂), other pollutants and greenhouse gases. These emissions contribute to severe air pollution, particularly in the Mpumalanga Highveld region, leading to substantial health impacts (Myllyvirta, 2021).

In terms of CO₂ emissions per capita, South Africa is among the highest globally due to its heavy reliance on coal for electricity. According to the World Bank, South Africa's CO₂ emissions per capita were around 8.2 metric tons in recent years, which is higher than many other developing countries but lower than some of the largest emitters like the United States (around 15 metric tons) and China (around 7.4 metric tons) (Myllyvirta, 2021).

The critical need to mitigate load shedding in the country has necessitated the intensified utilization of existing infrastructure and the adoption of environmentally harmful alternatives to stabilize the grid during peak demand periods. Notably, Open Cycle Gas Turbines (OCGTs), which exhibit higher emissions per megawatt-hour (MWh) compared to coal-fired plants and Combined Cycle Gas Turbines (CCGTs), have been employed for this purpose (CCGT’s) (Pram, Njabulo, & Adepoju, 2022).

The severe air pollution from South Africa's ageing coal-fired power plants and OCGTs has dire health implications which could increase crime rates. High levels of pollutants like sulfur dioxide (SO₂) and particulate matter (PM2.5) are linked to heightened aggression, impulsivity, and mental health issues, directly influencing aggressive crimes such as assault (Burkhardt, et al., 2019). Additionally, air pollution correlates with higher social inequality, lower cognitive function, and increases in violent crime (Abubakr, 2023), highlighting the multifaceted impact of environmental degradation on societal well-being. Thus, South Africa's current energy
infrastructure may perpetuate a vicious, mutually reinforcing cycle of environmental and social destruction.

A pivotal aspect of the socio-economic impact of load shedding in South Africa is its potential influence on crime rates, although to-date, few studies have been done to examine the impact of load shedding on crime, there is a general perception amongst South Africans that load shedding leads to increases in crime (TIMESLIVE, 2023). Police Minister, Bheki Cele, has mused that load shedding directly impedes the work of police, whether through bringing Police Stations to a standstill (Smit, 2023), through impacting communication systems or more directly, due to decreases in visibility when blackouts occur during the night (Nkanjeni, 2022).

Cele has also acknowledged the need to establish an identification strategy to quantify the impact of load shedding on crime but notes significant data constraints to achieving this aim (Maqhina, 2023).

**Blackouts and Crime: Theoretical and Comparative Perspectives**

A further argument for the potential link between load shedding and crime grounded in established criminological theories could be made. Routine Activity Theory, pioneered by Cohen and Felson, suggests that disruptions to routines, such as those created by blackouts, create opportunities for motivated offenders and diminish guardianship (e.g. gridlocked traffic) (Cohen & Felson, 1979). Opportunity Theory emphasizes the heightened sense of anonymity and reduced risk perception that can arise during blackouts as potentially encouraging criminal behavior (Clarke & Felson, 1993). Rational Choice Theory posits that individuals may reassess the cost-benefit analysis of crime based on how situational factors change (Derek & Clarke, 1986), suggesting that environmental changes such as those during blackouts result in a decreased perceived risk of detection (e.g. non-functional surveillance systems or lower levels of visibility), possibly motivating criminal activity during times of increased load shedding.
International comparisons offer further behavioral insights that persistent blackouts affect behavior. Research from Brazil finds that electricity rationing, and frequent power outages led to changes in behavior, such as lower energy consumption and lower appliance ownership, which are persistent even ten years after the initial shock (Alves, Faria, & Hiratuka, 2020). Although not directly related to crime, this finding highlights the possibility that the impact of load shedding on behavior could be more lasting than just for the duration of the blackouts.
Methodology

Geographic Focus
South Africa has nine provinces, or states. Gauteng, as the most urbanized province in South Africa, presents a unique and fertile ground for studying the impact of load shedding on crime, and this will be the geographic focus of the analysis presented.

This province, despite comprising only 1.5% of the country’s land area, is home to more than 25% of South Africa's population (15 million people) and is the most urbanized province in South Africa. Gauteng also contributes over 33% of the country's GDP (Four facts about our provincial economies, 2024).

Gauteng's distinct characteristics make it a compelling case study for investigating the nexus between load shedding and crime. The province's disproportionate population density, coupled with its urbanization, suggests that the repercussions of load shedding, particularly on crime, may be more readily observable and quantifiable in this context. Moreover, the concentration of economic activity and infrastructure in Gauteng could exacerbate the vulnerabilities exposed by power outages, potentially leading to more observable criminal responses to blackouts.

Map of South Africa: Gauteng is highlighted in red (Gauteng, 2024)
Data

Eskom Load Shedding Schedule
To improve its communication strategy, Eskom engaged in developing and implementing load shedding schedules in late 2008. This change came after the severe and unexpected power outages in January 2008, which highlighted the need for better management and communication. The implementation of these schedules allowed Eskom to provide more predictable and manageable power cuts, helping both businesses and households to plan around the disruptions. Implementation of load shedding and changes to its stages were communicated via Eskom’s website, through push messages, and occasionally on its Twitter feed.

The introduction of these schedules represented a shift towards greater transparency and reliability in Eskom's management of the electricity grid. This approach has continued, with Eskom regularly updating and communicating load shedding stages and schedules to the public (A Short History of ESKOM, Part 1 (1923-2001), 2022; Busisipho & Mischka, 2022).

The schedule of load shedding provided by Eskom provides guidance on the timing that individuals and businesses could expect to be disconnected from the electrical grid. The 24-hour day is segmented into twelve 2.5 hour timeslots with each slot overlapping the first 30 minutes of the next consecutive slot. An individualized blackout schedule can then be determined based on three factors; first is location (at a suburb level), second is the calendar day of the month and third is the stage of load shedding being implemented. Using these three factors, individuals can determine at which time slots during the day they could expect to experience blackouts.

Suburbs are categorized into 16 groups, with every suburb in a group following the same schedule per timeslot and calendar day of the month for a given level of load shedding. Load shedding is equally distributed to every suburb using this system: for a sustained level of load
shedding every neighborhood could expect to experience the same number of blackout hours per month. The scheduled timing of blackouts between neighborhoods is evenly allocated over calendar days so that each neighborhood can expect to have an equal number of blackouts during each time slot of the day over a calendar month, allowing for fair use of power over the course of the day per suburb, on average.

<table>
<thead>
<tr>
<th>Day of the month</th>
<th>STAGE</th>
<th>Static monthly version. This schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1:00</td>
<td>2:30 1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td></td>
<td>2:00</td>
<td>4:30 1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Province</td>
<td>4:00</td>
<td>6:30 1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Gauteng</td>
<td>6:00</td>
<td>8:30 1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>Select City</td>
<td>8:00</td>
<td>10:30 5 6 7 8</td>
</tr>
<tr>
<td>City of Johannesburg</td>
<td>10:00</td>
<td>12:30 4 1 2 3</td>
</tr>
<tr>
<td>Select Suburb</td>
<td>12:00</td>
<td>14:30 4 1 2 3</td>
</tr>
<tr>
<td>Morningside Ext 10 (4)</td>
<td>14:00</td>
<td>16:30 4 1 2 3 8 5 6 7</td>
</tr>
<tr>
<td>Show individual stages</td>
<td>16:00</td>
<td>18:30 8 5 6 7</td>
</tr>
<tr>
<td>Yes</td>
<td>18:00</td>
<td>20:30</td>
</tr>
<tr>
<td></td>
<td>20:00</td>
<td>22:30 3 4 1 2</td>
</tr>
<tr>
<td></td>
<td>22:00</td>
<td>0:30 3 4 1 2</td>
</tr>
</tbody>
</table>

**Excerpt of Eskom Load shedding Timetable**: This table shows the load shedding schedule for Morningside Extension 10, which falls into Zone 4, under Stage 8 load shedding for the first 8 calendar days of any month. The shaded blocks numbered 1 to 8 show the incremental, additional time slots.

---

2 Eskom provides the following guidance for interpreting the table:

- The load shedding timetable starts when there is a formal announcement from Eskom.
- This is a monthly time table for Eskom customers applicable for all months of the year.
- Example: If you are scheduled from 16:00 to 20:30, but load shedding is declared at 17:00, you will only be load shed from 17:00 to 20:30.
- If one is scheduled on a lower stage and a higher stage is declared, then your current time slot will not change. E.g., a time slot from 16h00 to 20h30 in a stage, will be completed, even if a higher stage is declared during that time.
cumulative blackout periods this suburb faces corresponding to its respective stage of load shedding. For example, the 1st day of the month has 12 hours of blackouts given by blocks 1, 5, 4, 8 and 3 (although the last 30 minutes of block 3 technically fall into the next calendar day).

**How Load Shedding is Implemented and Changes to its Stages**

Although the load shedding schedule remains constant monthly, the stage of load shedding implemented can change in real-time based on the balance between electricity supply and demand. As load shedding stages are adjusted, a suburb may experience varying numbers of blackouts on a given day, with higher stages resulting in more frequent and longer blackouts. Each stage corresponds to shedding approximately 1000 MW from the grid (Loadshedding Explained, 2024). Supply constraints, including unexpected maintenance, labor strikes, coal supply disruptions, sabotage, and theft, contribute to the unpredictability of load shedding levels (Rathi, 2022) (Engel, 2023).

Consequently, while the timetable aims to distribute blackouts equitably, actual experiences vary, with some neighborhoods facing significantly more blackouts. This study leverages variations in the implementation of load shedding and its stages to analyze the impact of blackouts on crime, using actual blackouts as the unit of randomization.
**Blackout Data Considerations**
Assessing the impact of blackouts on crime in Gauteng, and more broadly in South Africa, requires identifying the most reliable sources for the dependent and independent variables. In gathering actual load shedding history disseminated nationally by Eskom, two approaches were evaluated. The first involved scraping data from Eskom’s Twitter feed, which has provided load shedding updates since 2008. However, this unverified source is prone to missing data points, posing significant accuracy issues for reconstructing an historical schedule through this method.

Example of a change in load shedding announced on Eskom’s X (Twitter) feed (https://twitter.com/EskomSA)
The second approach to obtaining load shedding history involves using data from EskomSePush (ESP), a third-party data collector. ESP diligently alerts South Africans to load shedding changes and provides schedules for specific areas. Since 2014, ESP has collated and verified historical blackout data from multiple public sources (EskomSePush (ESP), 2024). They offer an app for Android and iOS, along with an API portal for real-time notifications. The app, which has become the primary source of load shedding updates, also features a community forum for discussions. Although this method provides a comprehensive dataset, it lacks information predating 2014.

ESP application showing load shedding stages, expected blackout timetables and community forums ([https://esp.info/images/screenshot.png?webp](https://esp.info/images/screenshot.png?webp))
Weighing the benefits and potential costs of both options, this study utilizes ESP as the primary historical database for load shedding data, reported at a national level. Since Eskom implements load shedding at a national grid level rather than provincially, neighborhood-level blackouts are identified using Eskom's provincial load shedding timetable. By combining ESP's historical data with Eskom's neighborhood-level timetables, an index of actual blackouts per neighborhood was created, identifying affected zones during specific time slots. This index, covering 2015 to 2022, is then matched with crime statistics for the same period.

**Crime Data and Calculation of Treatment**

Crime data is collected nationally by the South African Police Service (SAPS) annually until 2019, after which reporting switched to a quarterly basis. Crime is broadly categorized into 30 types, further subdivided into subcategories, with this analysis focusing on Contact Crimes, Contact Related Crimes, and Crimes Detected as the Result of Police Action. Despite the introduction of new categories and further segmentation, broad crime categories have remained consistent. SAPS reports crime spatially by province and police district, with 76 districts in Gauteng. Annualized SAPS data, matched to neighborhoods, allows for assessing blackout impacts per district annually. A crosswalk from suburb-level blackouts to police districts calculates district-level blackouts as a weighted average, based on the number of suburbs within each district.
A crosswalk from suburb-level blackouts to Police District-level then results in district-level blackouts calculated as:

\[
\text{District level blackouts} = \sum_{i=1}^{n} \left( \frac{S_i}{T_d} \times B_i \right)
\]

Where:

- \( S_i \) is the number of suburbs in the \( i \)-th police district
- \( T_d \) is the total number of suburbs in the police district \( d \)
- \( B_i \) is the total number of blackouts in the \( i \)-th suburb
- \( n \) is the number of suburbs within each police district

In South Africa, generally, the number of suburbs in an area generally correlates with the population density of that area. More densely populated regions, such as Johannesburg and Pretoria, tend to have a higher number of suburbs compared to less populated regions. This correlation is influenced by urban planning, the distribution of economic activities, and residential development patterns (Spatial Transformation, 2024).

The weighting scheme is based on the number of suburbs (\( S_i \)) within the spatial boundaries of each police district. Each geographic neighborhood is further subdivided into groups that represent specific divisions of Eskom’s electrical grid. For example, within the Ivory Park police district, the densely populated suburb of Kaalfontein is divided into 23 extensions (Kaalfontein 1 to 23), all falling under Zone 7 of 16. Although it is common for all subdivisions to fall under the same zone, there are instances where different subdivisions experience different load shedding schedules. This subdivision according to the electrical grid means that the weighted average estimation of blackouts is often close to the unweighted total average. However, in cases where
neighborhood subdivisions fall under different zones, they experience varying levels of blackouts, which affects the treatment estimation per period – a bias which is then corrected by the weighting scheme to reflect the actual treatment of blackouts more closely per person.

**Research Design**
This paper tests four hypotheses to investigate the impact of load shedding on crime dynamics in South Africa. Each hypothesis is crafted to explore different dimensions of how blackouts may influence criminal activities and law enforcement efficacy. Hypothesis 1 aims to establish a broad understanding of the correlation between blackouts and crime rates. Hypothesis 2 narrows the focus to contact crimes, which are likely to be opportunistic in nature and likely to be influenced by complimentary environmental changes, as well as having direct and immediate consequences for individuals. Hypothesis 3 considers the operational challenges faced by law enforcement during blackouts by using the crime category Crime Detected as the Result of Police Action as a proxy for the efficacy of policing during blackouts. Changes in this crime category given blackouts could be driven by decreases in policing effectivity during blackouts, as noted in the literature, or by changes to the level of policing taking place during blackouts. Finally, Hypothesis 4 seeks to discern whether the time of day modifies the relationship between blackouts and crime:

**Hypothesis 1 (H₁)**

H₁: Blackouts do not significantly influence the overall incidence of crime.

Alternative Hypothesis (H₁a): Blackouts significantly influence the overall incidence of crime.

**Hypothesis 2 (H₂)**

H₂: Blackouts do not have a significant impact on the incidence of contact crimes, such as assaults and robberies.

Alternative Hypothesis (H₂a): Blackouts have a significant impact on the incidence of contact crimes.
Hypothesis 3 (H₃)

H₃: Blackouts do not affect the police's ability to detect crimes.

Alternative Hypothesis (H₃a): Blackouts affect the police's ability to detect crimes.

Hypothesis 4 (H₄)

H₄: There is no difference in the impact of blackouts on crime during the day compared to the night.

Alternative Hypothesis (H₄a): There is a significant difference in the impact of blackouts on crime during the day compared to the night.

**Daylight v. Night blackouts**

To support the identification of H₄, blackouts over the 8-year period are classified as occurring either during daylight or darkness. This is done on a seasonal basis, with equinoxes and solstices marking inflection points in the number of daylight hours, or conversely hours of darkness per day. The regression model specification below is used in two further implementations to test the differential impact of blackouts on crime during daylight and hours of darkness.
Regression Model Specification

\[
\text{arcsinh(\text{Crime})}_{i,j,t} = \beta_0 + \beta_1 \text{BlackoutHours}_{j,t} + \gamma_j + \text{Year}_t + \epsilon_{i,j,t}
\]

Where:

- \text{arcsinh(\text{Crime})}_{i,j,t} is the Inverse Hyperbolic Sine transform of the total count of crime category \(i\) in Police District \(j\) at Time \(t\)
- \text{BlackoutHours}_{j,t} is the Load shedding in Police District \(j\) at Time \(t\) (in standard deviations. 1 standard deviation is approximately 85 hours of blackouts per district)\(^4\)
- \(\beta_0\) is the constant/intercept term
- \(\beta_1\) is the coefficient for the Load shedding
- \(\gamma_j\) represents the fixed effects for Police District \(j\)
- \(\text{Year}_t\) is a control variable to remove any linearity of crime trends across time
- \(\epsilon_{i,j,t}\) is the error term

*Specification Motivation*
This econometric approach is motivated for below:

**Handling Non-Linearity**: The use of the arcsinh transformation helps manage the skewness and non-linearity present in crime data, enabling a more accurate estimation of the model parameters while allowing for correct handling of zero values (as is occasionally the case in certain crime categories, such as Bank Robbery).

**Fixed Effects**: Incorporating fixed effects allows control for unobserved heterogeneity across police districts. This is crucial as neighborhoods and resultantly, districts in Gauteng have inherent characteristics influencing crime rates, such as socio-economic conditions, policing quality, infrastructure, and population density which remain relatively constant over time.

**Temporal Trends**: Including a time variable (\(\text{Year}_t\)) helps to account for any underlying trends in crime rates that are not attributable to load shedding, ensuring that our estimates for the effect of load shedding are not biased by these trends.

\(^4\) Blackouts announced in between load shedding timeslots are rounded to the next hour.
Assumptions
For the model to provide reliable and unbiased estimates, several key assumptions need to hold:

1) Crimes Occur in the Police District They’re Reported:
This assumption posits that all reported crimes are committed within the boundaries of the reporting police district. This is crucial for accurately linking the crime data to the corresponding load shedding data.

2) No Measurement Error in Crime and Load shedding:
The accuracy of the model relies on precise measurement of both crime incidents and load shedding hours. Any errors in these measurements could bias the results and lead to incorrect conclusions about the relationship between load shedding and crime.

3) Strict Exogeneity of Load shedding:
This assumption means that load shedding is not influenced by past, present, or future crime rates. Strict exogeneity ensures that the load shedding variable is independent of the error term, thereby providing unbiased estimates of its effect on crime. While it is possible that this assumption could be violated in cases of planned sabotage to electrical infrastructure and illegal strikes, the widespread nature of load shedding and the broad crime categories being analyzed make this assumption reasonable.

4) No Unobserved, Time-variant Factors Correlated to Blackouts and Impacting Crime
The fixed effects model assumes that all relevant time-invariant factors influencing crime rates are adequately captured. This includes socio-economic factors, policing policies, and other
district-specific characteristics that do not change over time. Any such factors not included in the model could potentially bias the results.

By adhering to these assumptions, the model aims to isolate the effect of load shedding on crime rates.

**Results and Discussion**

To reiterate, the total number of blackout hours per police district are regressed on six crime categories (see appendix for details of each category), being:

- Total Crime (30 categories)
- Contact Crimes (10 categories)
- Sexual Offences (4 categories)
- Contact Related Crimes (2 categories)
- Crime Detected as a Result of Police Action (4 categories)

Complete regression tables are presented in Tables 1-3 in the Appendix.

*Total Blackout Hours*

The results of the regression fail to reject $H_1$ whether controlling for time ($\text{Year}_t$) or not. The coefficient for blackouts is not significant at any level, implying that blackouts do not significantly increase or decrease total crime. However, contact crimes and sexual offences both exhibit strong, positive relationships with the level of blackouts per police district. Contact crime shows a 7.8% (5.9% controlling for time) increase given one standard deviation increase in blackouts, while sexual offences increasing by a staggering 31.4% (22.6% controlling for time). Policing, using our sixth category as a proxy, shows a strong negative relationship with blackouts, implying that policing effectivity is reduced by 15% given one standard deviation in blackouts (9.7% controlling for time). All results are significant at a 1% level, which provides evidence in support of rejecting null hypotheses $H_2$ and $H_3$. 
Contact related crimes – being Arson and Malicious Damage to Property show no significant relationship with blackouts, which could possibly underscore the opportunistic nature of crime during blackouts, wherein damage to property and consequent attempted destruction of evidence is not employed when contact crimes are being committed. Another consideration of why this could be the case could possibly be due to these two categories being motivated by certain kinds of contact crimes, which are unrelated to the biggest driver of contact crimes given blackouts – sexual offences.

*Differential impact of daylight and nighttime blackouts*

Surprisingly, blackouts that occur during daylight hours are more damaging to contact crimes and sexual offences than those at night. Contact crimes rise to 8.6% (6.7% controlling for time) during the day, and sexual offences rise to 34.5% (25.6% controlling for time) given one standard deviation increase in blackouts. Policing effectivity is not as badly affected during daylight blackouts, with a -14.5% change in crime detected as a result of police action during the day (-8.9% controlling for time). This could possibly be due to greater visibility during daylight hours, and safer operating conditions for police officers. All results are again significant at a 1% level.

Interestingly, night time blackouts show a weak negative relationship with total crime, all crime categories fall by 1.7% over the period, a result which is significant at a 5% level. This could possibly be attributed to lower levels of nighttime activity by the population, given a blackout, which could then result in fewer opportunities for crimes of most types to occur.

Contact crime and sexual offences both still show strong positive relationships with blackouts at night, however the size of the effect drops to 6.7% for contact crime (4.8% controlling for time) and 27% for sexual offences (18.2% controlling for time). Policing is more damaged by blackouts during darkness, and crime detected as the result of police action falls by 15.6% given a one standard deviation increase of load shedding at night (-10.5% controlling for time).
The difference in the effects of blackouts on crime during day and night support rejecting H4.

**Summary**
The analysis revealed that blackouts do not significantly influence the overall incidence of crime, indicating no broad effect on total crime rates which refuted H1. However, blackouts were shown to have a substantial impact on specific types of crimes. Contact crimes and sexual offences increased significantly during blackouts, with contact crimes rising by 7.8% and sexual offences by 31.4%. The effectiveness of policing was also negatively affected, decreasing by 15% during blackouts. These findings support H2 and H3.

The analysis further revealed that the impact of blackouts varies between day and night. Daytime blackouts had a more pronounced effect on increasing contact crimes and sexual offences compared to nighttime blackouts. Despite a general weak negative relationship between nighttime blackouts and overall crime, contact crimes and sexual offences still showed significant increases, though to a lesser extent than during the day which support H4. These findings highlight the need for targeted interventions to mitigate the adverse effects of load shedding on crime, which consider specific crime categories and also the timing of blackouts.

**Limitations**

*Control Variables and Data Resolution*

One of the primary limitations of this study is the challenge in finding data with appropriately matching frequencies and spatial levels. Crime data is reported at a police district level, and not per neighborhood. Although blackout data is available in real time, crime is only reported annually, or more recently (since 2019), quarterly. Census data is available at the municipality level, which comprises only ten municipalities for the entire Gauteng province. This granularity does not align well with the data resolution available for the 76 police districts and 2,053 suburbs within Gauteng. The discrepancy in spatial resolution between these datasets can lead
to difficulties in accurately modeling and interpreting the relationship between blackouts and crime. It also makes it difficult to estimate the number of individuals living in a district or suburb, which could improve the accuracy of the weighting of treatment.

*Neighborhood Heterogeneity*

There is significant heterogeneity between neighborhoods within Gauteng, which affects the study’s outcomes. Private security services and well-organized local community police forums, which significantly impact crime levels, are more prevalent in affluent neighborhoods. These services can mitigate the adverse effects of blackouts, leading to a disproportionate impact on poorer areas that cannot afford such measures. Consequently, the damage caused by blackouts is more pronounced in economically disadvantaged neighborhoods, which is uncontrolled for in this study.

*Measurement Error and Bias*

The study is subject to measurement error due to the non-random crosswalk between the 2,053 suburbs and the 76 police districts. This spatial joining could result in attenuation bias in the regression results, potentially underestimating the true effect of blackouts on crime.

*Changing Neighborhood Dynamics*

Over the eight-year period considered in this study, neighborhood demographics and characteristics may have changed significantly. Affluent neighborhoods might have implemented alternative energy sources such as generators, solar panels, and inverters, which could affect the regression results by reducing the impact of blackouts in these areas. Additionally, migration patterns could alter the demographic composition of neighborhoods. Residents might move to avoid high crime areas, and criminals might relocate to take advantage of the increased opportunities during blackouts. These dynamic changes add another layer of complexity to the analysis, which perhaps could be controlled for in future work.
Future research should aim to address these limitations by utilizing more granular data, considering the heterogeneity of neighborhoods, and accounting for changing demographics and adaptive behaviors over time.

**Conclusion**

This study has illuminated the complex and nuanced relationship between load shedding and crime in Gauteng, South Africa. While the broad impact of blackouts on overall crime rates may not be statistically significant, the disproportionate increase in contact crimes and sexual offenses, particularly during daylight hours, paints a stark picture of the vulnerabilities exposed by power outages. The observed decrease in police effectiveness during these periods further underscores the challenges faced by law enforcement in maintaining public safety amidst energy insecurity.

The findings challenge the notion that blackouts uniformly affect all crime types, highlighting the importance of disaggregating crime data and considering the specific contexts in which criminal activity occurs. The differential impact of daylight and nighttime blackouts suggests that the interplay of environmental factors, such as visibility and activity levels, plays a crucial role in shaping criminal behavior during power outages.

While this study has provided valuable insights, the limitations related to data granularity, neighborhood heterogeneity, and evolving demographics call for further investigation. Future research should strive to overcome these limitations by incorporating more detailed data at the neighborhood level, accounting for the diverse socio-economic conditions and adaptive behaviors within communities and examining the long-term consequences of load shedding on crime patterns.

The implications of these findings extend beyond the academic realm. They underscore the urgent need for policymakers and stakeholders to develop comprehensive strategies that
address the multifaceted challenges posed by load shedding. These strategies should prioritize the safety and security of vulnerable populations, enhance law enforcement capabilities during power outages, and invest in alternative energy solutions that promote sustainable development and mitigate the societal costs of energy insecurity.

In the face of ongoing energy challenges, a nuanced understanding of the relationship between load shedding and crime is essential for crafting effective policies and interventions. By acknowledging the complexity of this issue and pursuing further research, South Africa can move towards a future where energy security and public safety are mutually reinforcing goals.
Appendices and References

Appendix A: Regression Tables 1-3

Appendix B: Eskom Load Shedding Timetable

Regression Tables

Table 1: Regression of Total Blackouts on Crime

<table>
<thead>
<tr>
<th>Variables</th>
<th>Blackout Hours (sd)</th>
<th>Year</th>
<th>Constant</th>
<th>Observations</th>
<th>Adjusted R²</th>
<th>F-Statistic</th>
<th>District Fixed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δ Total Crime</td>
<td>Δ Total Crime</td>
<td>Δ Contact Crime</td>
<td>Δ Contact Crime</td>
<td>Δ Sexual Offences</td>
<td>Δ Sexual Offences</td>
<td>Δ Contact Related</td>
</tr>
<tr>
<td>(1)</td>
<td>-0.012</td>
<td>0.008</td>
<td>0.078***</td>
<td>0.059***</td>
<td>0.314***</td>
<td>0.226***</td>
<td>0.004</td>
</tr>
<tr>
<td>(2)</td>
<td>(0.008)</td>
<td>(0.0081)</td>
<td>(0.013)</td>
<td>(0.041)</td>
<td>(0.033)</td>
<td>(0.014)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>(3)</td>
<td>-0.03***</td>
<td>0.031***</td>
<td>0.138***</td>
<td>-0.030***</td>
<td></td>
<td>-0.084***</td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td>(0.003)</td>
<td>(0.004)</td>
<td>(0.0141)</td>
<td>(0.005)</td>
<td></td>
<td>(0.008)</td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>8.822***</td>
<td>69.343***</td>
<td>-53.889***</td>
<td>5.139***</td>
<td>-274.343</td>
<td>5.923***</td>
<td>66.673</td>
</tr>
<tr>
<td>(6)</td>
<td>(0.007)</td>
<td>(5.620)</td>
<td>(7.719)</td>
<td>(8.480)</td>
<td>(0.035)</td>
<td>(28.513)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>(7)</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td>605</td>
</tr>
<tr>
<td>(8)</td>
<td>0.931</td>
<td>0.942</td>
<td>0.896</td>
<td>0.904</td>
<td>0.433</td>
<td>0.514</td>
<td>0.886</td>
</tr>
<tr>
<td>(9)</td>
<td>2.290</td>
<td>61.580</td>
<td>32.890</td>
<td>37.270</td>
<td>58.160</td>
<td>48.280</td>
<td>0.110</td>
</tr>
<tr>
<td>(10)</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

*∗, ** and *** indicate significance at the 10%, 5% and 1% levels respectively
Standard Errors are in parenthesis
Table 2: Regression of Daytime Blackouts on Crime

<table>
<thead>
<tr>
<th>Variables</th>
<th>30 Categories</th>
<th>10 Categories</th>
<th>4 Categories</th>
<th>2 Categories</th>
<th>Policing (4 Categories)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
<tr>
<td>Δ Total Crime</td>
<td>-0.007</td>
<td>0.013</td>
<td>0.086***</td>
<td>0.067***</td>
<td>0.345***</td>
</tr>
<tr>
<td>(sd)</td>
<td>(0.008)</td>
<td>(0.008)</td>
<td>(0.014)</td>
<td>(0.013)</td>
<td>(0.043)</td>
</tr>
<tr>
<td>Δ Contact Crime</td>
<td>-0.031***</td>
<td>0.029***</td>
<td>0.135***</td>
<td>-0.03***</td>
<td>-0.085***</td>
</tr>
<tr>
<td>(Year)</td>
<td>-0.031***</td>
<td>0.029***</td>
<td>0.135***</td>
<td>-0.03***</td>
<td>-0.085***</td>
</tr>
<tr>
<td>(Constant)</td>
<td>8.822***</td>
<td>70.535***</td>
<td>7.719***</td>
<td>-51.821***</td>
<td>-266.414***</td>
</tr>
<tr>
<td>(Observations)</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td>605</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.931</td>
<td>0.942</td>
<td>0.898</td>
<td>0.906</td>
<td>0.448</td>
</tr>
<tr>
<td>F-Statistic</td>
<td>0.840</td>
<td>62.480</td>
<td>37.840</td>
<td>38.480</td>
<td>63.800</td>
</tr>
<tr>
<td>District Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*, ** and *** indicate significance at the 10%, 5% and 1% levels respectively

Standard Errors are in parenthesis
Table 3: Regression of Night Blackouts on Crime

<table>
<thead>
<tr>
<th>Variables</th>
<th>30 Categories (1)</th>
<th>10 Categories (2)</th>
<th>4 Categories (3)</th>
<th>2 Categories (4)</th>
<th>Policing (4 Categories) (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Total Crime</td>
<td>-0.017**</td>
<td>0.001</td>
<td>0.067***</td>
<td>0.27***</td>
<td>0.001</td>
</tr>
<tr>
<td>(Night Blackout Hours (sd)</td>
<td>(0.007)</td>
<td>(0.008)</td>
<td>(0.013)</td>
<td>(0.038)</td>
<td>(0.0017)</td>
</tr>
<tr>
<td>Δ Contact Crime</td>
<td>0.048***</td>
<td>0.032***</td>
<td>0.144***</td>
<td>-0.03***</td>
<td>-0.084***</td>
</tr>
<tr>
<td>(Year)</td>
<td>(0.004)</td>
<td>(0.005)</td>
<td>(0.008)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Sexual Offences</td>
<td>0.182***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>8.822***</td>
<td>67.824***</td>
<td>7.719***</td>
<td>-56.719***</td>
<td></td>
</tr>
<tr>
<td>(Observations)</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td>605</td>
<td></td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.931</td>
<td>0.942</td>
<td>0.893</td>
<td>0.902</td>
<td></td>
</tr>
<tr>
<td>F-Statistic</td>
<td>5.460</td>
<td>60.770</td>
<td>26.450</td>
<td>35.870</td>
<td></td>
</tr>
<tr>
<td>District Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

*, ** and *** indicate significance at the 10%, 5% and 1% levels respectively

Standard Errors are in parenthesis
# Appendix B

## Eskom Load shedding Timetable

Eskom’s timetable in spreadsheet format is available at the below URL:

https://www.eskom.co.za/distribution/customer-service/outages/downloadable-load-shedding-spreadsheets-for-eskom-customers/

The same timetable itemized for neighborhood zones for Ekurhuleni Municipality is excerpted below:

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Stage</th>
<th>DAY OF THE MONTH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>00:00</td>
<td>4</td>
<td>1 13 9 2 7 14 10 6</td>
</tr>
<tr>
<td></td>
<td>02:00</td>
<td>6</td>
<td>1 15 12 8 7 14 11 3</td>
</tr>
<tr>
<td>03:00</td>
<td>06:00</td>
<td>6</td>
<td>5 1 1 8 7 14 11 3</td>
</tr>
<tr>
<td>04:00</td>
<td>06:00</td>
<td>6</td>
<td>5 1 1 8 7 14 11 3</td>
</tr>
<tr>
<td>06:00</td>
<td>08:00</td>
<td>6</td>
<td>5 1 1 8 7 14 11 3</td>
</tr>
<tr>
<td>08:00</td>
<td>10:00</td>
<td>6</td>
<td>5 1 1 8 7 14 11 3</td>
</tr>
</tbody>
</table>

Appendix C

Crime Categories as Defined by SAPS:

**Total Crime:** All theft not mentioned elsewhere, Arson, Assault with the intent to inflict grievous bodily harm, Attempted Sexual Offences, Attempted murder, Bank robbery, Burglary at non-residential premises, Burglary at residential premises, Carjacking, Commercial crime, Common assault, Common robbery, Contact Sexual Offences, Driving under the influence of alcohol or drugs, Drug-related crime, Illegal possession of firearms and ammunition, Malicious damage to property, Murder, Rape, Robbery at non-residential premises, Robbery at residential premises, Robbery of cash in transit, Robbery with aggravating circumstances, Sexual Assault, Sexual Offences detected as a result of police action, Shoplifting, Stock-theft, Theft of motor vehicle and motorcycle, Theft out of or from motor vehicle, Truck hijacking

**Contact Crime:** Murder, Rape, Sexual Assault, Attempted Sexual Offences, Contact Sexual Offences, Attempted murder, Assault with the intent to inflict grievous bodily harm, Common assault, Common robbery, Robbery with aggravating circumstances

**Sexual Offenses:** Rape, Sexual Assault, Attempted Sexual Offences, Contact Sexual Offences

**Aggravated Robbery:** Carjacking, Robbery at residential premises, Robbery at non-residential premises, Robbery of cash in transit, Bank robbery, Truck hijacking

**Contact Related Crime:** Arson, Malicious damage to property

**Other Serious Crime:** All theft not mentioned elsewhere, Commercial crime, Shoplifting

**Crime Detected as the Result of Police Action:** Illegal possession of firearms and ammunition, Drug-related crime, Driving under the influence of alcohol or drugs, Sexual Offences detected as a result of police action
References


Lambongang, M. (2023). Criminal Behavior During Electricity Blackouts: Evidence from Load Shedding in Cape Town, South Africa. Retrieved from ProQuest: https://search.proquest.com/openview/00ff0d02717ed1f2be9ba33110aaca09/1?pq-origsite=gscholar&cbl=18750&diss=y&casa_token=c7jVkncnl1oAAAAAY50wEaeFGuVBUH


*Spatial Transformation*. (2024). Retrieved from The Gauteng City-Region Observatory: https://gcro.ac.za/
