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Electricity Supply Interruptions and Its Impact on Local Economies

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Abstract

Electricity serves as a crucial input to many businesses and household activities. As such, the government has historically focused its efforts in expanding the populations' access to electricity. By contrast, electricity reliability has received less attention from policymakers, despite the economic disruption caused by electricity supply interruptions. This paper seeks to deepen the discussion on electricity reliability in the Philippines by providing empirical evidence on the impact of electricity supply interruptions on local economies. Our results show that frequent electricity supply interruptions lead to lower local government income due to reductions in receipts from economic enterprises, business taxes and real estate taxes. We also found that consequently, the local government's ability to provide services related to housing and community development, as well as labor and employment, is constrained, placing the local population at a disadvantage.

Keywords: electricity reliability, electricity supply interruptions, local economies

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Electricity Supply Interruptions and Its Impact on Local Economies

Kris A. Francisco and Michael R.M. Abrigo[1]

I. Introduction

Having access to electricity has a whole host of benefits that have already been proven in literature and have been widely acknowledged, as evidenced by government policies worldwide focusing on universal electrification. Empirical studies have established the impact of electrification on household income, education, and labor productivity (Saing 2017, Bridge et al. 2016a, 2016b, Khandker et al. 2012, 2013, Dinkelman 2011, Barnes et al. 2009). The United Nations likewise incorporates "*Ensuring Access to Affordable, Reliable and Sustainable and Modern Energy for All*" in its list of Sustainable Development Goals. What is often overlooked in the conversation, however, is that the benefits of having electricity access can be constrained by unreliable electricity supply.

There exists a separate strand of literature that looks at the impact of unreliable supply of electricity to the economy. A lot of the available references focus on the correlation between power outages and firm performance. To name a few, the study of Cole et al. (2018) for instance, found that power outages impact firm sales, with a much harsher effect on firms not owning generators. They estimated that a reduction in average outage levels in South Africa would increase overall sales of firms by 85 percent, and could go even higher at 117 percent, for firms without generators. A similar study (Allcott et al. 2016) using data on Indian manufacturing sector showed some variation in effect on firm performance, depending on access to back-up generation. It was observed that firms with generators face higher production costs in the event of electricity supply interruptions, while firms without generators ultimately stop production and lose non-storable inputs altogether. Another study (Mensah 2024) looked further into the mechanism through which electricity supply outages affect job creation and unemployment. The study confirmed the negative impact of electricity outages on employment, more particularly, a reduction of 4.7 to 13.5 percentage points. It was found that the impact is highly concentrated in the non-agricultural sector, specifically on skilled jobs. Furthermore, the study revealed that electricity shortages constrain the entry of new firms and force incumbent firms to operate below capacity. The study of Dang and La (2019) meanwhile, assessed the impact of electricity reliability on the welfare and economic decisions of rural Vietnamese households. They found that better electricity reliability not only leads to higher household income, but also results to increased investment in farm production and higher purchase of household assets. Despite this information, however, government policies in most countries remain centered on improving the populations' access to electricity, with less regard to enhancing the reliability of electricity supply.

While the world is closing the gap in electricity access, persistent electricity supply interruptions continue to pose challenges, especially in developing countries. Using the World Bank's Doing

[1] The authors are grateful for the research assistance of Valerie Lim and Jan Bianca Abellera, Research Analysts in the Philippine Institute for Development Studies.

Business reports[2], Gertler et al. (2017) shows that although electricity reliability is a general issue for many countries, developing countries experience lower access rates and more frequent power outages when compared with high-income countries. In a similar vein, electricity supply interruptions are prevalent in many parts of the Philippines. A study (Francisco 2022) revealed that in 2021, an average consumer in the country has experienced 5.7 electricity supply interruptions within the year, equating to about 9 hours of no electricity. It was also revealed that consumers in Luzon experienced more frequent power outages while consumers in Visayas endured longer hours without electricity, over the study period. Overall, the insufficient supply of power to Electric Cooperatives was tagged as the main reason for frequent and long hours of power outages.
This study intends to encourage more discussions about electricity reliability in the Philippines by providing empirical evidence on the extent to which such disruptions impact local economies. We particularly make use of local government data to examine how the performance of the local government as well as economic activities within the locality are affected. To the extent of the authors' knowledge, this study is the first to link electricity supply interruptions with local government performance. Findings from this study will not only enrich the literature but will also serve as guide for policymakers.

This paper is organized as follows. We discuss our estimation strategy and sources of data in Section II. In Section III, we present our results and findings. And lastly, in Section IV, we summarize our paper and discuss policy implications.

II. Methodology

Estimation strategy

We assess the dynamic contribution of unreliable electricity supply on local government finances by estimating impulse response functions (IRF). An IRF shows how a shock or change in one variable, in this case either the frequency or the duration of electricity interruption, affects other variables in a system, in this case local government finances, over time. This allows us to document how electricity interruptions may affect local government finances beyond the initial period of the shock.

To implement the impulse response analysis, we follow Jorda's (2005) local projection approach in modeling the dynamics between electricity supply interruption and local government finance; and estimate impulse responses as the difference between two forecasts. More specifically, we estimated the following dynamic fixed-effects model

$$Y_{it+w} = \mu + \theta_i + \phi_t + \gamma_{fw} X_{it}^{f} + \gamma_{hw} X_{it}^{h} + \sum_{l>0} \alpha_{lw} Y_{it-l} + \varepsilon_{it}$$

where Y_{it} is a local government finance account for local government unit $i = \{1,2,\dots,N\}$ at year $t = \{1,2,\dots,T\}$, while X_{it}^{f} and X_{it}^{h} are measures of electricity reliability based on aggregate

[2] The World Bank Doing Business reports allow for comparison as these show the System Average Interruption Duration Index ("SAIDI") and System Average Interruption Frequency Index ("SAIFI") for the capital city of countries included in the report.

frequency and duration of electricity interruption for the period. The variable ε_{it} is the model residual, which we assume to have the usual properties for unbiased estimation. In the model, we control for time-invariant effects specific to each local government through θ_i and time-varying effects common across local governments through ϕ_t. Similar to standard IRF estimation in the time-series case, we control for past information by including lags of the outcome in the model.

We are interested in estimates of γ_{fw} and γ_{hw}, which capture the average change in a particular government finance account at period $t + w$ for $w = \{0,1,2,3,4,5\}$ in response to a respective unit change in the annual frequency and duration of electricity supply interruption at period t. To facilitate interpretation and minimize the contribution of outliers, we convert our outcome variables using inverse hyperbolic sine transformation. This transformation is akin to a logarithmic transformation but has the attractive property of approximating a linear function as the variable to be transformed approaches zero and, more importantly, of being defined at zero.

Due to limitations in the time dimension of our panel of local governments, we limit our IRF to a maximum of five years since the initial shock. The limited time dimension of our local government panel also potentially introduces non-trivial Nickell bias in the estimation of our dynamic linear fixed-effects model. To correct for such, we use Arellano and Bond's (1991) difference-generalized method of moment estimator, wherein the fixed-effects model is estimated in differenced form with the lags of the differenced outcome variable instrumented by further lags but in levels. We follow the literature by using forward orthogonal deviations, which subtracts a weighted average of future values, instead of using the more common first-differences to optimize the number of observations available for estimation.

Unlike IRFs based on vector autoregression (VAR) models, the local projection-based IRF requires fewer assumptions, are more flexible, and may be estimated using simpler estimation techniques such as in above. In a VAR-based IRF, estimates of the VAR model is transformed into its moving average equivalent to recover the IRF, which is not necessary in a local projection approach since the IRF is estimated directly.

Data

The main data used in this study is the Monthly Interruption Report (MIR) of Electric Cooperatives (ECs) over the period of 2009 to 2022, sourced from the Energy Regulatory Commission. The MIRs provide EC-level information on the two indices used in our analyses: the System Average Interruption Frequency Index (SAIFI) –which indicates the total number of times power interruption occurred for an average consumer, and the System Average Interruption Duration Index (SAIDI) –which indicates the total number of hours of power interruption experienced by an average consumer. SAIFI and SAIDI were used as proxy for electricity reliability and were annualized to match information on local government units.

The Statement of Receipts and Expenditures by LGU from the Department of Finance Bureau of Local Government Finance, on the other hand, serve as a useful source for different types of income and expenditure items of local government units.

We specifically made use of data on the following variables for years 2009 to 2022:

- On income: Total current operating income, Local tax income, Local non-tax income, Externally sourced income
- On Tax revenues: Real estate taxes, Business taxes, Other taxes, Regulatory fees, Service charges, Enterprise income, Other income
- On income from other sources: Internal revenue allotment, Share from other national taxes, Inter-local transfers, Extraordinary receipts
- On expenditures: Total current expenditures, General public services, Education, culture and sports, Population, health and nutrition, Labor and employment, Housing and community development, Social services, Economic services

Lastly, we harmonize the municipality-level information on government income and expenditure with the EC-level information on electricity supply interruptions, by tagging the municipalities and cities covered within the franchise area of each EC included in our analyses. A map of each ECs franchise area is provided in the Department of Energy's website.

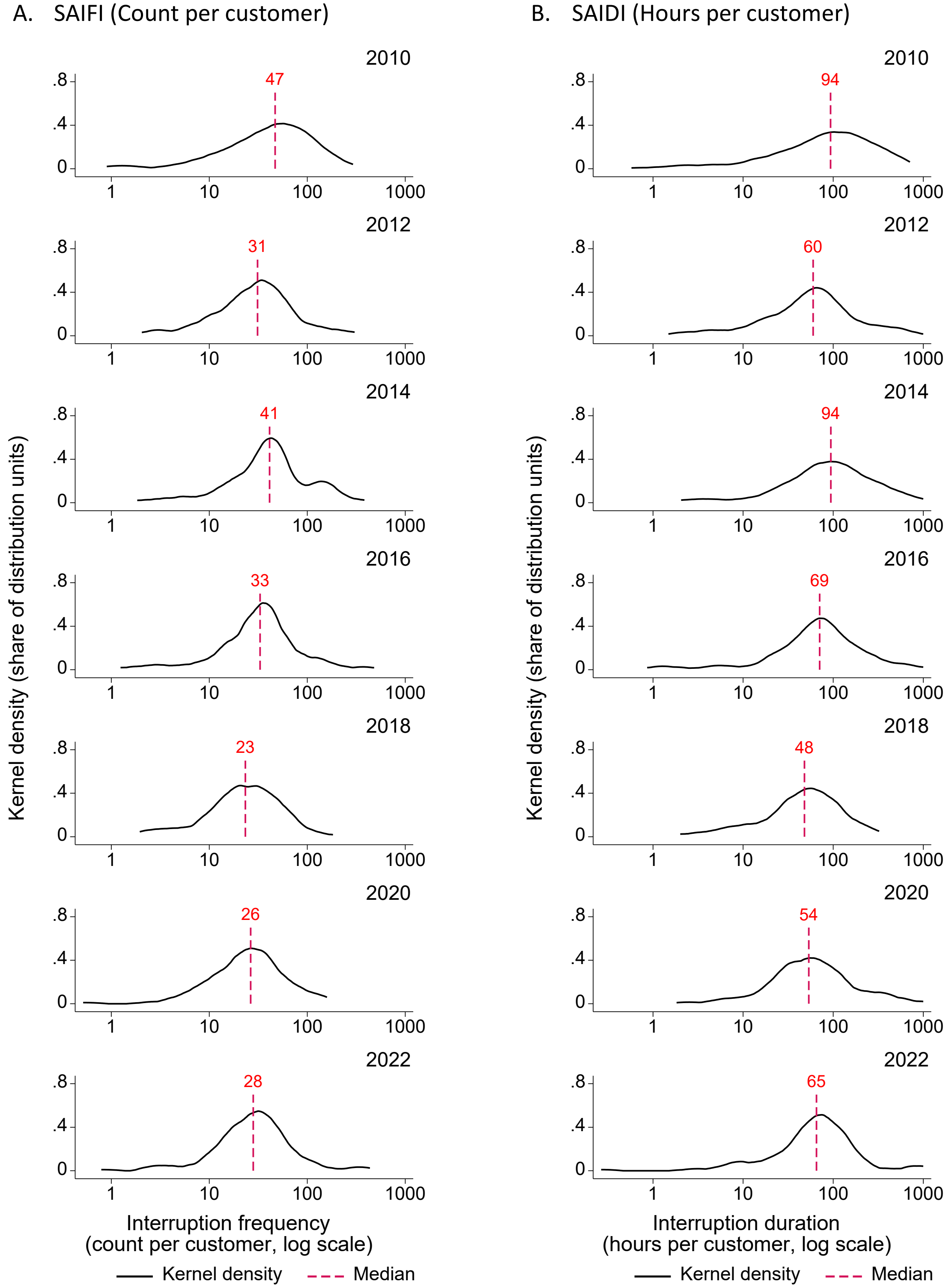
III. Results and discussions

Our strategy to analyze the impact as well as the persistence of effects of electricity supply interruptions to local economies is to utilize impulse responses calculated by local projections. In this section, we present the results of our estimation and discuss the associated responses to unreliable electricity supply.

Sample distribution

Prior to showing our main results, we first examine the distribution of electricity interruption indices used in our study. As presented in Figure 1, the frequency of electricity supply interruptions between 2010 and 2022, based on median count, has decreased over time. In 2010, consumers of most ECs in our sample have experienced around 47 power outages in total. In 2022, these were down to 28. Correspondingly, the experienced number of hours without electricity has also been reduced over the period of 2010 to 2022, for most ECs. The total hours of power outages were lessened to just 65 hours, compared to previously 94 hours in 2010. Overall, the median frequency and duration of electricity supply interruptions is 28 times and a total of 65 hours, respectively, in 2022, based on our sample.

Figure 1. Distribution of electricity system interruption indices, 2010-2022

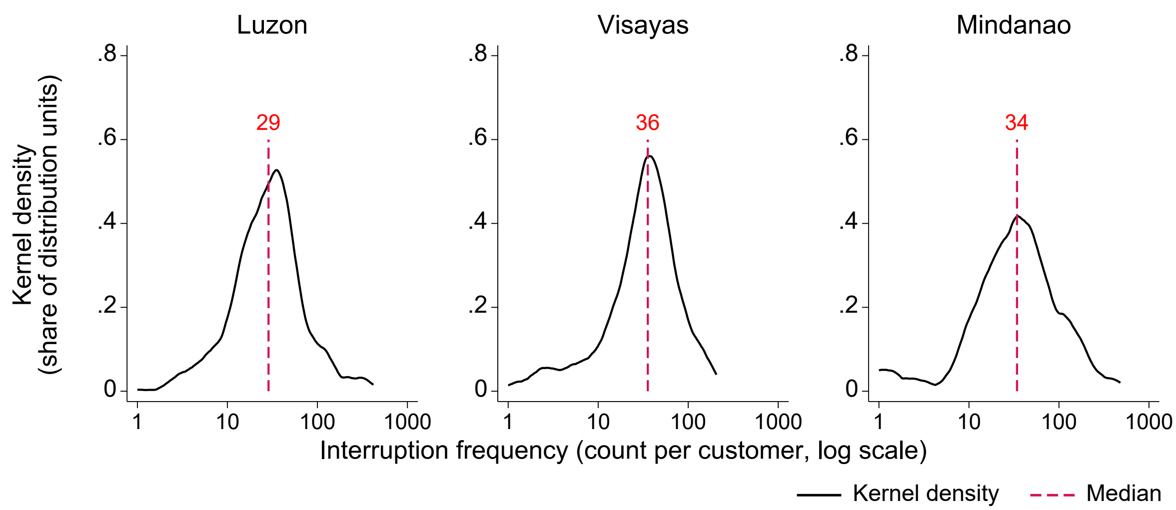


Source: Authors' calculations based on ERC data. Note: Interruption frequency refers to the annual system average interruption frequency index (SAIFI) while duration refers to the annual system average interruption duration index (SAIDI) of reporting electricity distribution units for the specified year. For clarity of visual exposition, SAIDI and SAIFI are censored at 1,000. Numbers in red font refer to the median.

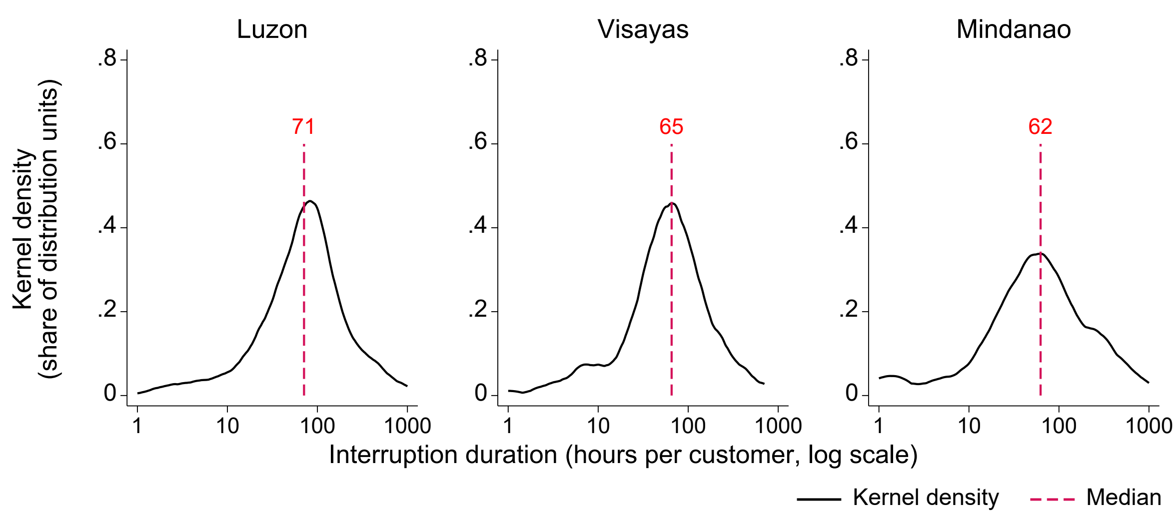
We also present the distribution of electricity system interruption indices based on broad region in Figure 2. We observe that over our sample period, median frequency of electricity supply interruptions is highest in Visayas and lowest in Luzon. Longer duration of power interruptions, however, is experienced by many consumers in the Luzon region. We underscore that the frequency and duration of power outages are dependent on numerous factors; and explaining these are beyond the scope of our study. A prior study (Francisco 2022) meanwhile, offers a thorough discussion on this.

Figure 2. Distribution of electricity system interruption indices by broad region, 2010-2022

A. SAIFI (Count per customer)



B. SAIDI (Hours per customer)



Source: Authors' calculations based on ERC data. Note: Interruption frequency refers to the annual system average interruption frequency index (SAIFI) while duration refers to the annual system average interruption duration index (SAIDI) of reporting electricity distribution units for the specified year. For clarity of visual exposition, SAIDI and SAIFI are censored at 1,000. Numbers in red font refer to the median.

Main results

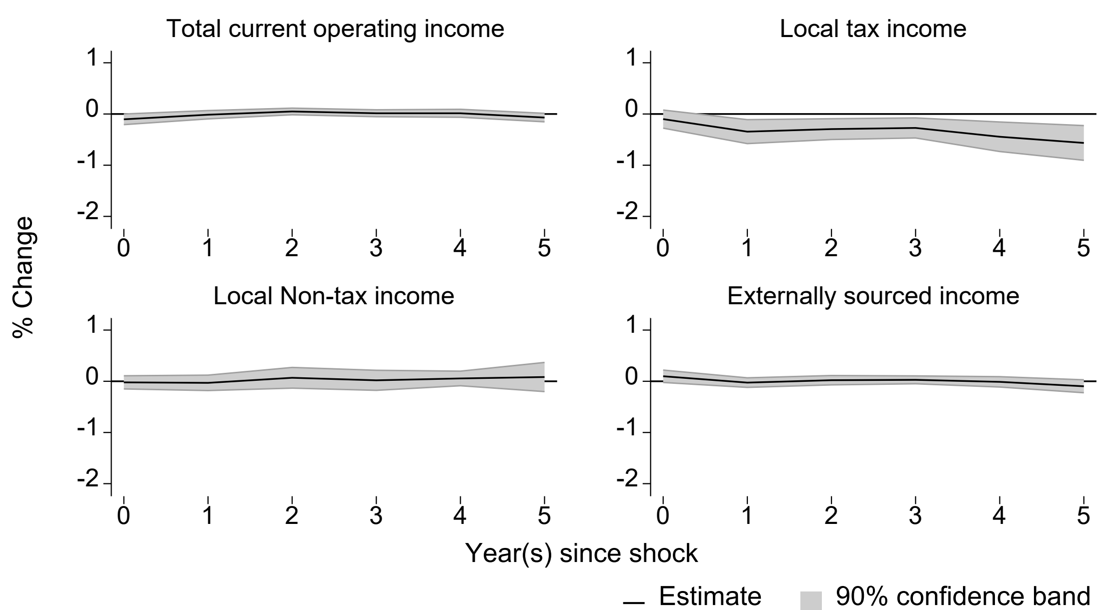
The results of our impulse-response estimations are shown in Figure 3 to Figure 9. In our local projections, we treat electricity supply interruption as a shock to the system and examine how it affects income and expenditure-related variables of local governments over the span of 5 years. Our discussions are presented in the succeding paragraphs.

We generally observe a significantlty negative impact of electricity supply interruption on local tax income as shown in Panel A of Figure 3. Our result suggest that an additional electricity supply interruption experienced by ECs leads to lower tax income during the same year the interruption was experienced, and would have an incessant effect until 4 years after. Total current operating income, Local non-tax income and Externally sourced income, on the other hand, appears to be unaffected.

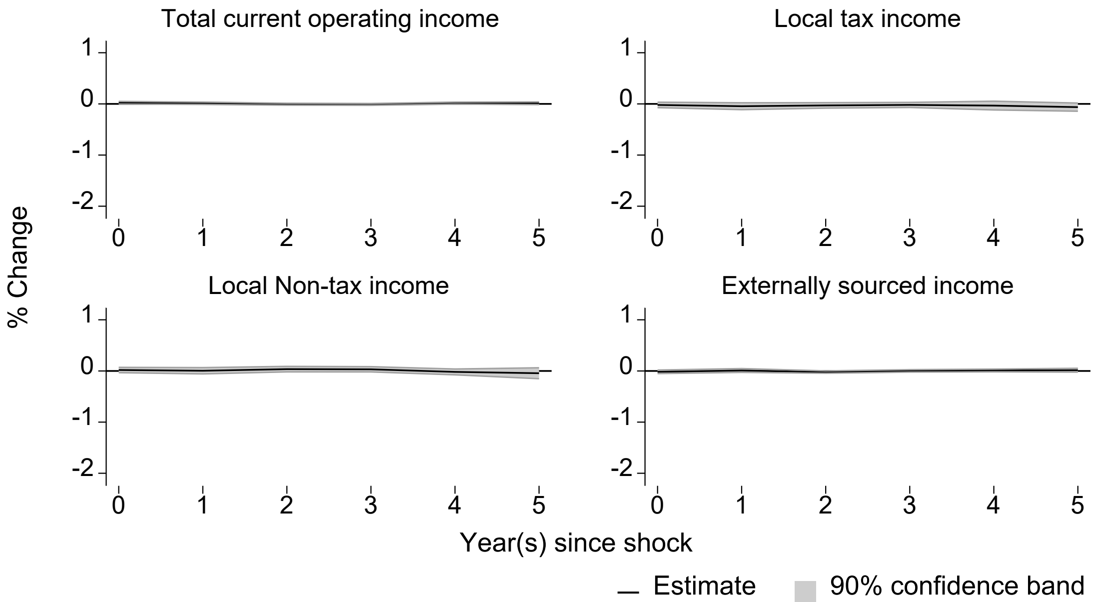
In Panel B of Figure 3, we also observe no considerable impact of an additonal hour of electricity supply interruption on any of the income variables considered. With these results, we surmise that frequent episodes of electricity supply interruptions are more harmful to local economies than longer hours of power interruption. The reason behind this finding however, cannot be explained by our estimation technique. Hence, we reserve this topic for future research.

Figure 3. Electricity reliability and local government income

A. SAIFI (Count per customer)



B. SAIDI (Hours per customer)

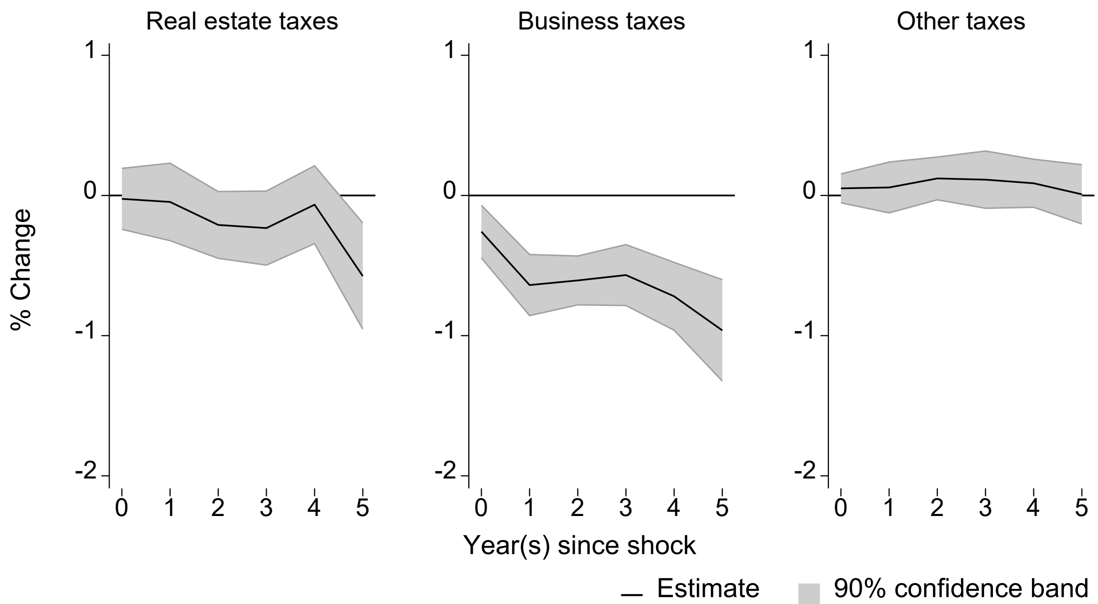


Source: Authors' calculations. Note: The estimates show local projection-based impulse response functions (Jorda, 2005), calculated as the difference between the h-step ahead forecasts with a unit shock of either SAIFI or SAIDI and with no electricity interruption, controlling for lags of the outcome variable. The dynamic panel model is estimated using Arellano-Bond's system GMM estimator to correct for Nickel bias. SAIFI – System average interruption frequency index. SAIDI – System average interruption duration index.

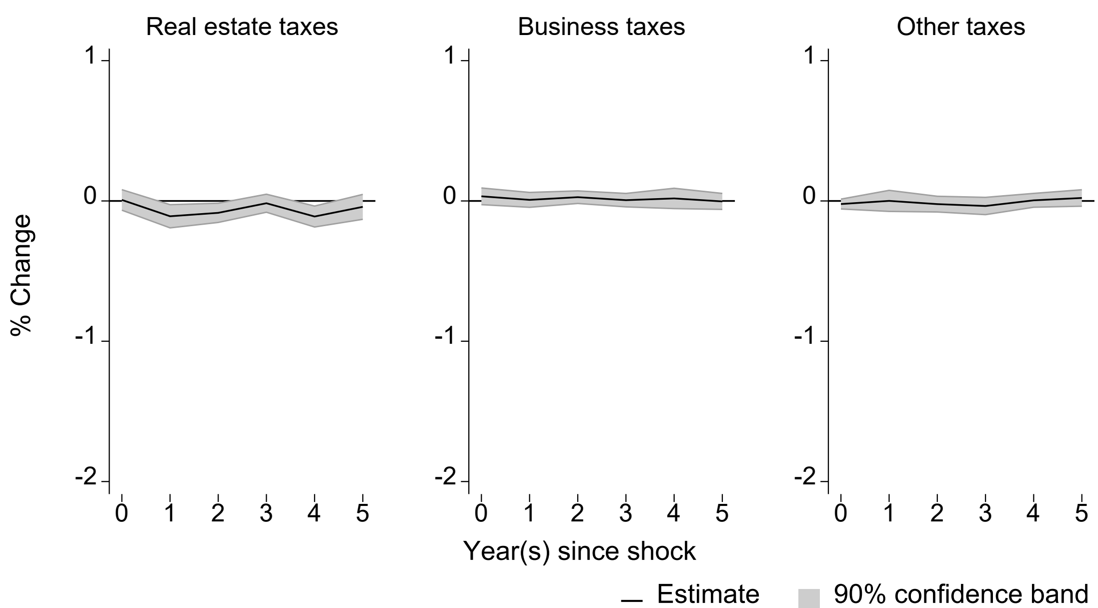
Local government income that comes from taxes are from the charges collected from businesses, real estate properties and other types of taxes. Figure 4 implies that the decrease in local tax income observed in Panel A of Figure 3, can be attributed to the lower business tax and real estate tax collection, resulting from electricity supply interruptions. Based on our local projection, for every additional electricity interruption experienced by ECs, business tax collection is reduced by about .2 percent during the initial year, and would reach up to around 1 percent reduction, over the next 4 years. We likewise observe a significant decrease in taxes collected from real estate. We note that the impact on real estate tax is not as intense as the impact on business taxes. Given these findings, we confirm that electricity supply interruptions are detrimental to economic activities within the local communities.

Figure 4. Electricity reliability and local government tax income

A. SAIFI (Count per customer)



B. SAIDI (Hours per customer)



Source: Authors' calculations. Note: The estimates show local projection-based impulse response functions (Jorda, 2005), calculated as the difference between the h-step ahead forecasts with a unit shock of either SAIFI or SAIDI and with no electricity interruption, controlling for lags of the outcome variable. The dynamic panel model is estimated using Arellano-Bond's system GMM estimator to correct for Nickel bias. SAIFI – System average interruption frequency index. SAIDI – System average interruption duration index.

Another portion of local government funds are from non-tax-related activities. These include collections from regulatory fees, service/user charges as well as receipts from economic enterprises of the LGU. Panel A of Figure 5 implies that even the business income of LGUs is affected by unreliable electricity supply. We particularly observe that receipts from local government enterprises decrease by almost 2 percent during the first year, in response to an additional electricity supply interruption experienced by ECs. This negative impact will be sustained until 4 years after.

External sources of income are also included in our analysis. Figure 6 suggests some reallocations of local government funds, in response to the effects of unreliable electricity supply. We particularly observe in Panel A of our figure, how an electricity supply interruption induces volatility in inter-local transfers –comprised of subsidies from LGUs and from other funds, over a 5-year period. Additionally, we notice an increase in extraordinary receipts –from grants and donations, subsidy income, and extraordinary gains and premiums from forex, assets, bonds, and investments, of about 1 to 3 percent over 5 years, due to an electricity supply interruption.

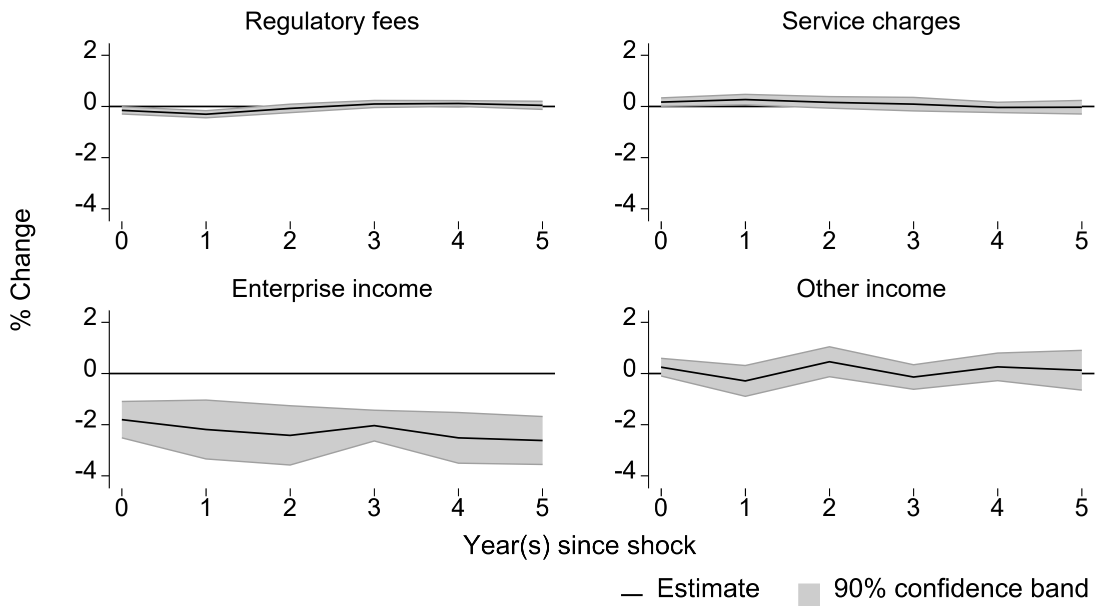
On a different note, we spot that the internal revenue allotment to LGU is unaffected by electricity supply interruptions, which is rationally expected. This placebo test serves as a vouch for the reliability of our impulse response estimates.

We further deepen our analysis by looking at local government expenditures related to social services it provides to local population. As implied in Panel A of Figure 7, the negative impact of electricity supply interruptions extends to the local government's capacity to perform services related to labor and employment as well as on housing and community development. Expenditure on labor and employment includes costs related to the formulation and implementation of labor policies, including the regualtion of domestic and overseas employment; promotion; and placement. Local services on housing and community development, on the other hand, covers the administration of housing projects; street cleaning; garbage collection: sewerage and drainage system; street lighting: administration of community development; activities related to resettlement, zonal improvement; maintenance of plaza, park, monuments and overall beautification of the local area.

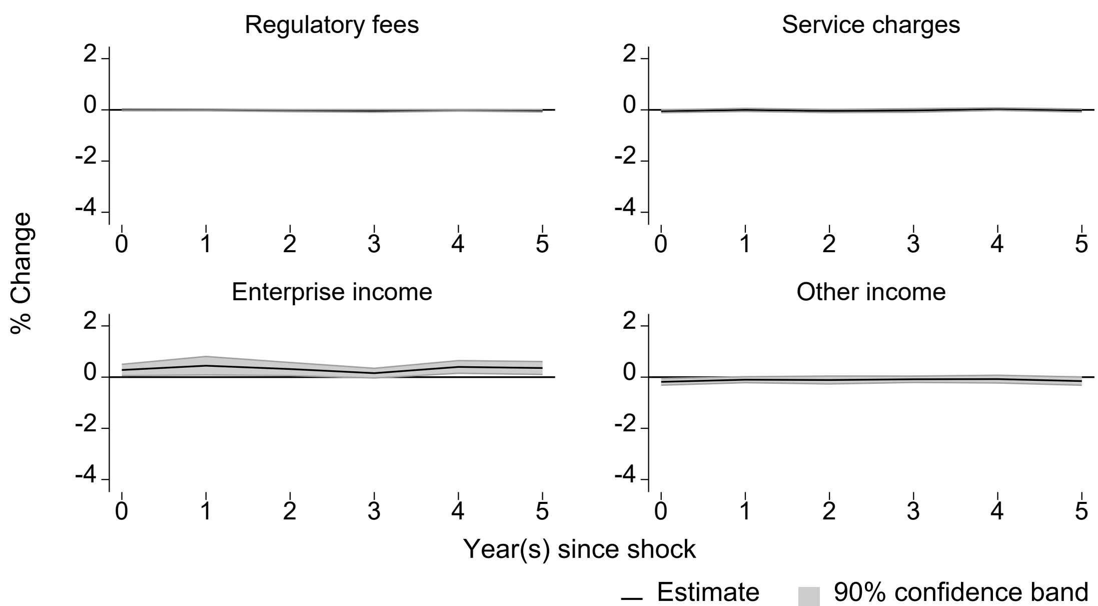
Our estimates show that expenditures on housing and community development is reduced, in response to an electricity supply interruption experienced by ECs. This reduction appears presistent and increasing through time; to about 10 percent, 5 years after. We similarly observe a reduction in expenditure on labor and employment for 3 years, following the disruption in electricity supply. Interestingly, we notice that the reduction on labor and employment-related services is already evident during the initial year where the electricity supply interruption was experienced. By contrast, the reduction on housing and community development-related services is done more gradually over the next few years.

Figure 5. Electricity reliability and local government non-tax income

A. SAIFI (Count per customer)



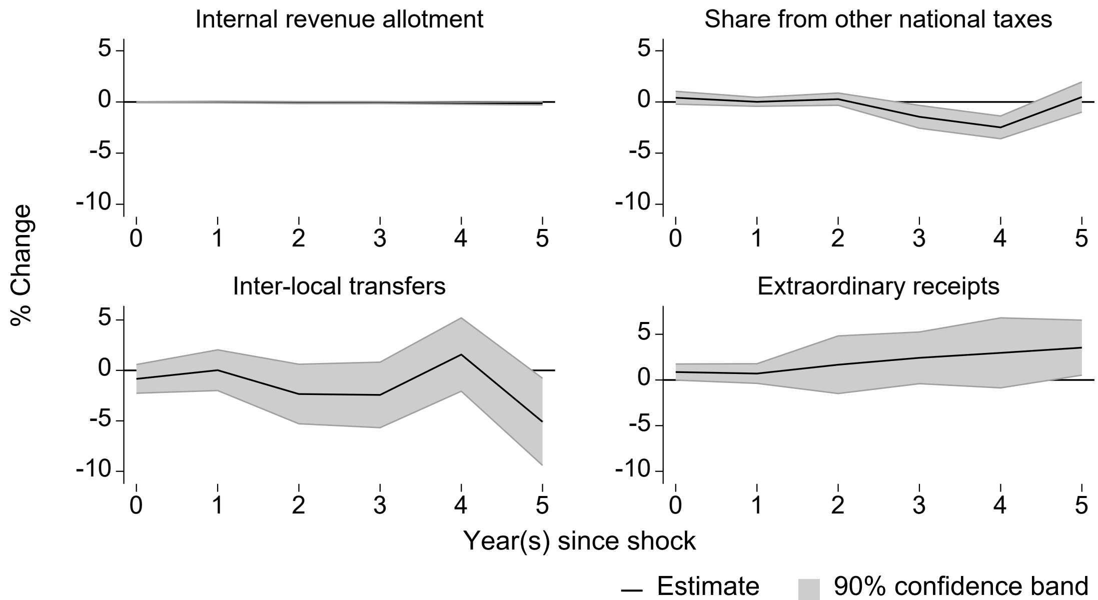
B. SAIDI (Hours per customer)



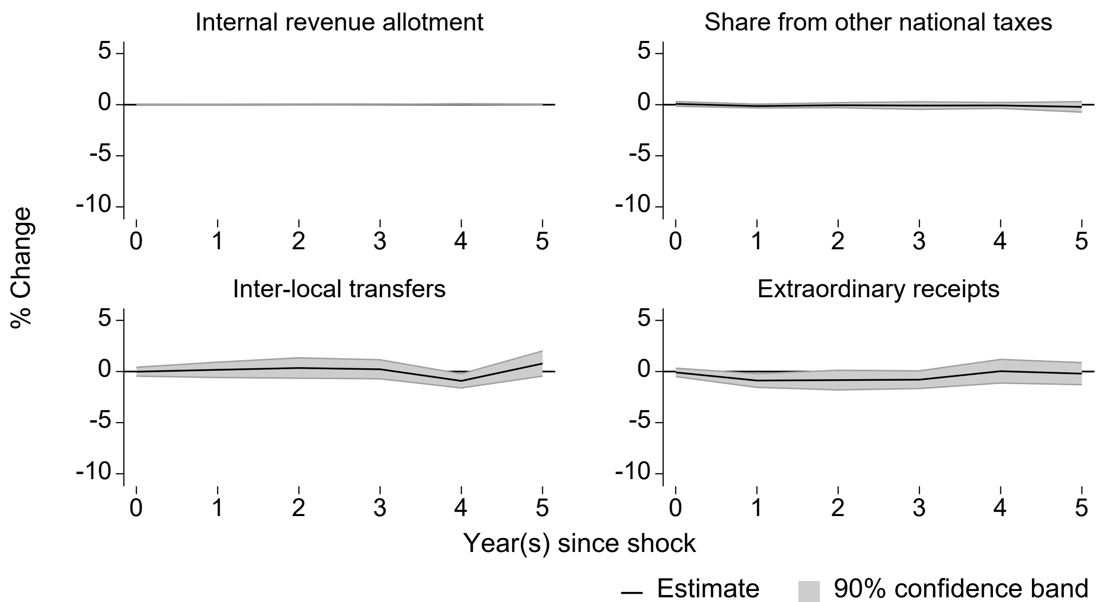
Source: Authors' calculations. Note: The estimates show local projection-based impulse response functions (Jorda, 2005), calculated as the difference between the h-step ahead forecasts with a unit shock of either SAIFI or SAIDI and with no electricity interruption, controlling for lags of the outcome variable. The dynamic panel model is estimated using Arellano-Bond's system GMM estimator to correct for Nickel bias. SAIFI – System average interruption frequency index. SAIDI – System average interruption duration index.

Figure 6. Electricity reliability and local government income from external sources

A. SAIFI (Count per customer)



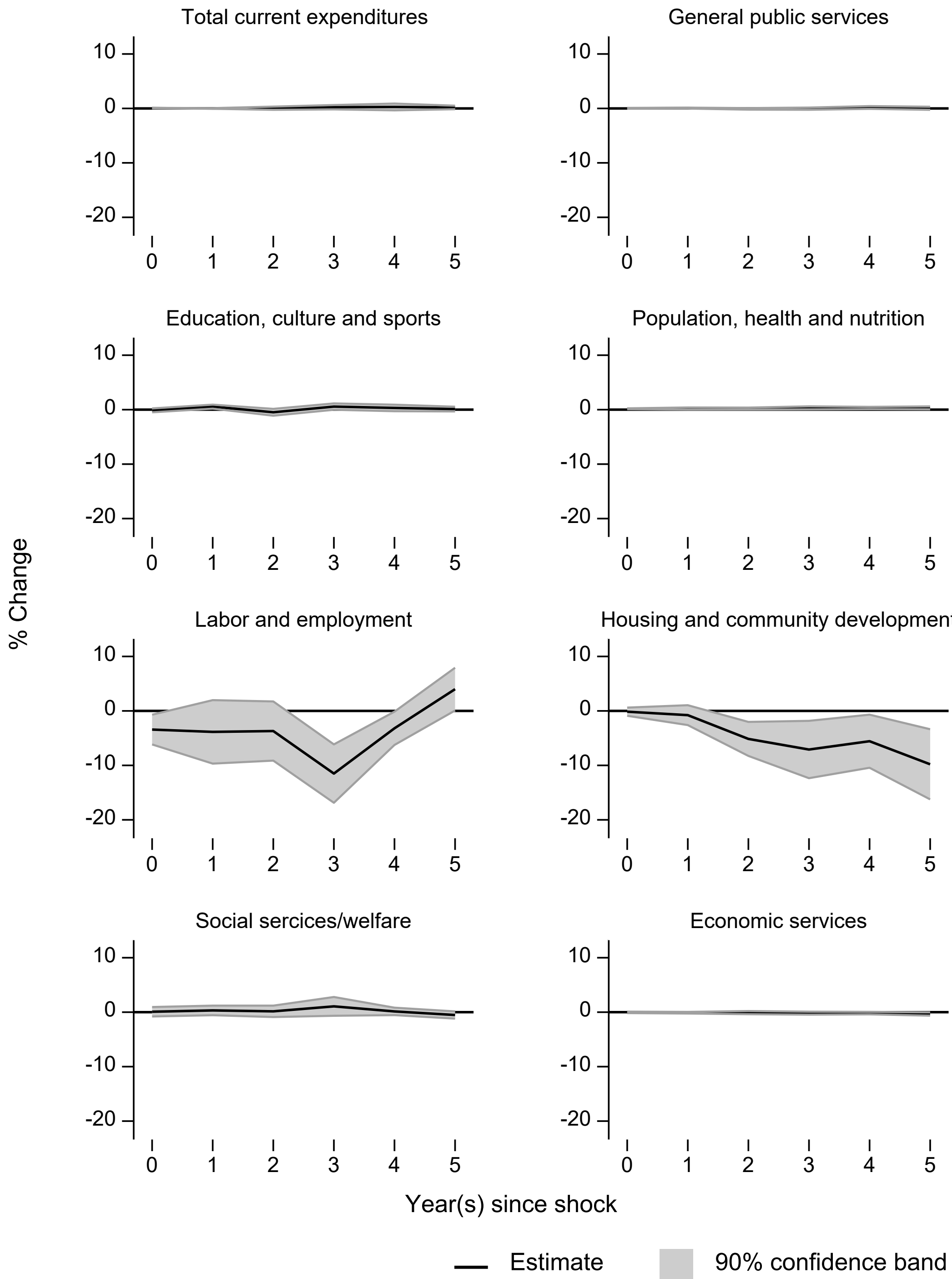
B. SAIDI (Hours per customer)



Source: Authors' calculations. Note: The estimates show local projection-based impulse response functions (Jorda, 2005), calculated as the difference between the h-step ahead forecasts with a unit shock of either SAIFI or SAIDI and with no electricity interruption, controlling for lags of the outcome variable. The dynamic panel model is estimated using Arellano-Bond's system GMM estimator to correct for Nickel bias. SAIFI – System average interruption frequency index. SAIDI – System average interruption duration index.

Figure 7. Electricity reliability and local government expenditures by broad categories

A. SAIFI (Count per customer)

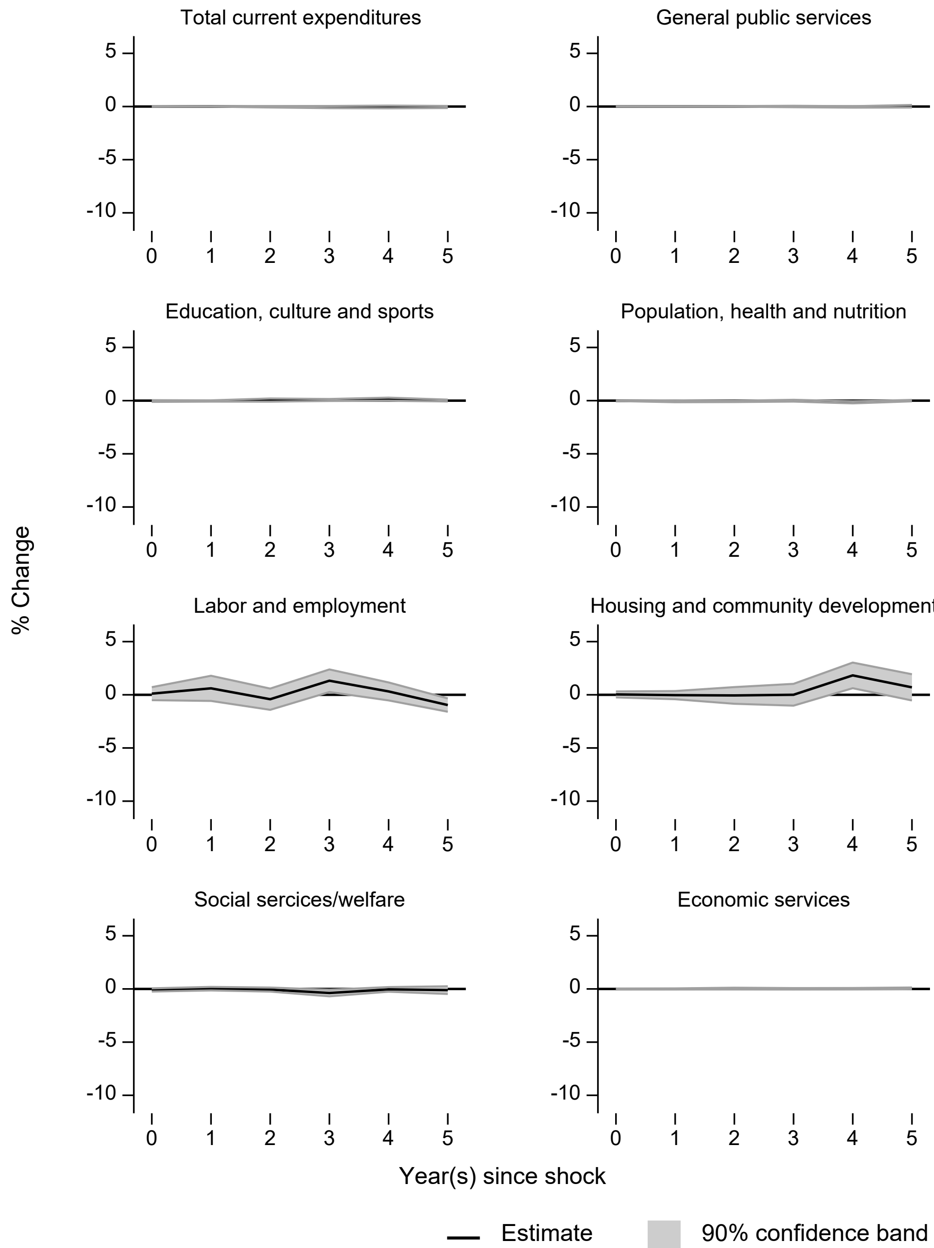


Source: Authors' calculations. Note: The estimates show local projection-based impulse response functions (Jorda, 2005), calculated as the difference between the h-step ahead forecasts with a unit shock of either SAIFI or SAIDI and with no electricity interruption, controlling for lags of the outcome variable. The dynamic panel model is estimated using Arellano-Bond's system GMM estimator to correct for Nickel bias. SAIFI – System average interruption frequency index. SAIDI – System average interruption duration index.

Figure 8 meanwhile shows modest to no change in income variables, in response to an additional hour of electricity supply interruption. This is consistent with our initial proposition that frequent electricity supply interruptions are more burdensome for local governments.

Figure 8. Electricity reliability and local government expenditures by broad categories (continued)

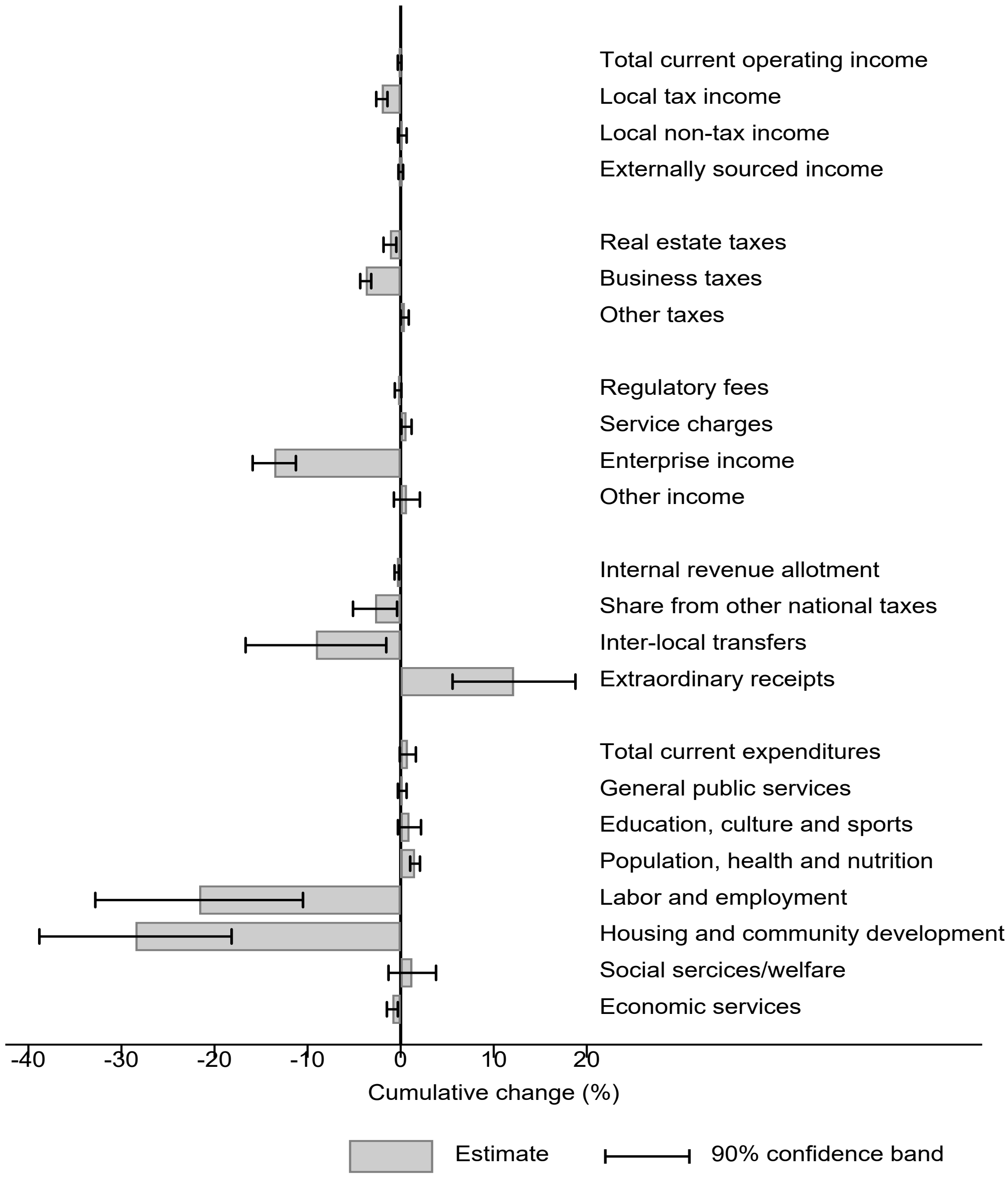
B. SAIDI (Hours per customer)



Source: Authors' calculations. Note: The estimates show local projection-based impulse response functions (Jorda, 2005), calculated as the difference between the h-step ahead forecasts with a unit shock of either SAIFI or SAIDI and with no electricity interruption, controlling for lags of the outcome variable. The dynamic panel model is estimated using Arellano-Bond's system GMM estimator to correct for Nickel bias. SAIFI – System average interruption frequency index. SAIDI – System average interruption duration index.

To demonstrate the extent of damage electricity supply interruptions are causing local governments, we plot the accumulated change in local government income and expenditure items over the span 5 years, in response to a single experience of electricity supply interruption. Figure 9 shows that in terms of income, the most affected is the LGU's enterprise income resulting to an accumulated reduction of about 15 percent, over a 5-year period.

Figure 9. Cumulative change in local government accounts, SAIFI (Count per customer)



Source: Authors' calculations. Note: The estimates show cumulated local projection-based impulse response functions (Jorda, 2005), calculated as the sum of differences between the h-step ahead forecasts with a unit shock of either SAIFI or SAIDI and with no electricity interruption, controlling for lags of the outcome variable. The dynamic panel model is estimated using Arellano-Bond's system GMM estimator to correct for Nickel bias. SAIFI – System average interruption frequency index. SAIDI – System average interruption duration index.

Impact on business and real property tax collection is about 5 and 2 percent accumulated reduction, respectively. On the other hand, the largest impacts in terms of government expenditure are on housing and community development, with an accumulated reduction of almost 30 percent; and on labor and employment, with a total decrease of around 23 percent, over a 5-year period.

Finally, we translate these accumulated percentages into actual values using the 2022 figures shown in Table 1. Table 1 provides an idea of the average values of income and expenditure items of local governments included in our analysis.

Based on our back-of-the-envelope calculations, local governments lose around 10.7 billion PhP from a single electricity supply interruption experienced by ECs, in a span of 5 years; due to reduced income from government enterprises (3.8 billion PhP), business taxes (5.3 billion PhP) and real property taxes (1.6 billion PhP). We also compute that an electricity supply interruption deprives the community of about 3.8 billion PhP-worth of undelivered public services related to housing and community development (3.6 billion PhP), and labor and employment (0.3 billion PhP), over a 5-year period.

Table 1. Local government current income and expenditure, 2010-2022

	PhP billions in constant 2018 prices				
	2010	2013	2016	2019	2022
Current income	402.1	380.5	555.4	756.9	1,087.1
Local tax revenue	85.6	94.0	126.1	187.9	201.8
Real property tax	39.7	40.2	50.9	71.8	81.7
Business tax	40.5	48.2	67.7	104.7	106.4
Other taxes	5.4	5.5	7.4	11.4	13.7
Local non-tax revenue	42.8	38.1	53.9	72.1	73.1
Regulatory fees	8.5	8.1	11.3	16.4	16.9
Service/user charges	7.0	7.6	14.6	23.2	25.1
Economic enterprise income	15.3	16.2	22.0	25.3	25.1
Other receipts	12.1	6.1	6.0	7.2	5.9
External sources	273.7	248.5	375.4	496.8	812.3
Internal revenue allotment	254.4	234.6	349.4	468.5	754.4
Other shares from national tax collections	12.0	9.0	17.7	21.3	44.8
Inter-Local Transfer	3.6	2.4	2.1	4.1	7.2
Extraordinary Receipts	3.6	2.5	6.1	3.0	5.8
Current expenditures	303.6	292.1	360.8	478.9	664.3
General public services	170.1	159.5	198.5	260.4	359.2
Education, culture and sports	16.0	16.2	16.4	24.2	27.5
Population, health and nutrition	32.3	35.0	43.0	64.7	94.0
Labor and employment	0.2	0.2	0.4	0.7	1.3

Housing and community development	8.1	7.5	8.5	10.8	12.7
Social services and welfare	14.1	15.8	24.7	36.0	59.1
Economic services	58.0	53.6	65.1	77.1	104.2
Debt servicing (excluding principal)	4.8	4.3	4.2	4.9	6.3

Source: Bureau of Local Government Finance Statement of Receipts and Expenditures, various years. Note: Values are converted to 2018 prices using the implicit price index of government final consumption expenditure in the Philippines' national account for the relevant year.

IV. Summary and Policy Implications

The issue of electricity reliability, as opposed to electricity access, is not as widely recognized among researchers and policymakers in the Philippines. It this study, we present solid empirical evidence on the detrimental impacts of electricity supply interruptions to local economies, which we hope to initiate further research and policy dialogue.

Using our results, we highlight that unreliable electricity is not only inconvenient but also detrimental to local governments and local communities as it leads to lower income and constrained ability to provide for social services. In our analysis, we showed that a single electricity supply interruption experienced by ECs results to a 10.7 billion PhP loss for local government from just the reduced earnings from economic enterprises, business taxes and real estate taxes. It likewise causes a contraction in local government expenditure related to housing and community development, and labor and employment, depriving the local population of around 3.8 billion PhP-worth of undelivered public services. These findings are worrisome given that the median frequency of electricity supply interruptions in 2022 is 28 times, based on our sample.

Our results point to several policy implications. First, we underscore that improving electricity reliability especially outside the NCR, is both crucial and urgent as unreliable electricity supply has major repercussions on local growth and development. Second, our results suggest that the policy focus should be on minimizing the frequency of power outages. Hence, developing policies that would help boost the performance of ECs as well as ensuring they have access to enough power supply should be high in the list of priorities.

As a final note, while our study serves as a good starting point in research, there are a few related topics that can be further explored. One interesting topic is to examine why longer hours of electricity supply interruptions is less harmful to local economies than frequent interruptions. Another is to look at more specific impacts of electricity supply interruptions on households and businesses.

References

Allcott, H., Collard-Wexler, A. and O'Connell, S. 2016. "How do Electricity Shortages Affect Productivity? Evidence from India." *American Economic Review* 106(3): 587-624.

Arellano, M. and S. Bond. 1991. Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies* 58(2): 277-297.

Barnes, D.F., Khandker, S.R., Nguyen, M.H., and H.A. Samad. 2009. Welfare Impacts of Rural Electrification: Evidence from Vietnam. World Bank Policy Research Working Paper No. 5057. Washington, DC: World Bank.

Bridge, B., Adhikari, D., and M. Fontenla, M. 2016a. Electricity, Income, and Quality of Life. *The Social Science Journal* 53(1): 33–39.

Bridge, B., Adhikari, D., and M. Fontenla, M. 2016b. Household-level Effects of Electricity on Income. *Energy Economics* 58: 222–228.

Cole, M. A., Elliott, R. J. R., Occhiali, G., and E. Strobl. 2018. Power Outages and Firm Performance in Sub-Saharan Africa. *Journal of Development Economics* 134: 150–159.

Dang, D.A. and H.A. La. 2019. Does Electricity Reliability Matter? Evidence from Rural Viet Nam. *Energy Policy* 131: 399-409.

Dinkelman, T. 2011. The Effects of Rural Electrification on Employment: New Evidence from South Africa. *American Economic Review* 101(7): 3078–3108.

Francisco, K. 2022. Electricity Supply Interruptions in the Philippines: Characteristics, Trends, Causes. PIDS Discussion Paper Series 2022-48. Quezon City, Philippines: Philippine Institute for Development Studies.

Gertler, P., Lee, K., and A.M. Mobarak. 2017. Electricity Reliability and Economic Development in Cities: A Microeconomic Perspective. Accessed from https://escholarship.org/uc/item/7jb0015q.

Jorda, O. 2005. Estimation and Inference of Impulse Response by Local Projections. *American Economic Review* 95(1): 161-182.

Khandker, S.R., Barnes, D.F., and H.A. Samad. 2012. The Welfare Impacts of Rural Electrification in Bangladesh. *The Energy Journal* 33(1): 187–206.

Khandker, S.R., Barnes, D.F., and H.A. Samad. 2013. Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam. *Economic Development and Cultural Change* 61(3): 659–692.

Mensah, J. 2024. Jobs! Electricity shortages and unemployment in Africa. *Journal of Development Economics* 167, 103231.

Saing, C.H. 2017. Rural Electrification in Cambodia: Does It Improve the Welfare of Households? *Oxford Development Studies* 46 (2): 1–17.