The Unintended Consequences of Energy Reduction*

How an Act of Environmental Protection Led to the Deaths of Many

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Abstract

Nuclear energy is a clean power source that produces electricity while operating with low-carbon emissions. Although nuclear power generation has its advantages, many concerns have been raised regarding its safety after the Fukushima nuclear accident of 2011. This paper analyzes the utilization of nuclear energy, the price of electricity and electricity consumption, and the temperature-mortality relationship in Japan before and after the accident. We reveal that the use of nuclear energy in Japan sharply decreased following the nuclear accident, resulting in a power shortage scare and surge in electricity prices across Japan. This prompted the country's government to push an energy saving mindset to the public, and as a result, electricity consumption plummeted. However, we find that the government's efforts created adverse effects as days with high temperatures coupled with an energy saving mindset led to a higher mortality rate and a shift to fossil fuel dependent energy poses grave consequences to the environment. These findings prompt discussions about the true cost of energy saving.

1 Introduction

The 2011 Fukushima nuclear disaster changed the relationship Japanese citizens have with nuclear energy. From the 160,000 Fukushima residents that had to evacuate the city to the citizens who may not have been affected directly, the public as a whole turned their backs against the entire nuclear industry (Do 2019). However, we find that Japan's halt in nuclear energy generation is not without its fatal consequences.

The nuclear disaster was triggered by an earthquake, generating tsunami waves that flooded the Fukushima Daiichi plant and shut off power to its cooling systems, causing the meltdown of three reactor cores and radiation release (*Fukushima Accident* 2024). Fortunately, there was no death toll as a result of radiation exposure; however the aftermath of the accident did not leave the Japanese public unscathed. Thousands of residents' mental and physical health deteriorated as they were forced to evacuate and be permanently relocated (Disease Control and Prevention 2023). According to the CDC, the disaster triggered an increase in deaths among elderly citizens placed in temporary housing and a rise in post-traumatic stress disorder rates among those affected (Disease Control and Prevention 2023). The public lost trust in nuclear energy and demanded the use of nuclear power plants be eradicated from Japan (Suzuki 2019).

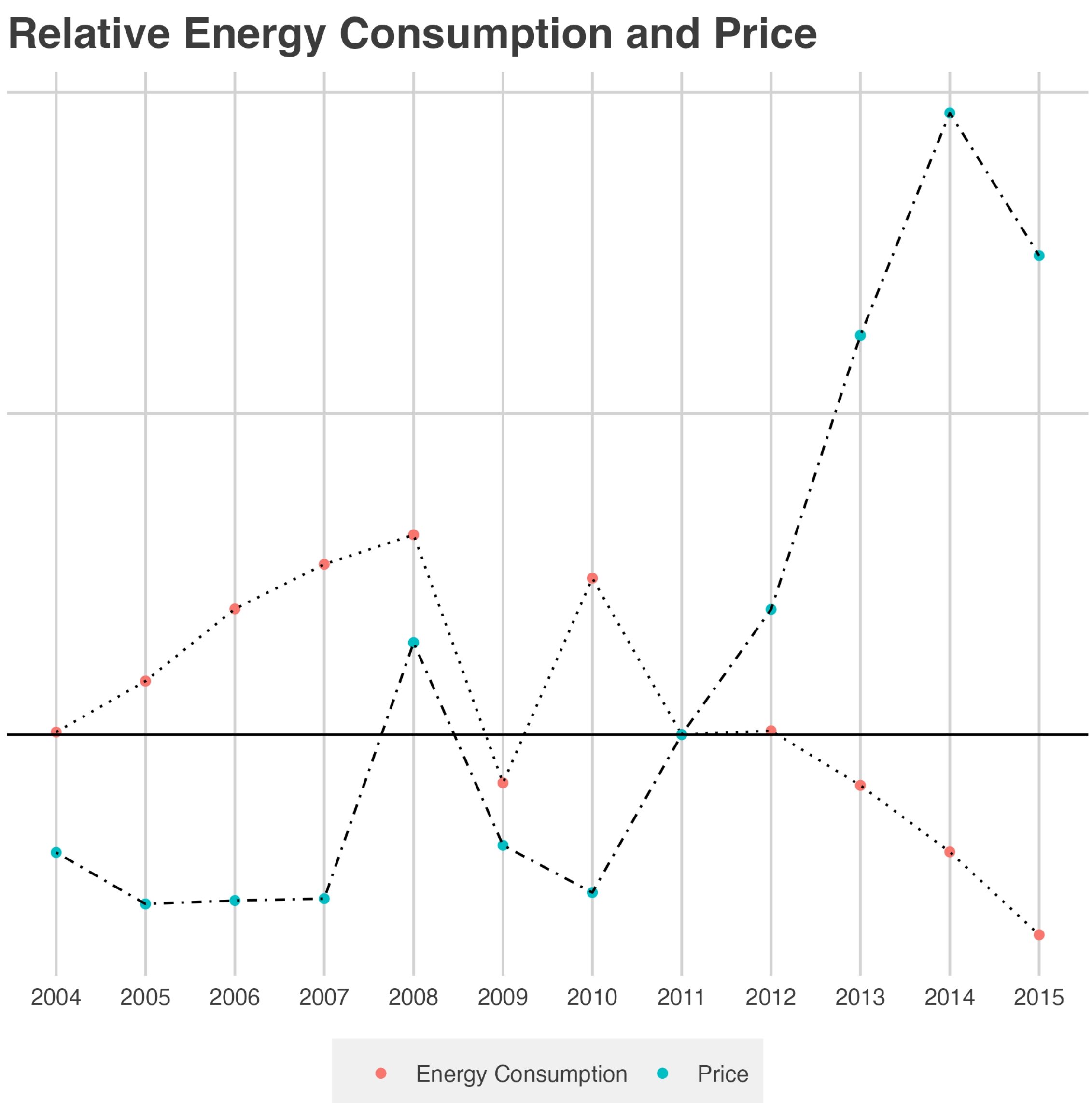
As a response to the growing public outcry, the government of Japan took swift action to significantly reduce nuclear power generation by implementing a new energy policy to eliminate nuclear power by 2030 (Suzuki 2019). Before the accident, nuclear energy comprised 25% of Japan's energy market (Suzuki 2019). After the accident, its market share stayed under 1.7% until 2016 (Suzuki 2019). The significant and abrupt reduction in overall power generation caused Japan to steer dangerously close to potential countrywide power shortages (Crace 2011). To combat this, the government pushed a power saving campaign to the

*Code and data are available at: https://github.com/apang00/Energy-Policy.git public (Crace 2011). In fear of blackouts, energy saving was quickly adopted by Japanese citizens, resulting in a considerable decrease in electricity consumption (Suzuki 2019).

We find that the energy saving campaign was not the sole factor in the sharp decline in energy consumption as the price of electricity also surged. As many nuclear reactors were shut down, fossil fuels grew to dominate Japan's energy market. In 2011, oil usage rose by an estimated 85% while natural gas increased by 25% (Nakano and Pumphrey 2012). This shift to predominately fossil fuel usage had a substantial impact on the price and consumption of electricity as the majority of fossil fuels utilized in Japan are imported from other countries, resulting in expensive prices (Nakano and Pumphrey 2012). Relative to the mean price of electricity in 2011, the price of electricity increased by over 10% in 2013 and further increased by nearly 20% in 2014 (Nakano and Pumphrey 2012). Consequently, electricity consumption decreased each year as the commodity became less affordable. The Japanese government was successful in reducing energy consumption; however, their energy-saving policies and campaigns may cause potential detrimental consequences to the public.

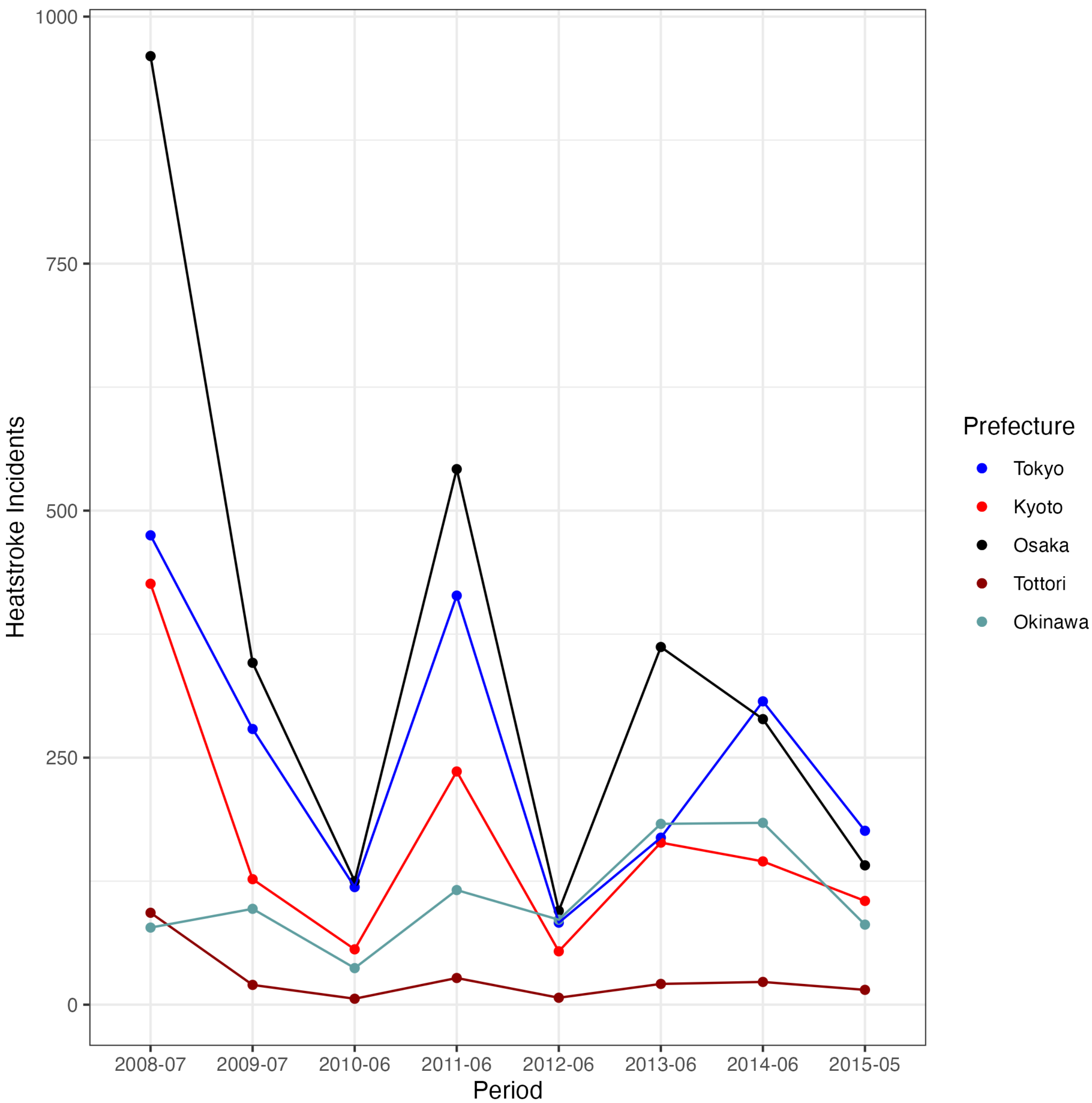
In this paper, we follow He and Tanaka's paper (2019) to produce a reproduction of their findings and discuss further about Japan's future as their government reverses their stance on nuclear energy and begins restarting the use of old power plants as a response to fossil fuel shortages and the public pressure to reduce the country's carbon footprint. The estimand for our study is the effect of energy price on energy consumption. We analyze the major reduction in energy consumption from 2005 to 2015 caused by the decline in nuclear energy usage, the sharp increase in electricity prices, and the energy saving campaign pushed by the Japanese government in order to investigate their impact on the mortality rate related to high temperatures. We find that the mortality rate increases as energy consumption decreases. An important finding is that air conditioner usage plays a vital role in preventing deaths related to high temperatures. Therefore, the pressure to conserve energy and hence not utilize air conditioners, increases the mortality rate in Japan.

The remainder of this paper is structured as follows: the Data section details the collection and processing of nuclear energy production, energy consumption, energy price, and temperature-mortality data. Additionally, the section includes discussion on the measurement of the original dataset. The following Results section displays and analyzes tables and figures that illustrate the trends found in the data. The Discussion section draws conclusions from those tables and figures and details the importance of our findings and weaknesses of our paper.



Relative Energy Consumption and Price
1.2
1.1
1.0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Energy Consumption
Price

FIGURE 1



After the Fukushima incident, the government tried to ensure sufficient backup capacity to avoid power blackouts. While other factors could affect the saving target, the primary determinant of the saving target was a region's dependence on nuclear power before the accident.(Kim, et al.) This caused more health issues for individuals as they were encouraged to not use AC and other cooling devices during hotter days. Previous to the implementation of the energy policy, throughout the period between 1960 and 2004, the mortality rate at over 32.2 degrees Celsius has dropped tremendously while that of between 26.7-32.3 degrees Celsius remained consistent. However, it becomes evident that after the policy implementation, at similar ranges of 25-30 degrees Celsius and over 30 degrees Celsius produced a higher mortality rate. [figure 5]

You can and should cross-reference sections and sub-sections. We use R Core Team (2023) and (**rohan?**).

The remainder of this paper is structured as follows. Section 2. . . .

2 Data

In an attempt to understand impact of the Fukushima disaster through data we looked at the changes over time of many variables. The first variable we examined was the number of ambulance calls for heatstroke. This data was collected from the Fire and Disaster Management Agency in Japan and was a good fit for our analysis as we wanted to really wanted to study the changes in heatstroke occurrences over time.

Additionally, we also considered health datasets which may have helped us analyze heatstroke occurrences directly, but they were all in Japanese and usually consisted of multiple other illnesses making these datasets difficult to parse through. We felt that this particular dataset could capture the relationship between heatstroke and time well.

Looking at ambulance calls was our way of measuring heatstroke occurrences. This way of measurement has the advantage of being concrete while trying to measure health symptoms can be challenging and subjective. A flaw with this way of measurement is that it misses people with heatstroke who didn't call an ambulance.

The second variable we examined was the domestic energy production of Japan in terajoules. We collected this dataset from the International Energy Agency. This variable is easy to measure due to the high barrier of entry energy production at a large scale requires. Japan has 10 major energy companies that supply energy to the nation and any additional energy production wouldn't go unnoticed.

Another variable we also considered was Japan's mortality rate. We used the data from the National Institute of Population and Social Security Research of Japan in our analysis due to the reputability of the source. Mortality can be difficult to measure considering just how large human populations can be. Documenting all cases of mortality may not be possible, especially for people with few friends and family.

Lastly we studied energy consumption (MWH), and the price of 1MWH in yen. To study these variables we used data from the Federation of Electric Power Companies of Japan (FEPC). This is data directly from the source of Japan's domestic energy, so we preferred it over other datasets. Measuring energy consumption is easy because it has a price tag attached to it. Since most transactions occur via the internet these days, it's pretty easy to keep track of all price and consumption data. However, a human error of records could affect the measurements.

3 Model

The goal of our modelling strategy is twofold. Firstly,...

Here we briefly describe the Bayesian analysis model used to investigate... Background details and diagnostics are included in Appendix B.

4 Results

Our results are summarized in **?@tbl-modelresults**.

5 Discussion

Our findings give insight into the consequences of energy saving in Japan, particularly the potential fatalities that may occur. It is also important to discuss the growing use of fossil fuel dependent energy generation as a response to the Fukushima nuclear accident and its devastation on the environment.

5.1 Findings

After the Fukushima accident, the Japanese public's trust of nuclear power was retracted and the use of nuclear power began to diminish. Figure 1 emphasizes this sharp decline in nuclear power energy production in Japan. As a consequence of the decline in nuclear energy production, Figure 2 shows the extreme increase in energy prices and the decline in energy consumption. These findings can be attributed to the Japanese government urging the public to use less energy and the expensive cost of fossil fuel use for energy production. Figure 3 demonstrates that the energy saving campaign orchestrated by the government and the use of expensive fossil fuels can have harmful effects. Specifically, Figure 3 illustrates the potential increase in the mortality rate of Japanese citizens due to their reduction in energy consumption. In particular, Barreca et al. (2016) states that air condition usage reduces the mortality rate related to high temperatures by a significant amount (Barreca et al. 2016). By utilizing their findings and He and Tanaka's (2019) findings, we draw the conclusion that the mortality rate increases by 0.8% during temperatures between 25°C and 30°C and by 0.19% during temperatures over 30°C (He and Tanaka 2019). This is significant as it demonstrates that the push for energy saving may cause fatalities in high temperature environments. This consequence of energy saving can be further illustrated by Figure 4 and Figure 5, whereby the number of heatstroke incidents sharply increased from 2010 to 2011.

5.2 Japan's Relationship with Nuclear Energy and its Impact on the Public

As shown in Figure 1, the use of nuclear energy is slowly becoming obsolete in Japan in light of the Fukushima accident. However, in 2022, the Japanese government announced a plan to revitalize the use of nuclear energy (NPR 2022). This decision comes as a potential solution to fossil fuel shortages and the push for low carbon emissions. Nuclear energy production produces little waste, is less expensive to operate, and generates low carbon emissions (Nuclear Energy 2021). The government plans on maximizing the output of all existing nuclear power plants and they aim to build new reactors, proclaiming that nuclear energy will contribute to 20-22% of the country's energy output by 2030 (NPR 2022). The government reversed the nuclear energy policy, but low public demand for nuclear energy persists. Thus, energy prices will remain high as individuals continue to advocate against nuclear energy usage and turn to fossil fuels. Additionally, there are barriers to reinstating nuclear power generation that exacerbate the trend found in Figure 3. One barrier is the Nuclear Regulation Authority which enforced stricter safety regulations for reactors (Suzuki 2019). Restarts of existing nuclear reactors have been slow due to these stricter regulations put in place following the Fukushima accident (NPR 2022). Additionally, the government's new stance on nuclear energy does not come without opposition by the public. One survivor of the Fukushima disaster voices their frustration, "The Fukushima disaster is not over yet and the government seems to have already forgotten what happened." (NPR 2022). Furthermore, citizens can bring forth injunctions to prevent the operation of nuclear reactors. After the Fukushima tragedy, many courts in Japan may grant these injunctions to protect the public's safety (Suzuki 2019). Thus, as the return to nuclear energy is met with resistance, the use of fossil fuels persists; thereby causing the price of energy to increase and the consumption of energy to decrease, leading to potentially more fatalities in high temperatures.

5.3 Future Research Proceedings

For future research, more data should be collected regarding deaths due to high temperatures to investigate its relationship with energy prices. Additionally, as global temperatures continue to soar each year, it is imperative that more environmentally friendly solutions to energy generation be adopted.

5.4 Weaknesses and next steps

A few weaknesses with the analysis comes from the limitation of data.The scope of analysis for the post-Fukushima incident and the effects of the energy policy is only Japan. There is no comparison to other countries and their markets trends after nuclear accidents such as Ukraine with the Chernobyl incident. Furthermore, the data is limited only from the Fukushima incident up until 2016 allowing for a short term analysis. The physical effects of nuclear incidents along with the economic effects of the energy policy are both issues that can use a more long term approach. Additionally, there is a lack of robustness as the analysis is fixated on the effects caused by the transition from nuclear energy to fossil fuels. However, there are other energy sources such as renewable energy which includes solar and wind energy that should be taken into consideration.

The next steps would be to find more recent data. As aforementioned, the datasets only extend until 2016 and to complete a long-term analysis, more recent Japanese energy data needs to be collected. Moreover, data from before and after other global nuclear incidents should be gathered and evalauted in comparison to Fukushima to evaluate whether the Japanese government's apporoach was the most optimal. Another step that can be taken to futher the analysis could be to explore more granular effects. For example, in addition to looking at how ambulance calls and heat strokes can be correlated and how increased temperature can cause higher mortality rates before and after the energy policy, other factors such as energy price variation and seasons or energy jobs and employment rates can be observed as well.

Appendix

A Additional data details

B Model details

B.1 Posterior predictive check

In **?@fig-ppcheckandposteriorvsprior-1** we implement a posterior predictive check. This shows…

In **?@fig-ppcheckandposteriorvsprior-2** we compare the posterior with the prior. This shows…

B.2 Diagnostics

?@fig-stanareyouokay-1 is a trace plot. It shows… This suggests…

?@fig-stanareyouokay-2 is a Rhat plot. It shows… This suggests…

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