

Safety Regulation Impact on Weakened Economy: Japan nuclear industry and macroeconomic analysis post Fukushima Daiichi nuclear accident

By Arshia Shrimali

ABSTRACT

The Fukushima Daiichi Nuclear disaster that occurred, displacing thousands of lives, became one of the well-known nuclear disasters in history that shaped the nuclear safety regulations held up till date. However, organizations such as the NRA (nuclear regulatory authority) were opened to enforce regulation, a strict policy known to decrease economic activity. With the decrease of nuclear energy by 18% months after the Fukushima accident, the investigation qualitatively aims to examine the role safety regulation had to play on the nuclear industry and whether it was the sole reason for a decrease in industrial activity from nuclear energy. Data from public data bases were examined and analyzed to understand how safety regulation could've affected the economy along with many articles detailing events that occurred during the scope of 2010 to 2021. Upon examining the data of industry activity and how the nuclear industry was affected, several factors as to how Japan's safety regulations on nuclear energy were received was then examined to see the effects on the economy and if safety regulation was the sole reason for the nuclear energy to decrease activity.

INTRODUCTION

In 2011, Fukushima, a prefecture in Japan, experienced natural disaster that led to the shutdown of the coolants of the Fukushima Daiichi nuclear powerplant. The result led to the meltdown without the availability of coolants to mitigate the heat that the nuclear fission process caused within the reactors, resulting in radiation leakages in Fukushima. Approximately 200,000 people were displaced due to the accident, and a section of Fukushima's region remains uninhabitable, even today, adding exertion and strain on the people due to the reduced resources in Japan's economy.

Fukushima's citizens still experience struggles in infrastructure rebuilding, electrical supply, unemployment, and environmental issues today. All these impacts are the negative production externalities left behind by the nuclear accident. As a result of these externalities, the confidence of citizens toward the state of the economy in general has decreased, but the mental wellbeing of households in Fukushima has also decreased due to radiation anxiety and other mental health struggles. Additionally, some indirect deaths were also caused by the accident—due to the high doses of radiation, survivors of the accident had higher risks of cancer. All these externalities have decreased the standard of living in Fukushima.

Current studies focus largely on psychological or environmental impacts on households in Fukushima, but many articles also show the deterioration of Japan's resources amongst its prefectures, such as the deterioration in land or electricity as a resource after the nuclear accident through several predictions and models. Still, this investigation aims to focus on the safety legislations and strict regulations Japan had held up after the Fukushima accident, and how these policies then affected the economy in comparison to the situation before and after the legislations.

Often in the short run, licensing adds more pressure on nuclear industries, reducing employment due to workers being unable to meet new requirements, and regulations may lead to increasing costs within the nuclear industry and worsening the diseconomies of scale after the accident, resulting in more pressures that lead to less production from nuclear industries. Therefore, a macroeconomics perspective of poverty and unemployment due to industry activity and government policies is to be explored. However, many factors are bound to affect the expenditure of the nuclear industry within Japan's economy—such as the replacements for nuclear energy, government intervention prioritization, etc. Thus, although economic theory and public data will be taken into consideration, the investigation will primarily be qualitative and reliant on sources for its analysis.

LITERATURE

The Lost Decade of Japan (1990-2001)

After World War II, Japan experienced a period of industrial expansion that led to an economic boom in the mid 1980s. This was due to the deregulation in the economy—loose monetary policy that allowed more market freedom, with low rates of interest and flexible lending because of commercial bank incentives toward market shares. During 1985, a meeting between country officials, including USA and

Japan, had also taken place, in which it was agreed upon to degrade the US dollar to Japanese yen value. This resulted in the appreciation of Japan's yen. This appreciation in the domestic currency led to the increased price of exports in the view of foreign countries, which would lead to less foreign demand. As a result, producers focused resources toward domestic production and assets. As the prices of land and stocks increased as a result of the growing value of assets, demand increased as well because collateral value would have increased. This period of economic welfare in Japan was known as *the bubble*. The bubble reached its economic peak during the years of 1987 and 1990.

However, in 1989, Japan's central bank, the Bank of Japan, increased the rate of interest, implementing contractionary monetary policy. This was to counteract the significant increases in the aggregate demand of the economy that were leading to demand-pull inflation. However, land and stock prices rely on the low rates of interest to increase the incentive for borrowing. With higher rates of interest, there was a drop in real estate and stock prices. Banks, as a result, were burdened with non-performing loans more frequently due to low value collateral. This increased government debt led to economic stagnation, and a series of recessions known better as the *lost decade* (Halton, 2021; Schiff, 2015). This is a significant reason for the demand-side deflationary characteristic of Japan, and needs to be accounted for in Japan's history before the Fukushima Daiichi Nuclear accident.

The Global Financial Crisis (2008-2009)

During 2008, the USA experienced economic difficulties, leading to their decreased activity toward exports and imports. This is the cause of the financial crisis that led to several countries experiencing external shock. Japan was one of the countries who experienced the consequences due to the prior trade of exporting heavily to the USA. It was how Japan received a trade surplus from the USA.

Still, despite the dip in Japan's real GDP as a result of the global financial crisis, according to CEIC databases, the GDP increased once again promptly, going from approximately 115 million yen to approximately 125 million yen from September 2009 to December 2009. This is likely due to Japan's and other global resolution policies to combat the consequences of the situation.

Nuclear Energy Industry

Reported in a study observing the impact of Fukushima power plants before the disaster (Shimada, 2024), the Fukushima powerplants, including Daiichi, had positive effects on the prefectures and country before the nuclear disaster in 2011. Nuclear energy was very competitive at the time, with the costs of production from 2006-2010 approximating to ¥7.0 per kWh. Neither fossil fuels nor renewable energy had prices as low, with ¥10.20 per kWh and ¥8.20 per kWh respectively (Nuclear Still Cost Competitive in Japan, Study Says, 2011; Matsuo et al., 2013). Nuclear energy at the time faced significant economies of scale, becoming the staple source of energy in Japan as a result with 30% of energy in Japan being generated from nuclear power (World Nuclear Association, 2025).

With the increased significance and resource allocation toward nuclear energy, Japan saw benefit in industries such as agriculture and construction industries. Despite the negative impacts in the

manufacturing industries, assumed to be caused by employment shifts within secondary firms of the prefecture, the economy still had more growth (Shimada, 2024).

One of the plausible reasons that nuclear energy became so competitive is likely due to the government intervention. Since the 1970s, the Japanese government has used nudging techniques and subsidization toward the nuclear energy industry. This is likely to mitigate the amount of energy imported in Japan due to fossil fuels or other resources required.

The Great East Japan Earthquake and Nuclear Accident (2011)

Preceding the Fukushima Daiichi nuclear accident was the Great East Japan Earthquake, more commonly known as Tōhoku earthquake. Japan has a high likelihood of earthquakes due to the geographic location, resting above four seismic plates. The Tōhoku Earthquake was 9 meters in magnitude, producing intense shaking. It would end up generating a large Tsunami, estimated to be 40 meters tall, hitting the coastline where switchgear and control electricity panels rested (National Centers for Environmental Information, 2021). This would destroy the panels, resulting in electricity in the Fukushima Daiichi nuclear power plant to shut down.

However, there was residual thermal energy (estimated to 6-7%) that continued the nuclear fission process, even after the electrical loss led to the coolants shutting down as well. Within the Daiichi nuclear powerplant, there were 6 units. Units 4-6 were already offline due to management prior to the Earthquake, but 1-3 were still running. Unit 1 experienced collapse first as the heat uncovered and exposed the fuel rods to steam, leading to further heat damage in the core and reactor. Units 2 and 3 had a different coolant run on via batteries when the electricity was gone, but eventually, those batteries would run out as well, causing meltdown as well. With the product of the fuel rods and steam resulting in the light gas of hydrogen, it leaked upward. Hydrogen is a generally flammable gas, and when reacted with oxygen in specific concentrations, it can lead to an explosion. These were the explosions in units 1, 3, and 4, which incited emergency responses (World Nuclear Association, 2024).

METHODOLOGY

During the investigation of how the nuclear energy safety regulations impacted the economy, a scope of Japan's economy from 2010-2021 will be taken. Events throughout those 10 years will be investigated through news articles from the time and other such reports on any such activity. Any trends in economic factors, however, will be viewed through online statistical sources, such as Japan's official databases or other online, official databases. Papers with quantitative data reported either in the past or originally coming from the paper's findings will also be taken into account. Characteristics of the economy caused by any of the economic events noted in the *Literature Review* will not be considered in the final results as to how safety regulation of nuclear power plants affected Japan's economy.

However, limitations in the discussion will arise from the Great East Japan Earthquake—because the Fukushima accident proceeded post-Earthquake, factors such as decreases in GDP due to the Fukushima accident will be difficult to separate from the Great East Japan Earthquake because both damaged resources significantly, the earthquake more so. To reduce inaccuracy, energy specific industrial

activity will also be considered alongside macroeconomic factors, such as energy imports, costs per kWh, etc. Still, macroeconomic factors such as real GDP, unemployment rate, and government spending will also be utilized to explain phenomena related to the accident.

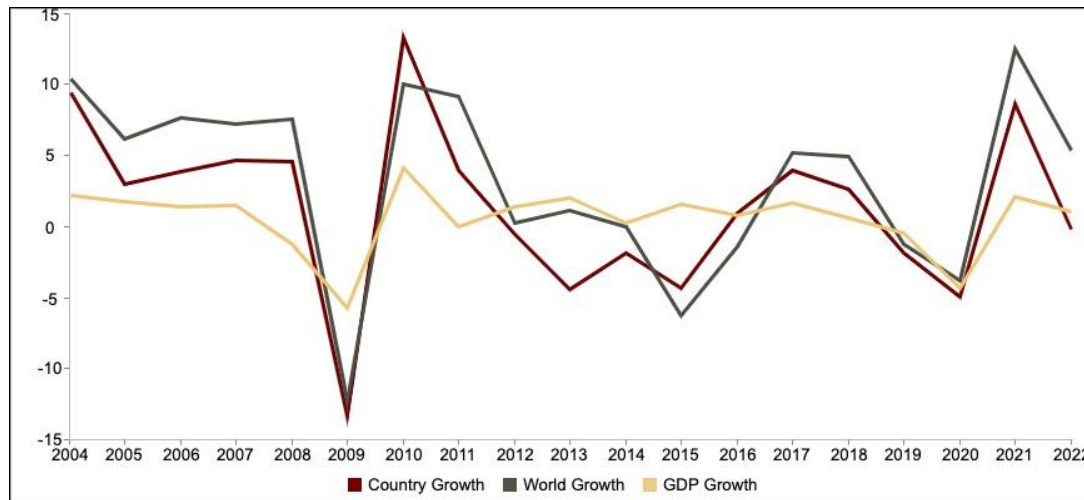
FINDINGS

Imported Energy

During 2011, for the first few months after the Fukushima accident, nuclear power plants were shut down. Studies show that fossil fuel energy imports rose as a result after the accident. By 2012, there were an additional cost of \$35 billion due to the increase in fossil fuel usage, where fossil fuel imports rose to nearly 28%. This came from increased imports in liquid natural gas (24%) and fuel oil (87.7%) (Matsuo & Yamaguchi, 2013; World Nuclear Association, 2025).

Real GDP

Figure 2: Real Gross Domestic Product of Japan, (World Integrated Trade Solution)



Data from the World Integrated Trade Solution (World Integrated Trade Solution, 2025) shows the real GDP trends of Japan during the years 2004-2022, but for the sake of the investigation, the years 2010-2021 for the GDP growth series will be focused on. From the years 2010-2011, there is a decreasing GDP, before the GDP started increasing from 2012-2013. This is likely due to the . The GDP then falls in 2014, before recovering and steadying from 2015-2017. The GDP then falls once again from 2019-2021, likely due to the global pandemic.

Unemployment Rate

Figure 3: Unemployment Rate of Japan, (World Bank database)



The graph shows the steady decrease in unemployment throughout the years, increasing slightly in 2020 but otherwise decreasing. A nearly natural unemployment rate is reached from 2018-2019 before the rise in 2020 (World Bank Group, 2025).

Other Factors

During the first few months after the Fukushima accident, nuclear power plants were shut down. It was only in August of 2011 that smaller power plants were beginning to open up, starting 17th August, 2011 (Donnelly, 2011), with a powerplant on Hokkaido island. However, bigger ones took far longer to open, possibly years after the accident (Japan's Nuclear Power Plants in 2024). Furthermore, costs spiked for the powerplants that reopened, coming approximately to ¥12.5 per kWh in 2011. Safety regulation costs come to around ¥0.2, ¥1.1 comes for policy measures, and ¥0.5 is added due to future nuclear risk (World Nuclear Association, 2025). With the economy starting to lean toward fossil fuels as well, this caused the energy generated from power plants to come to 12% of all energy in 2011, and 2% in 2012.

DISCUSSION

The investigation as of now details into the Fukushima accident and how other factors play a role into the economy as well, but in discussion about the nuclear industry's safety regulation and the economic impact as a result of it, some of the findings are able to shine a light on the accident's consequences.

Safety regulation in Japan, along with other government policies shown here, has likely been the reason for the decrease in energy generated by nuclear energy, with the drastic drop from 30% to 12%. This can be due to the costs of the safety regulation upgrades required of opening powerplants, along with other policies meant to ensure the safety of the people. It likely caused a higher dis-economies of scale. With the NRA (nuclear energy authority), an independent body from the government, enforcing the regulations instead of the Japanese government, which has a bias toward nuclear energy due to it being a better alternative to fossil fuels and still being efficient with the given climate of Japan, there is a higher

likelihood for it to be a stricter regulation to be followed than prior, especially with the relative increase in transparency about the nuclear energy regulations coming from the NRA.

However, this also means there's an increased dependence on imported energy such as fossil fuels. The findings report a higher amount of imported fossil fuels. This can likely diminish trade surplus for Japan, which is already facing quite a bit of trade deficit from past economic events. Furthermore, a similar dependency of trade noted from the global financial crisis is coming up again for Japan due to imported energy being an importance for the country. It makes Japan more vulnerable toward external shock, which can lead to several economic consequences such as a recession, reduced employment, etc.

Still, it is likely that safety regulation isn't the singular reason for Japan's reliance on imported energy. Safety regulation and policy accounted for an increase in ¥1.5 addition to the nuclear powerplants, and there were likely other factors that came into play of reducing nuclear powerplant production. Damage costs for the Fukushima accident came to around ¥1 trillion in 2011, and with the radiation trauma from the accident, the general public are also distrustful of nuclear energy. This was further exasperated by Japan's employment of workers for damage control, due to their viewings of the actual damage. Japan was enforcing Abenomics, drafted by the Prime Minister Shinzo Abe, where they relied on market supply-side and fiscal policies to regulate the economy. This was the primary reason there was a GDP recovery quickly after 2011—during 2012 and 2013, they had managed to increase the real GDP through fiscal stimuli. Still, by hiring more people to aid in disaster management, there isn't a direct productive increase in productive capacity in the economy to make up for the reductions in total aggregate supply due to the disasters and accident, and it also puts further mental strain on workers who already have low confidence in nuclear energy (Sawano et al., 2020). This would further increase reluctance toward the nuclear energy powerplants.

CONCLUSION

Although safety regulations played a significant role in the reduction of nuclear powerplant energy usage, it is likely due to public reluctance toward nuclear energy usage and its lack of past transparency that lead to the further low competitiveness of nuclear reactors today in Japan. This suggests that if the Japanese government were to continue ongoing operations, they would need more public trust, which requires further transparency and likely nudging tactics to be able to maximize nuclear power without public protest.

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