



Dreams of urbanization: Quantitative case studies on the local impacts of nuclear power facilities using the synthetic control method [☆]



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ABSTRACT

This paper uses the synthetic control (SC) method to examine how the establishment of nuclear power facilities (NPFs) in Japan in the 1970s and 1980s has affected local per capita income levels in the municipalities in which they were located (NPF municipalities). Eight quantitative case studies using the SC method clarify that the effects of NPF establishment on per capita taxable income levels are highly heterogeneous. The estimated effects are often economically meaningful and in some cases huge: the income level was 11% higher on average and 62% higher in one municipality in 2002 when compared with counterfactual units. On the other hand a few of the NPF municipalities have received only weak or negligible effects from NPF establishment. The post-estimation comparisons of employment between the NPF municipalities and the SC units suggest that the size of the direct labor demand shocks and subsequent indirect employment effects on nontradable service sectors have contributed to the increase in per capita income levels.

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You know, municipalities where nuclear power plants are located are all poor areas. Okuma town has a mild climate and it's comfortable to live there. But the main industry was agriculture and many people looked for jobs in large cities during the winter. In the winter, fathers had to leave home. Families had to live apart. [At the time we thought] "If a nuclear power plant comes, we won't have to leave home during the winter. We can get better jobs with steady incomes, instead of relying on volatile agriculture. We can receive education in nice school buildings. Grants will make the town rich." Nuclear power was called "the energy of the future".

-Toshitsuna Watanabe, mayor of Okuma town, Fukushima prefecture¹

1. Introduction

Since the Fukushima Daiichi nuclear disaster in 2011, it has been widely recognized in Japan that municipalities which have accepted the location of nuclear power facilities (NPFs) receive large employment opportunities and NPF-related fiscal benefits such as central grants and revenues from local property taxes. The quote above clearly expresses local residents' hope that NPF establishment would realize industrialization and urbanization in their municipality.

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¹ This passage is quoted from an interview with Toshitsuna Watanabe in Japanese at *Diamond Online* <http://diamond.jp/articles/-/16605>. The article was published on March 15, 2012 and accessed on June 20, 2014. The sentences are translated into English by the author. All the citizens in Okuma town were evacuated from their homes after the accident at the Fukushima Daiichi (I) Nuclear Power Plant on March 11, 2011.

The local economic development of municipalities with NPFs (subsequently “NPF municipalities”) is not an issue belonging only to the past. After the Fukushima disaster, Zengenkyo, the association of all NPF municipalities and several other neighboring municipalities, has clearly stated that it continues to support the utilization of nuclear energy and the promotion of a nuclear fuel cycle policy in Japan.² At first glance Zengenkyo’s firm political support for nuclear energy may seem incomprehensible, as all of the NPF municipalities in Fukushima, which have been devastatingly affected by the nuclear disaster, belong to this association. But considering the fact that the local economy of NPF municipalities is heavily dependent on the NPF industry, it is not strange for NPF municipalities to have held fast their essential political principles concerning nuclear energy even in the face of the Fukushima disaster.

In light of the ongoing debate in Japan about the nation’s post-Fukushima nuclear energy policy, it is increasingly important to understand the socio-economic impacts of NPF establishment on surrounding areas in order to assess the costs and benefits of NPFs to local communities. In this regard it should be informative to examine how NPF establishment can be a successful place-based economic policy and how it affects the living standards of local residents.³

It is, nevertheless, not clear how the establishment of NPFs has promoted local economic and income growth in Japan. Several official reports point out that the benefit of NPF establishment on local communities is generally weak.⁴ On the other hand, there is a stereotype that the economy of NPF municipalities depends heavily on the nuclear power industry. The following question then arises: does NPF establishment really lead to a significant increase in local income levels? In order to tackle this question, I examine the impact of the establishment of NPFs in the 1970s and 1980s on local per capita taxable income in Japan.

From an econometric point of view, however, it is not an easy task to estimate the impact of NPF establishment on local income levels. As in many studies that focus on the effects of specific economic shocks on economic outcomes, estimation strategies based on difference-in-differences (DID) approaches may be applicable, but there are several challenges concerning the application of DID estimation in this study.

First, because NPF sites are not randomly assigned but determined by various geographical, political and socio-economic factors (Aldrich, 2008a,b), the common trend assumption of simple DID may not be plausible. In addition, it is hard to control for confounding time-varying covariates because NPF establishment changes local socioeconomic situations in various ways and controlling for these endogenous factors is problematic. Second, the number of “treated” municipalities is small: in Japan, there are only 22 NPF municipalities and my limited dataset allowed me to examine only eight NPF establishment events. Although the time dimension of the dataset is relatively large (from 1972 to 2002), the small number of treated units could make it difficult to consistently estimate an average effect of NPF establishment and implement plausible inference.

Third, different characteristics of different NPF locations could also result in misleading conclusions: the timing of NPF establishment, periods of construction and operation, numbers and scales of NPFs differ considerably in each NPF municipality. Impacts of NPFs are also not uniform over time because construction and operation involve different economic activities and the revenue

from local property tax based on NPF-related assets decreases gradually due to depreciation once NPF operation starts. The estimated average treatment effect of the small number of NPF locations could thus be hard to interpret without taking into account this heterogeneity.

To deal with these problems, I adopt the synthetic control (SC) method that was firstly proposed by Abadie and Gardeazabal (2003) and then further developed by Abadie et al. (2010) and Abadie et al. (2014). The idea underlying the SC method is intuitively clear: a combination of control units is used to construct a “counterfactual” unit (called *synthetic control unit*) of a treated unit and the outcome of this counterfactual unit is then compared with the realized outcome of the treated unit. The construction of a synthetic control unit is based on the weighted average of control units, where weights are in general obtained so that the weighted average of the outcome variable and the relevant covariates of control units in pre-intervention periods are as close as possible to those of the treated unit.

One notable feature of the SC method is that the required number of treated units is only one. This means that using the SC method, I can investigate the effect of NPF establishment on per capita income, focusing on *individual* NPF municipalities as quantitative case studies. Although this makes it difficult to apply standard inference techniques to examine the statistical significance of my findings, this method allows me to investigate the magnitudes and mechanisms of the effects of NPF establishment as historical case studies, which may be more informative for policy makers and researchers who have an interest in not only *average* treatment effects of NPF establishment but in individual and historical consequences of NPF establishment given limited quantitative and qualitative information.

In addition, a permutation-like test proposed by Abadie et al. (2010) and some extensions of this test can be used as complementary methods of statistical testing. Another interesting feature of the SC method is that the common trend assumption in DID could be relaxed under relatively nonrestrictive conditions, as is discussed in Section 4.

Using the SC method, I find that NPF establishment makes per capita taxable income in NPF municipalities about 11.1% higher on average and around 61.7% higher as a maximum while the estimated effects are very heterogeneous and sometimes negligible.

This study will contribute to the following two research strands in economics. First, this study contributes to the literature on economic analysis of NPF establishment. To my knowledge, previous studies on the socio-economic impact of NPF establishment largely fall into two groups. The first group studies the effect of NPF establishment on property prices around NPFs, mostly using a hedonic approach such as Nelson (1981), Gamble and Downing (1982), Clark and Nieves (1994), Clark et al. (1997) and Folland and Hough (2000). Though not restricted to NPFs, Davis (2011) recently studied the effect of power plants on local housing values and rent in comparison to neighborhoods with similar characteristics. The second group of studies, such as Pijawka and Chalmers (1983), McGuire (1983), Lewis (1986), and Glasson et al. (1988) examines the impact on local industry and employment, using Keynesian multiplier models.⁵ Because little research has examined the economic consequences of NPF location from a quasi-experimental perspective, this paper can provide new insights into the study of NPF locations.

Second, this study is also related to the increasing literature in economics on the effects of energy-related industry or large plants establishment on local economies using some natural or quasi-experimental approaches, such as the effects of pipeline

² For example, in a petition concerning nuclear power generation issued in May 22th 2014, Zengenkyo argues that Japanese central government should unwaveringly promote nuclear power generation.

³ See Glaeser and Gottlieb (2008) and Neumark and Simpson (2015) for recent literature reviews on place-based policies.

⁴ For example, see the introduction of METI (2011).

⁵ When it comes to Japanese NPFs, Nishikawa (2000) studies the fiscal impact of NPFs in Japan using simple regression analysis.

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