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WHO ASKS FOR THEM, WHAT DO THEY DO?

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Nuclear Reactors in Japan:

Who Asks for Them, What Do They Do?

By J. Mark Ramseyer*

Abstract: Japanese communities with nuclear reactors have them because they applied for them, and they applied for them for the money. Among Japanese municipalities, they were some of the most dysfunctional before the reactors had even arrived. These were the villages that had long fought for targeted subsidies, but ignored infrastructural investments. Subsidies operate as a regressive tax on out-migration, of course, and the lack of private-sector infrastructure reduces the returns to high-value human capital. As a result, these were the villages from which the most talented young people had begun to disappear -- even before the reactors arrived. After the communities built the reactors, talented young people continued to leave. Unemployment rose. Divorce rates climbed. And in time, the communities had little other than reactor-revenue on which to rely.

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By early 2011, Japan produced 30 percent of its electrical power through nuclear fuel. It had little choice. What coal it had once had, it had exhausted. If it had any geo-thermal or wind potential, engineers did not yet know how to use it. Given that it had no oil of its own, Arab producers had already held its foreign policy hostage once. It could hardly afford to let them do it again.

And so, Japanese utilities built reactors. By early 2011, they operated 52. They did not try to site them away from metropolitan centers. Neither did they attempt to avoid the most volatile geological faults.

Instead, Japanese utilities placed their reactors in the towns that asked for them. Some were near cities, others not. Some were on fault lines, others not. But all of the locations were places whose residents had specifically applied for the reactors.

To towns that agreed to take reactors, the government promised subsidies in the short-run, and tax revenues in the medium-. By definition, therefore, the towns that requested the reactors were the towns whose residents had chosen to sacrifice long-term risks for short- and medium-term financial gain. At one level of analysis, the towns had struck Pareto-improving bargains with the government, and let the latter locate the reactors where they did the least harm.

But as scholars, we can do better. To be sure, under plausible locally democratic government, community members could indeed collectively choose to take a nuclear risk because of the financial subsidy proffered. Table the very real problems of collective choice and preference agregation. Community members could decide to accept the reactors because the promised subsidies produced a net welfare gain.

Yet community membership is itself endogenous to the institutional structure in place. People choose whether to live in community: whether to arrive, whether to stay, whether to leave. Whether members stay in a community depends on the relative gains from out-migration. Whether outsiders come to a community depends on the gains from in-migration. And for both groups, the relative gains from out- and in-migration will depend on institutional structures in place.

Note two principles relevant here. First, local subsidies create a regressive tax on out-migration: leave, and a resident loses the flat-amount subsidy. Necessarily, the higher a resident's income, the lower the percentage income hit he takes when he jettisons the subsidy to leave town.

Second, infra-structural investments for the private sector create a progressive tax on out-migration: the higher the value of a worker's human capital, the more heavily his local returns will depend on heavy infrastructural investments. Engineers earn a premium on their skill only in those locations where firms have built facilities to exploit scientific talent. Blue-collar employees will earn higher wages in towns with higher levels of private investment too, of course. But they will not face as large a gap as those with unusually valuable skills.

In Japan, the communities that chose to accept nuclear reactors were communities that had already -- prior to the time they applied for the reactors -- invested in governent subsidies rather than private-sector infrastructure. As a result, they were the communities that had already begun to drive away their most talented and industrious young men and women. During the post-war decades, many rural communities fell into economic decline. Many struggled. But most did not place a priority on public-sector rent-seeking over private-sector investment. Those communities that asked for the reactors, however, were those that had earlier made exactly that choice.

The reactors exacerbated this preexisting pattern of selective out-migration. Reactors bring risks that directly threaten young families. Yet those families provide the social capital that most strongly binds a community together. On the one hand, reactors offer extremely high short- and medium-term benefits, but virtually none long-term. On the other, they pose high perceived (not necessarily actual) long-term health risks, but few (other than the tsunami generated melt-down) short-term. They bring what many residents see (accurately or no) as cancer risks from long-term exposure to low-level radiation, but none from just a year or two. Because young parents bring the longest time horizons, they more often find it advantageous to leave nuclear towns.

Given these out-migration patterns, modern-sector employers more readily invest in towns without a reactor than in those with one. With fewer young parents, reactor towns offer less of the social capital that firms want before they invest in a town. With fewer workers earning the highest market wages, reactor towns do not even offer the talented and industrious employees firms want for their managerial ranks.

In the article that follows, I detail evidence that tracks this dynamic. I first ask which communities apply for reactors (Section I). I then create a 30-year municipality-level panel data set, and use simple fixed-effect regressions to ask what the reactors do to the communities (Section II).

I. <u>Who Asks for the Reactors?</u>

A. <u>Applying for the Nuclear Plants:</u>

Local citizens can take the initiative to invite a reactor. Given a strong sentiment in favor of a reactor, vote-maximizing local politicians may try to attract one. Although local citizens do not hold a formal right to block a planned reactors, effectively they do have a veto. They can hold referenda on a proposed reactor. Even if the election does not bind, utilities often defer to a strongly negative vote. Vote maximizing governors can block reactors at a wide variety of regulatory steps. Faced with electoral pressure, governors often do (Ramseyer 2012).

In effect, town residents can usually decide whether to take a reactor. To explore which towns decide to invite and accept them, consider first the factors by which the government, utilities, and towns might locate their reactors -- if, counter-factually -- they chose on engineering considerations alone (Subsection B). Then consider actual siting decisions: where the real-world Japanese government has placed the reactors that utilities build (Subsection C).

B. <u>Engineering:</u>

1. <u>Introduction.</u> -- Reactors need massive amounts of water to cool the core. As a result, utilities might build them along the coast (Subsec. B.2). Given the radiation risk they present, utilities might build them far removed from urban centers (Subsec. B.3). And given the dangers posed by seismologically unstable environments, they might build them away from earthquake fault lines (Subsec. B.4).

2. <u>Coastal access.</u> -- Japanese utilities do indeed build their reactors along the coast. Because reactors need water, the French governent (reactors provide three-quarters of all French electric power) locates many along the Rhine. Perhaps because Japanese rivers tend to run fast but narrow, utilities in Japan avoid the streams and build their reactors by the sea.[1]

3. <u>Seclusion</u>. -- Japanese utilities do not build their reactors on distant sites. Meltdowns are non-trivial events. Given the risks, rational power companies and government regulators might reasonably locate reactors away from major cities. Japan does have many large cities, but it also has plenty of distant rural areas.

In fact, however, Japanese utilities site almost all their reactors near urban centers.[2] To be sure, utilities cannot transmit energy costlessly; the optimal location would not be the point farthest from greater Tokyo's 35 million residents. Yet the Japan Atomic Power Co. built the very first commercial reactor (Tokai 1, in Ibaragi) only 80 miles northeast of the center of the city (Yoshioka 2011, 108). Tokyo Electric built its 10 Fukushima reactors 160 miles from Tokyo, and Chubu Electric built the 4 Hamaoka reactors 150 miles away.

Other metropolitan centers fare no better. The 14 Fukui reactors (one of them a fast breeder reactor) lie 70 miles from greater Kyoto (with its 2.7 million residents) and 80 miles from Osaka (with 12 million). The 3 Ikata reactors sit 90 miles from Hiroshima (with 1.4 million); the 3 Tomari reactors are 60 miles from Sapporo (with 2.4 million); the 3 Onagawa reactors are 50 miles from Sendai (with 1.6 million); and the 4 Genkai reactors are 45 miles from Fukuoka (with 2.6 million). The 4 Hamaoka reactors lying 150 miles from Tokyo are also 105 miles from Nagoya (with a population of 5.5 million), 36 miles from Shizuoka (with 990,000), and 25 miles from Hamamatsu (with 1.1 million).

4. <u>Earthquakes.</u> -- (a) <u>Introduction.</u> Neither do Japanese utilities avoid earthquake fault lines. Again, utilities and regulators might reasonably build reactors as far from faults as possible. The danger is obvious. Pressurized reactors are risky enough when they run uranium. Japanese utilities equip many to run on more dangerous plutonium-enriched fuel besides. Granted, Japan lies on the boundary between two plates. Nowhere is as far from a fault as Dorothy's Kansas. Even within Japan, however, not all areas experience as many earthquakes as others.

Yet consider the three most productive reactor sites: Fukushima, Niigata, and Fukui (see Table 1).

[Insert Table 1 about here.]

(b) <u>Fukushima.</u> Pre-2011, the 10 reactors in Fukushima produced 9.1 million kWatts of electricity, 22 percent of total Japanese nuclear capacity. Tokyo Electric sited these reactors on a coast that massive tsunami assail every century (Table 2). This coast

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[1] The complex riparian water rights also make negotiations over the requisite water in rivers extremely costly. Nagai (2015, 39); see Ramseyer (1989).

[2] Some American reactors are also remarkably close to urban centers.

along northeastern Japan faced a 39-meter tsunami in 2011, a 38-meter tsunami in 1938, and a 28-meter tsunami in 1896.

[Insert Table 2 about here.]

Earthquakes hit this coast often and hard. Catastrophic 8+ quakes shake it once a century: in 2011, 1933, 1896, 1793, and 1611 (Table 2). Still deadly magnitude 7+ quakes hit several times a century: 2011, 2008, 1978, 1960, and 1938 (Table 3).[3] Writing in 1934, Akitune Imamura (1934, 79) of the Tokyo Imperial University Seismological Institute noted that "the eastern coast of the locality popularly known as the San-Riku [district, just north of Fukushima] is well known from historic times as the region frequently visited by tsunami." Indeed, he continued, "it is most notorious in this country, if not in the whole world."

[Insert Table 3 about here.]

(c) Niigata. In Niigata prefecture, the twin cities of Kashiwazaki and Kariwa house 7 reactors producing 8.2 million kWatts, or 19.5 percent of pre-2011 nuclear capacity (Table 1). Niigata's western coast faces fewer earthquakes than Fukushima's east, but even the west experiences some. The 7 Kashiwazaki-Kariwa reactors lie between two separate areas specially designated by the government as at high risk of magnitude 8+ earthquakes (Kansoku n.d.). During the first decade of this century, two magnitude 6.8 and one 6.9 earthquakes struck the prefecture, and together killed 87 people (Table 3). At the reactor complex, fire broke out and radioactive water leaked (Kashiwazaki 2007; Kainuma 2011, 98-99; Yoshioka 2011, 346-47).

(d) Fukui. The 10 reactors in Fukui prefecture generate 11.6 million kWatts, 27 percent of the pre-2011 Japanese capacity. To date they have escaped major earthquake damage, but only barely. Since the late 1800s, three magnitude 7+ earthquakes have hit the prefecture. The one in 1948 killed 3,700 (Table 3).

(e) Other. Japanese utilities have built their other 25 reactors in a variety of places, but many of them in sites that raise their own seismological doubts. Chubu Electric, for example, did not just build its 4 Hamaoka reactors 150 miles west of Tokyo; it built them directly over the "Suruga Trough." Government seismologists predict a magnitude 8 quake on the trough within the next few decades -- by some accounts, a 70 percent chance that it will hit within 30 years, and a 90 percent chance within 50 years (Shirundo 2017). Seismologists have already named it the upcoming "Great Tokai Earthquake" (Staffblog 2017; Sandee 2004). In the past, the fault generated magnitude 8+ earthquakes every 100 to 160 years -- most recently in 1498, 1707, and 1854.

Chubu Electric knew the Hamaoka risks when it made its plans, complains prominent University of Tokyo seismologist Kiyoo Moro, and made them anyway (Sundee 2004):

[3] The magnitude 8.1 earthquake of 1933 was centered 200 km off shore. On the Japan coast, it registered only magnitude 5. Largely as a result of the tsunami, 1500 people died, another 1500 disappeared, and 12,000 were injured. Most of the deaths and disappearances were in Iwate prefecture.

> It won't do to say, "we didn't know about the Tokai earthquake risk at the time." I pointed out the "risk of a massive magnitude 8 earthquake in the Tokai area" back in November 1969. That was six months before Chubu Electric even applied for the permit on Hamaoka Reactor 1. I pointed it out at the monthly meeting of the University of Tokyo Earthquake Research, ... and it became a major news story. It made both the national Mainichi and Asahi newspapers, and the NHK and private broadcast networks.

Moro recalled two senior Chubu Electric officers who had visited him three years earlier (Sundee 2004):

> I asked them, "why didn't you ask me what I thought?" "I don't know about back then," one of them replied. "But I'd guess they figured that if they consulted you, you'd berate them and declare that "you can't possibly build a reactor there."

Critics claim the 3 Ikata reactors sit directly on an active fault as well. They point to the nearby "Central Fault" (Sai kado 2016). The reactors do indeed lie within one of the government-designated special observation zones at risk of a magnitude 8+ earthquake (Kansoku n.d.).

The 2 Shimane reactors similarly lie within a special magnitude 8+ observation zone.

C. <u>The Communities that Take the Reactors</u>

1. <u>Introduction.</u> -- Japanese utilities do build their reactors along the coast. But they do not avoid metropolitan centers. And they do not avoid earthquake fault lines. Hence, the question: how do they decide where to build their reactors?

As different as the communities with reactors are on some dimensions, for several decades before they asked for a reactor they shared a common approach to distress: ignore infrastructural investment and lobby the government for cash.[4] It is not just that they were poor and declining. They were indeed poor and declining, but in the immediate post-War years most of rural Japan was poor and declining. Most still is. Yet most poor and declining rural Japanese communities did not request nuclear reactors. These few did.

For decades before they turned to nuclear power, these towns had chosen to invest (a) in rent-seeking activities, but not (b) in the infrastructure necessary for private sector growth. Hypothetically, they could have made both rent-seeking and infrastructural investments. Many rural communities do. These did not, and the result was a systematic bias toward the out-migration of those residents with the highest valued human capital.

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[4] By the logic of Tullock's (1975) "transitional gains trap," the value of the subsidies to the local community would have become impacted in the price of a land. If a community receives a substantial public "bad" like a nuclear reactor, of course, there may not be a significant net gain to capitalize. Where the government pays the subsidies to specific firms, of course, the value of the subsidy will be capitalized into the price of the firm's stock.

By the time the communities asked for reactors, their earlier institutional responses had already changed the composition of the community itself.

For two reasons, this focus on subsidies rather than infrastructure had created incentives toward selective out-migration. First, fixed monetary subsidies for residents constitute a regressive tax on out-migration. Necessarily, subsidies impose a higher tax rate on lower-income residents who leave than on high-. Second, the relative lack of private-sector infrastructure provides a parallel incentive. With low private-sector infrastructure, necessarily the residents with highest-value skills face the largest gap in expected returns between local and non-local employment.

As a result, the few communities that asked for the reactors were the communities that had already -- much earlier -- made choices that gave residents with the human capital bearing the highest market value the strongest incentives to leave. There were not many such communities. In fact, there were very few. But few as they were, they produced the bulk of Japanese nuclear power. Japan may have 52 reactors, they do not sit in 52 locations. Instead, the three complexes in Fukui, Fukushima, and Niigata produced over 65 percent of all Japanese nuclear power.

2. <u>Fukui.</u> -- For all practical purposes, Japanese nuclear power began in Fukui. The industry had opened its very first reactor 100 miles northeast of Tokyo in 1966, but it opened its second and third reactors four years later in Fukui (see Nagai, et al. 2015, 37-38; Yoshioka 2011, 150). Over the next two decades, it would build a series of reactors in five closely located Fukui sites. And by 1991, the government would add a fast breeder reactor running (in part) on deadly plutonium.

Fukui is a small prefecture along the Japan Sea coast. With a population of 803,000, it lies some 60 miles from the historic capital of Kyoto and 80 miles from massive Osaka. From one end to the other, its 13 reactors span 50 miles. The first two went into operation in 1970. The last began operating in 1993. The utilities placed some of the reactors in a city of 68,000 (Tsuraga). The others they sited in towns that ranged from 9,200 residents to 11,800. Together, the reactors produced 11.3 million kWatts (Table 1).

During the first half of the 20th century, Fukui had served as a center to high-end Japanese textiles. The cotton firms located many of their factories elsewhere, but the Fukui firms wove silk fabric for the export market. By 1907, that silk fabric constituted 38.7 percent of prefectural GDP (Tomizawa 2005, 18). When the demand for silk fell, Fukui firms turned to rayon, and by 1937 all fabric together accounted for 66.8 percent of prefectural output (Tomizawa 2005, 22). With the close of the Second World War, firms shifted yet again: this time, to thermoplastics like nylon and polyester (Tomizawa 2005, 25; Takemi et al. n.d. 37).

Already by the 1950s, however, the Fukui textile firms had begun to rely on government transfers. The strategy would reshape the prefecture entirely. At the behest of the firms, the government began restricting new investment in textile machinery. It limited production, and bought and scrapped equipment (Ike 1980, 538-40). Between just 1956 and 1959, it bought 14,000 looms from the Fukui firms (Tomizawa 2005, 26).

Fukui textiles peaked during the early 1960s. In 1960, 61 percent of Fukui employees still worked in the industry (Tomizawa 2005, 25), but contraction began within the decade (Table 4). As it did, the government lavished yet more subsidies on the industry. The Diet passed textile-specific statutes in 1967, 1969, 1972, 1974, 1979, 1984, 1989, and 1994 (Shirato 2009-10, 7; Tomizawa 2005, 29 et seq.; Ike 1980, 538-39). And when it acceded to U.S. demands for export restrictions in the early 1970s, it paid another 205 billion yen (Itami 2001, 283; see Ike 1980, 540 (different numbers)).

[Insert Table 4 about here.]

The result was an approach to distress that fed dependence. Given the government's willingness to buy "excess" equipment, wrote scholar Brian Ike (1980, 546), firms faced a "negative incentive for shifting resources out of the industry." Rather than shrink the industry, the programs caused "a perpetual problem of surplus capacity." In the process, they created what management scholar Hiroyuki Itami (2001, 18-19) called the "frightful result," a perpetual culture of "dependence" (id., 17-18):

> Japanese textile policy during the 1970s and 1980s rigidified the industry's dependence on government. Given the policy, the industry never developed the energy necessary to shift its structure and become internationally competitive.

Firms had no incentive to transform their structure when "the government transferred vast sums to the textile industry" (Itami 2001, 18-19). By protecting the firms, the government created a "dependence on government regulation." Each step, Itami (2001, 18-19) continued, "unintentionally gave rise to the next policy of dependence."

3. <u>Fukushima.</u> -- Tokyo Electric built its first Fukushima reactor in 1971 (see Table 1). Over the next several decades, it would build 9 more. It would allocate them between two sites -- Daiichi (meaning Number One) and Daini (Number Two). Effectively, however, the sites constituted one complex. Although it built the first site in the towns of Okuma and Futaba, and the second in Naraha and Tomioka, Futaba and Tomioka are adjacent towns. When operating, the 10 Fukushima reactors had produced 9.1 million kWatts.

Fukushima is a land of shuttered mines. Pre-war Japanese industry had run on coal, and industries in Tokyo had relied heavily on the mines in Fukushima (known by the regional name, "Joban" mines). Firms had used the coal for railroads, for cotton spinning factories, for ocean shipping (Kiyomiya 1955, app. tab.). The government had used it for military vehicles. The mines in northern Kyushu and Hokkaido had yielded more and higher quality coal. But given their proximity to Tokyo, the Fukushima mines offered a better price (Ishii 2003).

As the Second World War neared the end, so did the place for coal. During the first decade after the war, Japanese coal mines employed over 450,000 workers. By 1963, they employed only 123,000, by 1970 48,000, and by 1975 23,000 (Table 5). By the early years of the 21st century, they barely employed 1000. In 1952, coal firms operated 1,047 mines. By the 21st century, in all of Japan they ran only 8 (Keizai 2009, 5; see Samuels 1987, ch. 3).

[Insert Table 5 about here.]

Joban tracked this national decline. Between 1955 and 1968, the Joban firms closed 87 mines. They shut the last underground mine in 1976, and the last open-air unit in 1985. In 1948, they had employed 39,600 mine workers. By 1972 they employed 1,700, and by 1976 only 68 (Ishii 2003; see Ohara 1956, 6).

From the national government, though, the coal firms, towns, and workers extracted elaborate transfers. Already in the 1950s, the government controlled coal pricing. In time, it would pay firms to shutter mines that lost money anyway. It would pay firms to hire former coal miners (Ishii 2003; Waseda 2009; Keizai 2009, 8-10).

By the 1960s, the Fukushima towns had learned their lesson well: to weather fiscal distress, lobby the state. When they exhausted their coal revenues, they turned to the government for subsidies. When they exhausted their coal subsidies, they turned to nuclear power. And to keep that nuclear revenue flowing, they asked Tokyo Electric to add one reactor after another (Namie n.d., 7).

4. Niigata.-- The third mega-complex lies in Niigata, north of Fukui along the coast of the Japan Sea. Here, mountains climb steeply toward the eastern edge of the prefecture. Having swept through Siberia, the winds absorb moisture over the Japan Sea, hit these mountains, and drop massive precipitation: hard rains in the summer, bitter snow in winter. In 1937, Yasunari Kawabata set Snow Country -- his stark but haunting tale of an aging hot springs geisha -- in Niigata, and for it in 1968 would win the Nobel Prize. Given the latitude, wrote his translator Edward Seidensticker (1956, v), Niigata is probably "the snowiest region in the world." A "cross between Mississippi and Vermont," political scientist Chalmers Johnson (1986, 3) called it, "the part of the country that supplies workers, electricity, and rice (and that used to supply geisha and ricksha pullers) for ... the Tokyo megalopolis ...."

"At the turn of the century Niigata prefecture was the most densely populated prefecture in all of Japan," continued Johnson (1986, 3):

> but by 1972, ... it had been virtually depopulated. The heavy snows, normally about 15 feet, made the place close to impassable in winter, and most of the men had to set out on ... seasonal work in the big cities. ... Until very recently the children of small-town and rural Niigata lived in school dormitories if they attended school at all, and the only people left at home were mothers and old women.

Within this "snow country," two towns house seven reactors: Kashiwazaki and Kariwa. Kashiwazaki is a small city of 86,200. Kariwa is the adjacent town of 4,700. In these two communities, Tokyo Electric built a complex that generated 8.2 million kWatts.

Kashiwazaki and Kariwa had once produced oil. They still do. But as Japan switched from coal to petroleum in the 1950s, the Kashiwazaki-Kariwa oil looked increasingly trivial next to the amount imported. In 1970, domestic Japanese wells produced 901,000 kl, and in 2014 626,000. Niigata produced 60 percent of that 2014 total, but of all Japanese consumption the domestically pumped oil came to barely 0.3 percent.[5]

[5] Nihon sekiyu to Hokuetsu Kashiwazaki [Japan Petroleum and Hokuetsu Kashiwazaki], Nakamura sekiyu K.K., available at: http://www.nakamura-oil.co.jp/n_h.html (accessed Dec. 5, 2016);

For nearly half a century, Kashiwazaki and Kariwa elected and re-elected Kakuei Tanaka, the greatest pork-barrel politician of all time. Tanaka had been born in Kariwa in 1918. He married money, and then parlayed those funds into a larger fortune in Korea during the last chaotic months of the war. The local electoral district included both Kariwa and Kashiwazaki, and in 1947 its voters sent Tanaka to the parliament. After stints as Minister of International Trade & Industry and Minister of Finance, Tanaka became Prime Minister in 1972. By 1983, the courts would sentence him to four years in prison for taking bribes from Lockheed (and giving rise to the Foreign Corrupt Practices Act), but never mind. Voters continued to elect him anyway (16 successive terms in all), until he retired in 1990.

On behalf of his Kashiwazaki and Kariwa voters, Tanaka turned the national government into a perpetual revenue machine. He promised to send his constituents "highways, schools, reclamation projects, tunnels, railroads, and snow removal services in return for their votes," explained Johnson (1986, 4), "and that's exactly what he did." He double-tracked the railroad to this cross between Vermont and Mississippi. He brought the spectacular bullet train: 300 km of wide-gauge track, 100 km of tunnels, and five special stations, all at a cost of 480 billion yen. In 1962, Niigata received 12.1 billion yen in national subsidies. By 1965 it received 24.1 billion, and in 1970 53.3 billion. By the time Tanaka became prime minister in 1972, Niigata collected subsidies worth 80.6 billion yen. In 1982, Tokyo residents paid $3,060 in taxes for per capita public works of $815. Niigata residents paid $541 in taxes and received $1,644 (Ramseyer & Rosenbluth 1993, 123; Johnson 1986, 8).

For Tanaka, the reactors were merely the means to send his constituents more money. Sumio Habara (2012) reported for the <u>Asahi shimbun</u> newspaper:

> Kashiwazaki had been a prosperous town centered on the oil and machine industries. Both involved firms founded by local residents: Nihon Sekiyu (now, New Japan Oil) and Riken [a piston ring firm] (Riken kagaku kenkyujo). Yet both also disintegrated after the war. Only sand dunes separated Kashiwazaki and Kariwa. Together, they suffered depopulation, blizzards, and financial distress. Nuclear power was the way they chose to escape this pit.

And so it was that Tanaka delivered the reactors.

D. <u>The Funds:</u>

1. <u>The money.</u> -- For towns and villages that volunteered for the reactors, the government brandished lavish amounts of money.[6] Suppose a town took a nuclear plant that produced 1.35 million kWatts, suggested the Ministry of Economy, Trade & Industry

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Gen'yu seisan no kirifuda [The Trump to Crude Production], available at: http://www.chem-station.com/blog/2015/07/oil.html (accessed Jan. 26, 2017); dai28 hyo [genyu, kaigai jishu kaihatsu gen'yu yunyu ryo to kokunai seisan ryo no suii [Tab. 28: Crude Oil: Trends in Quantity of Crude Produced Overseas and Imported, and Quantity Produced Domestically], available at http://www.noe.jx-group.co.jp/binran/data/pdf/28.pdf (accessed Jan. 26, 2017)

[6] Excellent discussions of the subsidy legislation appear in Samuels (1987, ch. 6) and Aldrich (2008).

(Keizai 2011, 4). The wattage itself was not unreasonable. The Fukushima Daini reactors produced a mean 1.1 million kWatts (Table 1). The town could expect:

> Years 1-3: While the utility ran its environmental impact studies, the town would receive 520 million yen per year.
>
> Year 4: As the utility began construction, the town would receive annual subsidies of up to 7.92 billion yen -- at the January 4, 2011 exchange rate of 81.96 yen/$, about $96.6 million. Local firms and citizens would earn additional money by selling land, working in construction, or selling other services related to the project.
>
> Years 5-10: As the construction continued, the subsidies would climb to 8.23 billion yen in each of the next two years. Thereafter, they would begin to decline: to 6.64 billion for two years, and 4.4 billion in the next two.
>
> Operation: Once the utility started operating the reactor, the annual subsidies would fall further. For the next two decades, the government would pay about 2 billion yen a year.

As the subsidies declined, however, the property taxes began. As one observer (Ito 2011) calculated it, a 1.25 million-kWatt reactor a utility would initially pay about 6.3 billion yen.

2. The problem. -- It was good money. Unfortunately for the town, it did not last. Table 6 details the subsidies, and they were indeed large. In 2014, Japanese municipal governments spent less than $400 per capita.[7] Yet in Kariwa the nuclear subisides came to $3,000 per person. In one Fukui town they exceeded $4,000 per person. Yet although government initially paid lavish subsidies, the amounts fell. Even the property tax did not last. The tax code assigned reactors a 16-year useable life. Under the resulting depreciation schedule, the tax fell to half the initial amount by year five (Ito 2011; Namie n.d., 7).

[Insert Table 6 about here.]

So it is that the towns that took one reactor soon asked for a second. Under the earliest versions of the subsidy programs, the government earmarked the money for construction projects. Some communities that took the money found themselves needing another reactor just to maintain their new buildings. Program amendments eventually ameliorated this problem, but the question of "nuclear addiction" (as critics phrase it) remained: once a community began programs based on nuclear revenue, it soon needed another reactor just to keep the programs going.

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[7] In 2014, municipal governments spent 5.898 trillion yen. The population was 128 million. See Somu sho (n.d.).

The nuclear mega-complexes followed. As one Kashiwazaki city council member put it (Kasako 2012), "unless we keep building new reactors, the revenues stop. Our population doesn't increase. Neither does the number of firms in the city. Instead, the reactors just drive the firms away." Invite a reactor in, and soon little more than the government revenue remained. The Fukushima town of Futaba had six reactors (the Daiichi complex). By the 1990s, it was asking Tepco to build two more (Kato, et al. 2013). Since 2011, it has been a ghost town, and so it will remain indefinitely.

3. Kashiwazaki. -- Consider Kashiwazaki and Kariwa in more detail. Under Prime Minister Tanaka's pork-barrel patronage, the towns applied for their first reactor in 1969. Tokyo Electric placed it in service in 1985. The towns now found themselves with massively fluctuating revenues. In 1998, Kariwa received nuclear subsidies of 5.8 billion yen. In 2000 it received 25 million yen, and in 2001 it received 0.[8]

When an earthquake struck Niigata in 2007, Kashiwazaki found itself facing large rebuilding costs. Yet the subsidies had largely come to a close, and the property taxes were declining rapidly. By 2011, it was spending more than it received (Ikeda n.d.; see Kasako 2012). It owed 60 billion yen, and interest on that debt constituted 24.1 percent of its municipal expenses. As of 2016, the debt remained. Per capita, the debt came to 614,000 yen per person -- but Kashiwazaki lacked people who could earn money to pay it down: 38.9 percent of its citizens were 65 or older (Ikeda n.d.; Goo 2016; Usami 2014).

II. What the Reactors Do

A. Introduction:

As Section I showed, the communities that applied for a reactor had already adopted incentives that encouraged the residents with the highest levels of human capital to leave. The communities were indeed poor. They were in decline. But among poor and declining communities, they were the communities that had adopted particularly dysfunctional incentives.

Once these communities invited nuclear reactors, those incentives would turn them more dysfunctional still. Consider the evidence.

B. The Exercise:

1. Data. -- I start with an apparently straightforward exercise: construct a three-decade, municipality-level panel dataset of various proxies for social capital, and explore the impact that a nuclear power plant can have. Toward this end, I compile data on several variables from 1980 to 2010. In each case, I obtain the data for all 1,742 municipalities. Given that Japan has no unincorporated areas, they cover the entire country. Where municipal boundaries have shifted, I use data that reconstruct the values based on current borders. I treat Tokyo as a prefecture, and its composite wards as municipalities. I include selected summary statistics in Table 7.

[Insert Table 7 about here.]

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[8] Dengen sanpo kofukin jisseki [Subsidies Under Three Electricity Acts], Mar. 31, 2016. Available at: http://www.city.kashiwazaki.lg.jp/atom/genshiryoku/kofukin/kofukin-jisseki.html

I then regress a range of indices of social capital on the presence of a reactor. In a wide variety of ways, I find that social capital declines once the reactors arrive. Reactors are, as a friend once put it, a bit like casinos.

2. Endogeneity. -- Yet the regressions leave a nagging worry. Power companies do not pick the sites for their nuclear reactors (see Table 1) randomly, and communities do not apply for them randomly. Instead, for all the reasons discussed in Section I, the siting is endogenous to the level of social capital (see also Ando 2015, 69). Community dysfunction may seem to follow the arrival of a reactor -- but the reactor arrived in part because the community had turned dysfunctional already.

Consider then a simple exercise in the spirit of a regression-discontinuity design. Suppose two sets of communities differed only in the presence of a reactor. If a utility then allocated its reactors between them randomly, regressions using the variables below would indeed identify the effect that reactors have on the community.

In this spirit, take those communities where a utility initially announced but then abandoned its plan to build a reactor.[9] Then pair these communities with those where a utility did ultimately build a reactor, and re-run the regressions on these matched samples. Obviously, the result will not constitute a true regression-discontinuity design. Fate did not allocate the reactors between the two groups randomly.

Yet, the two sets of municipalities present basic similarities. In both, the utility thought the community presented a good site. It announced its plans only after studying the area elaborately. In both, the government at least initially thought the community an appropriate location too. The utility announced its plans only after clearing the project with the government. And in both, many residents wanted the reactor. The utility filed its plan only after elected municipal representatives pledged their support.

Whether a utility ultimately built an initially planned reactor turned on a balance. On the one hand, the outcome depended on (i) how closely the municipality resembled what the utility and the government considered an ideal site for a reactor, and on (ii) how badly local supporters wanted the transfer payments that came with the reactor. On the other, the outcome also depended on how vehemently the reactor's critics opposed its construction. Where the former outweighed the latter, the reactor arrived. Where the latter outweighed the former, it vanished.

Although reactor assignment is not random, the two groups of communities -- those where a utility ultimately built a reactor, and those where it did not -- are close. In the loose spirit of a simple regression-discontinuity study, I match (a) the municipalities where a utility ultimately built a reactor with (b) the municipalities where it announced plans for a reactor that it ultimately abandoned. I then re-run the regressions on the matched datasets.

3. Nuclear plants. -- I measure the social effect of nuclear plants through three key independent variables. They identify whether a power company has announced its plans for a nuclear plant, whether it has begun construction, and whether it has started to operate the reactor. If a municipality has an operating reactor and announces plans for an

[9] Shimonoseki city (Yamaguchi prefecture), Kushima city (Miyazaki prefecture), Ise village and Ooki village (Mie prefecture), Suzu city (Ishikawa prefecture), Niigata city (Niigata prefecture), Shirahama village (Wakayama prefecture), and Mihama village (Kyoto prefecture) -- from Japanese Wikipedia.

additional one, I ignore the new reactor and code the municipality as having an operating plant. I take the information from Gensuikin (2013: 14-17).

Plan: 1 if a power company has announced plans to build a nuclear plant in the municipality, 0 otherwise.

Construction: 1 if a power company has begun construction of a nuclear plant in the municipality, 0 otherwise.

Operation: 1 if a power company has begun operating a nuclear plant in the municipality, 0 otherwise.

4. Other variables. -- I take the other municipality-year panel variables from a variety of government sources.[10] For each variable, I calculate the per capita measure by the population statistics given in Somusho, Kokusei (various years; per 1000 population). Given that the government compiles population data only every five years, I interpolate the intervening years.

Revenue PC: Municipal revenues (sai'nyu kessan sogaku), per capita. Data from Somusho, Shichoson (various years).

Under 15 PC: The number of people under age 15, per capita. Data from the Somusho, Kokusei (various years).

Over 64 PC: The number of people over age 64, per capita. Data from Somusho, Kokusei (various years).

Unemployment PC: Number of unemployed workers, divided by the 15-65 year-old population. The calculation applies only to workers over age 15, and excludes those who deliberately opt out of the organized labor market. Data from Somusho, Kokusei (various years).

Marriages PC: The number of marriages, per capita. Data from Kosei, Jinko (various years).

Population: the population as given in Somusho, Kokusei (various years; per 1000 population). The government compiles population data only every five years; intervening years are interpolated.

In-migration PC: The number of in-migrants, per capita (not net of out-migrants). Data from Somusho, Jumin (various years).

[10] The data can be downloaded from the standard government website http://www.e-stat.go.jp/SG1/chiiki/ToukeiDataSelectDispatchAction.do.

Out-migration PC: The number of out-migrants, per capita (not net of in-migrants). Data from Somusho, Jumin (various years).

Divorce Rate: The number of divorces, divided by the number of marriages. Data from Kosei, Jinko (various years).

Throughout, I use municipality fixed effects and year fixed effects. I cluster the errors by municipality.

C. Results:

1. Revenue. -- To reward a community for taking a reactor, the government pays lavish subsidies -- as described in Section I.D., above. Note here that the government begins making substantial transfer payments as soon as construction begins (See Table 8, regressions (1) through (3)). When I regress government revenue on reactor construction and operation, the coefficients are large and significant. As the second and third columns in Table 8 show, they are also robust to the inclusion of controls for demographic and unemployment variation.

[Insert Table 8 about here.]

The regressions on the matched-sample database confirm these results about revenue: once construction begins, the local government receives large sums of money. In Regressions (1) through (3), I run the revenue regressions on the full dataset. In (4) through (6), I run them on a dataset that incudes only those municipalities that either took a reactor or ultimately abandoned a publicly announced reactor.

The coefficients in the matched sample regressions track those on the full database. In both cases, once a utility begins to construct a reactor, government revenues rise.[11] Both the magnitude and the significance of the coefficients in the two sets of regressions are close. In both, the results are robust to the inclusion of demographic and unemployment controls.

2. Population. -- According to Regressions (1) through (3) in Table 9, nuclear plants seemm to cause communities to atrophy. As they accept the plants, people apparently disappear. Perhaps some move away. When the elderly die, perhaps insufficient young people move to the community to take their place. The adjusted R2's are extremely low. Whatever the cause, however, perhaps population falls.[12]

[Insert Table 9 about here.]

The same regressions on the matched samples, however, present a puzzle. Regressions (1) through (3) on the full dataset suggest that municipalities with reactors

[11] Consistent with the results from the "synthetic control" study, Ando (2015).

[12] Note that because the census occurs only five years, I use interpolated values for the intervening years. This will cause the statistical significance to be exaggerated.

lose population. The same Regressions (4) through (6) on the matched samples yield no significant coefficients on the reactor variables.

The contrasting results probably track the differences in the two comparison populations. The first three regressions compare towns with reactors to all other municipalities. They suggest that the towns with reactors lost population relative to the rest of Japan. The last three regressions compare reactor-built towns only to the other communities where a utility had formally filed plans to build a reactor. They suggest that the reactor-built towns did not lose population faster than these other reactor-planned towns.

At root, the contrasting results probably reflect the fact that the utilities reached agreements to build reactors primarily only with communities that were already losing population. As discussed in Section I, only badly dysfunctional towns wanted a reactor. They were disintegrating towns. Some of those towns received a reactor, and continued to hemorrhage. At the others the reactor never arrived, but the towns continued to lose population all the same.

3. <u>Age distribution.</u> -- Nuclear plants cause communities to age. Necessarily, the perceived radiation risks fall most heavily on the young. Other than the catastrophic meltdown, the perceived risk from a reactor (largely, a cancer risk -- I take no position on whether the perception is accurate) accrues over several decades. For couples with young children, those risks can seem huge. For couples already retired, they will be more modest. Should a community accept a reactor, young parents will find it a less attractive place to raise their children. Older couples may not much care. .

For social capital, however, intact young families are crucial. As political scientist Charles Murray (2012, 165) put it, "families with children are the core" of well-functioning communities. Older couples may bring attitudes that value community, but as they age they withdraw and live increasing isolated lives. Older couples do not volunteer at the PTA. They do not coach soccer teams, and do not help at the local library. The young parents do. They -- not the retired couples -- contribute in the countless other ways that help a community cohere. Precisely because of the long-term nature of the risks to nuclear power, however, the young parents are the residents most threatened by a reactor.

Table 10 Panel A. reflects this dynamic. Once a power company announces plans to build a reactor, young families disappear. The fraction of children under age 15 falls while that of people over 64 rises. The coefficients are significant and robust to the inclusion of controls for marriage and unemployment rates.

[Insert Table 10 about here.]

The same regressions on the matched datasets (Panel B.) confirm this observation. Relative to the towns that rejected a reactor, those that accepted one find children disappearing. Both in Panel A. and in Panel B., as municipalities accept reactors, families with children disappear. With lower significance levels, both tables suggest the converse as well: as municipalities accept reactors, they find themselves increasingly dominated by the elderly.

4. Unemployment. -- Given the crucial role that young families play in maintaining social capital, their disappearance should reduce community cohesion. Existing employers may leave. New employers may avoid the town. The most intact couples may move away.

The first two regressions (on the full dataset) in Table 11 suggest -- albeit inconclusively -- that the reactors may indeed cause employers to stay away. In a simple regression on the three reactor variables, the coefficients are positive but insignificant. With the addition of controls for migration, the positive coefficient on the operation of the reactor becomes significant at the 5 percent level.

[Insert Table 11 about here.]

The last two regressions (on the matched samples) similarly indicate that reactors drive jobs away. Perhaps existing firms leave. Perhaps new firms hesitate to locate in the reactor towns. And perhaps industrious workers move elsewhere, leaving only those unable to and hold a job. Whatever the mix of reasons, the coefficients on reactor operation in Regressions (3) and (4) are significantly positive in both specifications: reactors cause unemployment rates to rise.[13]

5. Divorce. -- Table 12 suggests that the reactors coincide with an increase in divorce rates. Once a utility starts to construct a reactor, divorce rates climb. The increase in divorce rates during construction is robust both to the inclusion of demographic and employment controls, and to the use of either the full dataset or the matched samples. The coefficients are positive for the operating period as well, although not at statistically significant levels.

I hesitate to make too much of the regressions. The coefficients are significant only during construction, and the reason for the possible increase in divorce rates is not clear. The phenomenon is, however, consistent with a general decline in social capital. Obviously, reactors do not themselves cause divorce. But perhaps the most intact families move out, and leave less stable couples. Perhaps higher rates of unemployment add stress. Whatever the reason, reactor construction coincides with an increase in the rate of divorce.

[Insert Table 12 about here.]

III. Conclusions:

Reactors degrade communities. In Japan, they do not arrive by government fiat. Neither do they arrive by the devious machinations of a manipulative utility.

Instead, in Japan communities apply for reactors. They apply for a simple reason: the government pays towns that accept reactors massive resources. Disproportionately,

[13] By contrast, Ando (2015) uses a "synthetic control" approach, and concludes that nuclear plants cause per capita income to rise. He notes, however, that the plants lead (predictably) to employment in the construction sector, that manufacturing employment increased only in one of the sites; and that the employment results in the service sector are mixed. Note as well that he obtains the strongest positive economic effect at the Rokkasho complex. This is not a reactor, and therefore not in my dataset. Rokkasho is instead a fuel reprocessing facility.

the towns that applied for the reactors were dystopian worlds already. They were the communities in economic decline -- but among declining towns, they were the towns that had responded to the decline by shifting from private-sector entrepreneurship to public-sector rent seeking. In the process, they had created incentives for their best workers to leave. The reactors were merely the most recent in a long chain of government subsidies that they had engineered.

Once built, the reactors degraded the communities further still. Young families disappeared. Unemployment rose. Divorce rates climbed. And although the government transfer payments were massive, they were also irregular.

To maintain their level of income, the towns applied for another reactor.

Bibliography

Ando, Michihito. 2015. Dreams of Urbanization: Quantitative Case Studies on the Local Impacts of Nuclear Power Facilities Using the Synthetic Control Method. J. Urban Econ., 85: 68-85.

Aldrich, Daniel P. 2008. Site Fights: Divisive Facilities and Civil Society in Japan and the West. Ithaca: Cornell University Press.

Becker, Gary. 1981. Treatise on the Family. Cambridge: Harvard University Press.

Fukushima yori, Kawauchi, Ikata ga "cho" kiken na riyu [Why Kawauchi and Ikata Are Far More Dangerous than Fukushima], Diamond On-Line, 2016. Available at: http://diamond.jp/articles/-/82951?page=2.

Gensuikin. 1997. Nihon no genshiryoku hatsudensho ichiran [Survey of Japanese Nuclear Reactors] (effective July 1997). Available at: http://www.gensuikin.org/data/genpatuichiran.html

Goo. 2016. (Real estate industry website about Kashiwazaki). Available at: http://house.goo.ne.jp/chiiki/kurashi/niigata/15205.html, searched 11/29/2016.

Habara, Sumio. 2012. Tanaka Kakuei "giwaku" no zansho [Tanaka Kakuei: The Remaining Doubts], Oruta [Alter], March 20, 2012. Available at: http://www.alter-magazine.jp/index.php?

Ike, Brian. 1980. The Japanese Textile Industry: Structural Adjustment and Government Policy, Asian Survey, 20: 532-51.

Ikeda, Chikako. No date. Genshiryoku hatsudensho ga Kashiwazaki shi zaise ni ataeta eikyo [The Effect of Nuclear Power Stations on Kashiwazaki City Finance]. Niigata ken honbu, Jiji ro Kashiwazaki shi shokuin rodo kumiai.

Imamura, Akitsune. 1934. Past Tsunamis of the Sanriku Coast. Japanese J. Astronomy & Geophysics, 11: 79, 79 (1934).

Ishii, Hideaki. 2003. Book review: Iwaki shi shi [History of Iwaki City], 6 Chiiki kenkyu __. Available at: http://www.jyoban-coalfield.com/public/pu_sepa/iwakisisi_sepa/shohyouishii.html

Itami, Hiroyuki. 2001. Nihon no sen'i sangyo: Naze korehodo yowaku natte shimatte no ka? [The Japanese Textile Industry: Why Has It Become so Weak?]. Tokyo: NTT shuppan.

Ito, Hisao. 2011. Genpatsu no arumachi [Towns with Nuclear Power], Nogyo kyodo kumiai shimbun, Aug, 1, 2011, at http://www.jacom.or.jp/archive03/tokusyu/2011/tokusyu110801-14409.html

Jishin chosa kenkyu suishin honbu. 2012. Todofuken goto no jishin katsudo [Earthquake Activity by Prefecture] (effective 2012). Available at: http://www.jishin.go.jp/regional_seismicity/

Johnson, Chalmers. 1986. Tanaka Kakuei, Structural Corruption, and the Advent of Machine Politics in Japan. J. Japanese Stud., 12: 1-28.

Kainuma, Hiroshi. 2011. "Fukushima" ron ["Fukushima" Theory. Tokyo: Seido sha.

Kansoku kyoka chiiki, tokutei kansoku chiiki no keii [4 Strengthened Monitoring Areas, Special Monitoring Areas.] (no date given). Available at: http://cais.gsi.go.jp/YOCHIREN/history/1-2-4_strong-sp.pdf.

Kasako, Takahiro. 2012. Genpatsu yuchi de zaisei kiki ni ochiitta Kashiwazaki shi [Kashiwazaki Solicited Nuclear Reactors and Fell into Fiscal Crisis], Kasakoblog, Oct. 9, 2012. Available at: http://kasakoblog.exblog.jp/19004306/.

Kashiwazaki Kariwa genshi ryoku hatsudensho 6 go ki no hoshaseibutsu shitsu no roei ni tsuite [Regarding the Radioactive Leak from Reactor 6 at the Kashiwazaki Kariwa Nuclear Power Plant], July 16, 2007, at: http://www.tepco.co.jp/cc/press/07071604-j.html (Tepco press release).

Kato, Takaai, Shogo Takahara, Masashi Nishikawa, & Toshimitsu Homma. 2013. A Case Study of Economic Incentives and Local Citizens' Attitudes Toward Hosting a Nuclear Power Plant in Japan: Impacts of the Fukushima Accident. Energy Policy, 59: 808-818.

Keisansho. 2011. Dengen ricchi seido no gaiyo [An Outline of Policies Relating to Electricity Producing Regions]. Tokyo: Keisansho.

Keizai Sango sho sheen enerugii cho. 2011. Dengen richi seido no gaiyo [A Summary of the Electrical Generating Region System]. Tokyo: Keisansho.

Keizai sangyo sho. 2009. Waga kuni sekitan seisaku no rekishi to genjo [The History and Circumstances of the Coal Industry in Our Country]. Available at: http://www.enecho.meti.go.jp/category/resources_and_fuel/coal/japan/pdf/23.pdf

Kiyomiya, Ichiro. 1955. Joban tanden shi [History of the Joban Coal Fields]. Taira shi: Amago kai.

Lewis, Oscar. 1963. The Culture of Poverty, The New Yorker, Nov. 1963, at 17.

Massey, Douglas S., & Robert J. Sampson. 2009. Moynihan Redux: Legacies and Lessons. Annals, 621, Jan. 2009.

Miyoshi, Yu. 2012. Genshiryoku hatsudensho to Fukui ken Mihama cho zaisei [Nuclear Power Plants and the Public Finance of the Town of Mihama, Fukui Prefecture]. Available at: ci.nii.ac.jp/lognavi?name=nels&lang=en&type=pdf&id=ART0010105503

Miyoshi, Yu. 2009. Genshiryoku hatsudensho to jijitai zaisei [Nuclear Power Plants and Local Public Finance]. Ritsumeikan keizai gaku, 58: 43. Available at: http://r-cube.ritsumei.ac.jp/bitstream/10367/1083/1/30015872_584_miyoshi.pdf

Moynihan, Daniel Patrick. 1965. The Moynihan Report: An Annotated Edition, The Atlantic (2015; original published in 1965).

Moynihan, Daniel Patrick. 1968. The Professors and the Poor, in Moynihan, ed., On Understanding Poverty 3-35 (New York: Basic Books.

Murray, Charles. 1993. Welfare and the Family: The U.S. Experience. J. Labor Econ., 11: S224.

Nagai, Manabu, et al. 2015. Oi genshiryoku hatsudensho ha koshite dekita [This Is How the Oi Nuclear Reactor Came to Be]. Tokyo: Koninsha.

Namie cho no rekishi to higashi Nihon daishinsai [The History of Namie Town and the Great Eastern Japan Earthquake]. Available at: http://www.f-smeca.com/wp/wp-content/uploads/2015/08/2011cyousakenkyuu03.pdf.

Nihon chiiki banzuke [Regional Rankings in Japan] (2016). Available at: http://area-info.jpn.org/index.html

No author given. 1972. Nenryo kogyo no suii to shorai no tembo [A History of the Fuel Industry and the Outlook for the Future], 51 Nenryo kyokai shi 763 (1972). Available at: https://www.jstage.jst.go.jp/article/jie1922/51/10/51_10_763/_pdf

Nosei, Takemi, et al. 2013. Hokuriku shuyo sangyo no genjo to kadai [The Circumstances and Issues involving Major Industries in the Hokuriku Region], at 31. Available at: http://www.ide.go.jp/Japanese/Publish/Download/Report/2013/pdf/B406_ch2.pdf.

Ohara shakai mondai kenkyu jo, ed. 1956. Shitsugyosha no sonzai keitai [The Place of Unemployed Workers]. Tokyo: Toyo keizai shimpo sha.

Ramseyer, J. Mark & Frances McCall Rosenbluth. 193. Japan's Political Marketplace. Cambridge: Harvard University Press.

Ramseyer, J. Mark. 1989. Water Law in Imperial Japan: Public Goods, Private Claims, and Legal Convergence, 18 J. Legal Stud. 51 (1989).

Ramseyer, J. Mark. 2012. Why Power Companies Build Nuclear Reactors on Fault Lines: The Case of Japan. 13 Theoretical Inquiries L., 13: 45.

Sai kado shita ikata genpatsu ha Nihon de ichiban kiken na genpatsu da [The Restarted Ikata Reactor Is the Most Dangerous in Japan], Aug. 12, 2016. Available at: http://lite-ra.com/2016/08/post-2491.html.

Saikado shita ikata genpatsu ... [The Restarted Ikata Reactor ...]. 2016. Available at: http://lite-ra.com/2016/08/post-2491.html.

Samuels, Richard J. 1987. The Business of the Japanese State: Energy Markets in Comparative and Historical Perspective. Ithaca: Cornell University Press.

Sandee Mainichi. 2004. Tokai jishin saiko ken'i: moto jishin yochiren kaicho ga ikari no kokuhatsu [Highest Authority on Tokai Earthquake: Former Chair of Earthquake Prediction Federation Issues Angry Announcement], Sandee Mainichi, Feb. 29, 2004. Available at: http://www.stop-hamaoka.com/news/sunday.html.

Seidensticker, Edward G. 1956. "Introduction," to Yasunari Kawabata, Snow Country. New York: Alfred A. Knopf.

Shirato, Shin'ichi. 2009-10. Sen'i sangyo kozo kaizen seisaku to orimono sanchi ni okeru kozo kaizen jigyo no rekishiteki kensho [Historical Research into the

Structural Improvement Policy]. Meiji daigaku shakai kagaku kenkyujo kiyo, 51-2: 1. Available at: https://m-repo.lib.meiji.ac.jp/dspace/bitstream/10291/16537/1/shakaikagakukiyo_51_2_1.pdf

Shirundo. 2017. Nankai torafu daijishin, Tokai jishin 2017nen ka itsu [Will the Nankai Trough Earthquake, the Tokai Earthquake Hit in 2017? When?]. Available at: http://sirundous.com/nratzen/tokaitorafu/.

Somusho, ed. No date. Chiho zaisei no bunseki [An Analysis of Local Public Finance]. Available at http://soomu.go.jp.

Staffblog. 2014. Naniga nandemo Hamaoka genpatsu dake ha ugokashiteha naranai to iu riyu [The Reason to Avoid Running the Hamaoka Reactor at All Costs], Feb. 14, 2014. Available at: http://www.thinktheearth.net/jp/staffBlog/2004/02/post-334.html.

Tomizawa, Shushin. 2005. Fukui sen'i sanchi no kozo chosei shi [The History of Structural Adjustment in the Textile Region of Fukui], Keiei kenkyu, 56: 17. Available at: http://dlisv03.media.osaka-cu.ac.jp/infolib/user_contents/kiyo/DB00011775.pdf.

Tullock, Gordon. 1975. The Transitional Gains Trap. Bell J. Econ., 6: 671-78.

Usami, Noriya. 2014. Genpatsu ga tomatta genpatsu no machi "Kashiwazaki" no genjo [The Present Circumstances of the Nuclear City Kashiwazaki without a Operating Nuclear Reactor]. Blogos, Aug. 27, 2014. Available at: http://blogos.com/article/93288/.

Usami, T. 2003. Nihon higai jishin soran, [416]-2001 [Materials for Copmprehensive List of Destructive Earthquakes in Japan, [416]-2001].

Utsu, T., et al., eds. 2010. Jishin no jiten [Encyclopedia of Earthquakes] App. II (2d ed., 2010).

Utsu. 1982. Nihon fukin no M6.0 ijo no jishin oyobi higai jishin no hyo: 1885 nen - 1980 nen [Table of Magnitude 6.0 or Higher Earthquakes Near Japan and of Earthquakes Causing Damage], Jishin kenkyujo iho, 57: 401.

Waseda daigaku. 2009. Tanko rodosha no heizan rishoku to kyaria no saideisei [The Discharge of Coal Miners Due to the Closing of Mines and the Restructuring of Careers]. Available at: http://www.tankou.org/modules/tankou3/index.php?id=10.

Yoshioka, Hitoshi. 2011. Genshiryoku no shakai shi [A Social History of Nuclear Power]. Tokyo: Asahi shimbun shuppan.

Zenkoku zenchiiki no dengen ricchi chiiki taisaku kofu kin banzuke [Ranking of All Areas by Subsidies to Electricity Generating Areas], in Nihon chiiki banzuke, accessed 11/29/2016. Available at: http://area-info.jpn.org/PowerGrantAll.html#area182028.

Table 1: Reactor Complexes

Pref.	Town	Reactors	Power	Began operation	Notes
Niigata	Kashiwaz.	7	821.2	1985-97	
Fukui	Ooi	4	471	1979-83	
Fukushima	Fuk. 1*	6	469.6	1971-79	Decommissioned
Fukushima	Fuk. 2**	4	440	1982-87	
Shizuoka	Hamaoka	4	361.7	1976-93	Partially decom'd
Fukui	Takahama	4	339.2	1974-85	
Saga	Genkai	3	229.8	1978-94	Partially decom'd
Ehime	Ikata	3	202.2	1977-94	Partially decom'd
Kagoshima	Sendai	2	178	1984-85	
Fukui	Mihama	3	166.6	1970-76	Partially decom'd
Fukui	Tsuruga	2	151.7	1970-87	Partially decom'd
Miyagi	Onagawa	2	134.9	1984-85	
Shimane	Shimane	2	128	1974-89	Partially decom'd
Hokkaido	Tomari	2	115.8	1987-89	
Ibaragi	Tokai 2	1	110	1978	
Ishikawa	Shiga	1	54	1993	
Fukui	Tsuruga	1	28	1991	Experimental FBR
Ibaragi	Tokai 1	1	16.6	1966	Decommissioned

Notes: Power in 10,000 kW.
* Located in Futaba and Okuma.
** Located in Naraha and Tomioka.

Sources: Gensuikin, Nihon no genshiryoku hatsudensho ichiran [Survey of Japanese Nuclear Reactors] (effective July 1997). Available at: http://www.gensuikin.org/data/genpatuichiran.html

Table 2: Major Earthquakes and Tsunami in Northeastern Japan

Date	Magnitude	Epicenter	Tsunami .
1611	8.1	N39.0 E144.4	15-25 meters
1793	8.4	N38.5 E144.5	4-5 meters
1896	8.0	N39.5 E144.0	28.7 meters
1933	8.1	N39.2 E144.5	38.2 meters
2011	9.0	N38.3 E142.4	38.9 meters

Sources: J. Mark Ramseyer, Why Power Companies Build Nuclear Reactors on Fault Lines: The Case of Japan, 13 Theoretical Inquiries L. 457 (2012), T. Usami, Nihon higai jishin soran, [416]-2001 [Materials for Copmprehensive List of Destructive Earthquakes in Japan, [416]-2001] (2003); T. Utsu, et al., eds., Jishin no jiten [Encyclopedia of Earthquakes] App. II (2d ed., 2010); Utsu, Nihon fukin no M6.0 ijo no jishin oyobi higai jishin no hyo: 1885 nen - 1980 nen [Table of Magnitude 6.0 or Higher Earthquakes Near Japan and of Earthquakes Causing Damage], 57 Jishin kenkyujo iho 401 (1982).

Table 3: Earthquakes Causing Deaths, 1800-Present

Year	Magnitude	Deaths
Fukushima:		
1821	5.5-6.0	1+
1938	7.5	1
1978	7.4	1
2008	7.2	1
2008	6.8	1
2011	9.0	1,613
Niigata:		
1802	6.5-7.0	19
1828	6.9	1,400
1833	7.5	5
1847	7.4	12,000
1961	5.2	5
1964	7.5	13
2004	6.8	68
2007	6.9	4
2007	6.8	15
Fukui:		
1891	8.0	12
1948	7.1	3,728
1961	7.0	1

Source: Jishin chosa kenkyu suishin honbu, Todofuken goto no jishin katsudo [Earthquake Activity by Prefecture] (effective 2012). http://www.jishin.go.jp/regional_seismicity/

Table 4: Employment in the Fukui Textile Industry

	Workers
1960	52,342
1965	59,463
1970	62,091
1975	50,645
1980	48,378
1985	42,326
1990	36,922
1995	32,124
2000	25,440

Source: Tomizawa, Shushin, Fukui sen'i sanchi no kozo chosei shi [The History of Structural Adjustment in the Textile Region of Fukui], Keiei kenkyu, 56: 17, 25 (2005). Available at http://dlisv03.media.osaka-cu.ac.jp/infolib/user_contents/kiyo/DB00011775.pdf

Table 5: Domestic Coal Production in Japan

	Production	Workers
1963	5,110	122.8
1965	5,011	107.1
1970	3,833	47.9
1975	1,860	22.5
1980	1,810	18.3
1985	1,645	14.3
1990	798	4.7
1995	632	2.6
2000	296	1.3
2007	132	0.6

Notes: Production in 10,000 tons; workers in 1000 people.

Source: Keizai sangyo sho, Waga kuni sekitan seisaku no rekishi to genjo [The History and Circumstances of the Coal Industry in Our Country] 5 (2009). Available at: http://www.enecho.meti.go.jp/category/resources_and_fuel/coal/japan/pdf/23.pdf

Table 6: Electricity Generation Subsidies

Town	Pref	National subsidy	Pref'l subsidy	Total subsidy	Pop'n	$ Subsidy PC .
Ooi	Fukui	2,483	555	3,038	8,200	$4,258
Kashiwazaki	Niigata	1,823	844	2,668	86,200	$356
Takahama	Fukui	1,858	671	2,528	10,500	$2,767
Mihama	Fukui	2,238	16	2,254	9,800	$2,644
Ookuma	Fuk'ma	2,084	-	2,084	11,500*	$2,082
Kariwa	Niigata	1,042	211	1,253	4,700	$3,064
Tsuruga	Fukui	1,116	112	1,228	68,400	$206
Tomioka	Fuk'ma	1,060	14	1,074	16,000*	$771
Naraha	Fuk'ma	989	-	989	7,700*	$1,476
Futaba	Fuk'ma	769	13	782	6,900*	$1,302
Kawauchi	Fuk'ma	-	45	45	2,028	$255
Hirono	Fuk'ma	-	45	45	4,300	$120

Note: The last column converts the total subsidy to dollars, at the 87 yen/$ rate effective on December 31, 2012. Amounts in million yen, as budgeted for 2012.

* As of 2010; currently uninhabited, other than Naraha which has a population of 976.

Source: Zenkoku zenchiiki no dengen ritchi chiiki taisaku kofu kin banzuke [Ranking of All Areas by Subusidies to Electricity Generating Areas], in Nihon chiiki banzuke, accessed 11/29/2016. Available at: http://area-info.jpn.org/PowerGrantAll.html#area182028

Table 7: Selected Summary Statistics

	n	Min	Mean	Median	Max
Plan	54,002	0	.00046	0	1
Construction	54,002	0	.00085	0	1
Operation	54,002	0	.01068	0	1
Revenue PC	54,001	161.0	509.7	387.8	11843.3
Under 15 PC	54,001	.043	.170	.166	.353
Over 64 PC	54,001	.037	.190	.179	.572
Unempl't PC	54,001	0	.031	.028	.179
Marriage PC	54,001	0	.005	.005	.031
Population	54,002	0	71477	26685	3688773
In-migr'n PC	26,129	.002	.039	.035	.322
Out-migr'n PC	26,007	.005	.043	.040	.369
Divorce rate	53,916	0	.289	.266	4.00

Sources: See text.

Table 8: Determinants of Municipal Revenue

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:			*Revenue PC*			
Plan	68.59 (106.94)	6.65 (71.55)	15.87 (71.75)	25.23 (104.53)	33.49 (72.21)	56.59 (60.72)
Construction	256.30** (104.30)	272.38*** (103.63)	275.93*** (106.65)	221.38** (103.23)	299.26** (112.22)	308.50** (113.08)
Operation	438.93*** (170.89)	425.14** (166.61)	432.79*** (167.80)	374.33** (179.50)	431.53** (183.03)	461.12** (192.48)
Under 15 PC		2472.89*** (335.10)	1991.45*** (315.08)		3929.67** (1905.98)	3100.79* (1723.33)
Over 64 PC		2892.01*** (182.09)	2928.78*** (174.72)		1644.91* (921.70)	1495.038* (845.30)
Unemployment PC			-3743.10*** (744.87)			-5171.15 (3220.72)
Overall R2:	.09	.26	.29	.19	.21	.22
n:	54,001	54,001	54,001	961	961	961
Data:	Full data	Full data	Full data	Matched sample	Matched sample	Matched sample

Notes: Fixed effect regression with year and municipality fixed effects, and errors clustered by municipality. ***, **, *: significant at 1, 5, and 10 percent levels. Standard errors in parentheses.

Sources: See text.

Table 9: Determinants of Population

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:			*Population*			
Plan	-3481.6***	730.56	1153.1	-667.49	1520.62	1570.06
	(580.1)	(2928.9)	(2115.4)	(1600.23)	(2358.97)	(2294.16)
Construction	-2780.8***	-2157.4	-1994.8**	-332.65	-57.137	-37.38
	(674.8)	(1325.9)	(968.4)	(1589.09)	(2787.34)	(2762.35)
Operation	-7907.8***	-6254.4***	-5904.0***	-2408.56	-2168.06	-2104.74
	(1002.8	(1361.1)	(1123.9)	(3519.79	(4219.97)	(4002.49)
Under 15 PC		-74243.3***	-96296.9***		-37683.63	-39475.25
		(12015.6)	(13468.2)		(78022.74)	(83045.22)
Over 64 PC		-159999.8***	-158315.7***		-94413.35**	-94734.05**
		(11173.3)	(11007.6)		(44673.68)	(45148.8)
Unemployment PC			-171461.3***			-11065.19
			(29957.9)			(101498.5)
Overall R2:	.0003	.09	.09	.04	.14	.14
n:	54,002	54,001	54,001	961	961	961
Data:	Full data	Full data	Full data	Matched sample	Matched sample	Matched sample

Notes: Fixed effect regression with year and municipality fixed effects, and errors clustered by municipality. ***, **, *: significant at 1, 5, and 10 percent levels. Standard errors in parentheses.

Sources: See text.

Table 10: Determinants of Age Distribution

A. Full Database:

Dependent variable	*Under 15 PC*		*Over 64 PC*	
Plan	-.0125***	-.0101***	.0321*	.0322
	(.0037)	(.0015)	(.0190)	(.0203)
Construction	-.0242***	-.0223***	.0151**	.0142**
	(.0048)	(.0043)	(.0062)	(.0065)
Operation	-.0142**	-.0124**	.0169***	.0162**
	(.0065)	(.0055)	(.0062)	(.0066)
Marriage PC		-1.754***		-3.814***
		(.1519)		(.3426)
Unemployment PC		-.4873***		.1071
		(.0333)		(.0708)
Overall R2:	.66	.61	.45	.50
n:	54,001	54,001	54,001	54,001

B. Matched Samples:

Dependent variable	*Under 15 PC*		*Over 64 PC*	
Plan	-.0142***	-.0105***	.0288	.0296
	(.0042)	(.0021)	(.0197)	(.0209)
Construction	-.0253***	-.0221***	.0130*	.0129*
	(.0048)	(.0045)	(.0072)	(.0075)
Operation	-.0188***	-.0137**	.0100	.0104
	(.0062)	(.0057)	(.0090)	(.0104)
Marriage PC		-1.047		-3.003**
		(.825)		(1.353)
Unemployment PC		-.594***		-.0335
		(.1647)		(.4202)
Overall R2:	.57	.59	.50	.55
n:	961	961	961	961

Notes: Fixed effect regression with year and municipality fixed effects, and errors clustered by municipality. ***, **, *: significant at 1, 5, and 10 percent levels. Standard errors in parentheses.

Sources: See text.

Table 11: Determinants of Unemployment

	(1)	(2)	(3)	(4)
Dependent variable:		*Unemployment PC*		
Plan	.0044	.0064	.0059	.0061
	(.0062)	(.0070)	(.0062)	(.0069)
Construction	.0042	.0091	.0055	.0089
	(.0036)	(.0088)	(.0037)	(.0094)
Operation	.0040	.0272**	.0084*	.0276**
	(.0045)	(.0133)	(.0047)	(.0133)
In migration PC		-.0379*		-.0295
		(.0223)		(.0858)
Out migration PC		.1150***		-.0050
		(.0152)		(.0515)
Overall R2:	.48	.24	.47	.05
n:	54,001	26,007	961	463
Data:	Full Data	Full Data	Matched Sample	Matched Sample

Notes: Fixed effect regression with year and municipality fixed effects, and errors clustered by municipality. ***, **, *: significant at 1, 5, and 10 percent levels. Standard errors in parentheses.

Sources: See text.

Table 12: Determinants of Divorce

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:			*Divorce rate*			
Plan	-.052	-.061	-.065	-.051	-.045	-.056
	(.048)	(.034)	(.049)	(.047)	(.048)	(.043)
Construction	.057*	.061*	.059**	.066*	.074**	.070**
	(.031)	(.034)	(.026)	(.035)	(.033)	(.033)
Operation	.018	.017	.013	.027	.032	.019
	(.030)	(.032)	(.026)	(.033)	(.032)	(.030)
Under 15 PC		.451***	.723***		.261	.634
		(.099)	(.094)		(.573)	(.577)
Over 64 PC		.451***	.431***		-.076	-.009
		(.062)	(.061)		(.375)	(.334)
Unemployment PC			2.119***			2.327*
			(.286)			(1.180)
Overall R2:	.31	.31	.36	.37	.36	.43
n:	53,916	53,915	53,915	961	961	961
Data:	Full Data	Full Data	Full Data	Matched Sample	Matched Sample	Matched Sample

Notes: n = 53,916, 53,915. Fixed effect regression with year and municipality fixed effects, and errors clustered by municipality. ***, **, *: significant at 1, 5, and 10 percent levels. Standard errors in parentheses.

Sources: See text.