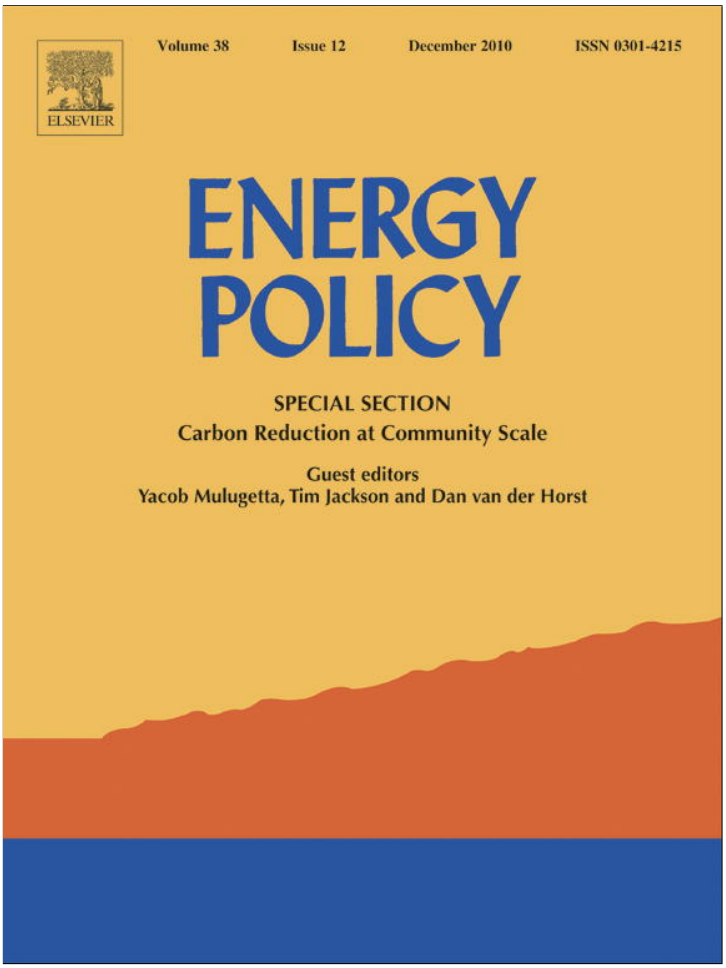

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The socio-political economy of nuclear power development in Japan and South Korea

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ABSTRACT

This paper analyzes the socio-cultural, political and economic conditions prevalent during the inception of nuclear power programs in Japan and South Korea in order to identify commonalities which support nuclear power program expansion. The study identifies six factors as having a clear influence on supporting nuclear power development: (1) strong state involvement in guiding economic development; (2) centralization of national energy policymaking and planning; (3) campaigns to link technological progress with national revitalization; (4) influence of technocratic ideology on policy decisions; (5) subordination of challenges to political authority, and (6) low levels of civic activism. The paper postulates that insights from this study can be used to assess the propensity of nations which have the emergent capacity to support nuclear power development to actually embark on such programs.

1. Introduction

Broadly speaking, nations that have the technological know-how to initiate nuclear power development programs exhibit one of three development paths: ideologically opposed, ideologically committed or ideologically untethered. Nations that have historically displayed staunch opposition include Norway, Greece and Australia. Conversely, nations that have staunchly supported a nuclear power development path include Japan, France and South Korea. Meanwhile, a host of other nations have historical track records which feature fluctuating levels of support and opposition. Nations which fall into this last grouping would include United States, Canada and Taiwan, all of which have experienced stages of nuclear power expansion followed by periods of nuclear power stagnation or even retrenchment. In the aggregate, these three development paths can be depicted on a spectrum, as outlined in Fig. 1.

Over the past few decades, the global economy has developed in such a way that there are now a number of nations that have either acquired or are on the cusp of acquiring the economic and technological capacity to consider pioneering nuclear power development programs. More than 60 countries have conveyed to the International Atomic Energy Agency interest in introducing nuclear power to their energy mixes.[2] In addition to high-profile initiatives in Iran, Iraq and North Korea, leaders in nations such as Bangladesh, Belarus, Indonesia, Jordan, Myanmar, Zimbabwe, Algeria, Morocco, and the United Arab Emirates as well as Argentina, Brazil, and South Africa have all registered interest in developing nuclear power programs in the near future (Marignac et al., 2008; Meldrum, 2005; Sovacool and Cooper, 2008; World Nuclear Association, 2009). Accordingly, for stakeholders concerned with international security, global energy policy, international environmental governance, energy sector business strategy or any other related field, the capacity to predict both the emerging players in the nuclear power sector and the vigor with which these nations will embrace nuclear power development will be significantly enhanced by the development of an analytical model for estimating the propensity of a nation to embrace nuclear power.

While all nations that have a track record of nuclear power development can be situated on the development spectrum (Fig. 1) by evaluating national nuclear power development trends, for nations that have not yet embarked on nuclear power development initiatives, the task of placing them on the development spectrum cannot be accomplished through such a quantitative analytical approach. Instead, what is needed is a method of identifying the socio-political economy (social, political and economic factors) that tends to support nuclear power development and somehow employ this socio-political economic profile to predict the extent to which

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[2] Interview with David Waller, Deputy Director General of the IAEA, May 6, 2009, Vienna, Austria.

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Fig. 1. The aggregate socio-political economy of nuclear power development.

nuclear power is likely to be supported within a given nation. This article attempts to devise and explicate just such a method.

The point of disembarkation for this intellectual exercise is the evaluation of the socio-political economic factors that supported the inception of nuclear power in two nations known for exhibiting strong support for nuclear power, Japan and South Korea. These comparative case studies identify common socio-political economic factors underpinning the emergence of nuclear power industries in these two nations. The premise behind this approach is that if common socio-political economic factors can indeed be identified, the same factors may also be evident in the emergence of nuclear power in other nations. If this is the case, the same conditions can be analyzed in nations which have the emergent capacity to support nuclear power development and the findings can be used to predict, albeit loosely, the propensity for these nations to embark on nuclear power development programs.

Japan and South Korea were chosen as baseline studies for this article due to the similarities of their socio-political economic profiles. Japan and South Korea have markedly similar cultural dynamics that include commonalities in regard to the vertical structuring of relationships, Confucian ideals and even shared ethnographic roots which include shared linguistic links to the rare Altaic family of languages (Bellwood and Sanchez-Mazas, 2005; Brown and Brown, 2006). There are also marked similarities in popular culture including a social appeal for emotion-packed drama and similar taste in pop-music. The nations have also pursued similar economic development paths (Castley, 1997). Although South Korea would be considered a laggard in terms of economic development when compared to Japan, South Korea has significantly narrowed the economic gap between the two countries in recent years and in doing so, has minimized the confounding effects of comparing two nations with vastly different economic profiles. It is our contention that these two socio-economically similar countries, which have been strong, unwavering advocates of nuclear power development, present an opportunity to search for socio-political economic commonalities related to nuclear power expansion without the confounding threats posed by studying nations with socio-cultural dissimilarities.

The layout of this article is as follows. Section 2 outlines the research and theoretical methods employed. Section 3 presents a socio-political economic analysis of the inception of nuclear power in Japan. Section 4 presents a similar analysis in regard to South Korea's nuclear power program. Section 5 draws from these cases to develop a socio-economic political framework for predicting nuclear power expansion. Finally, Section 6 discusses the limitations associated with this study and concludes with recommendations on ways to extend research into the socio-political economy of nuclear power.

2. Research and theoretical methods

A comparative case study approach was adopted for this research study. Rather than utilizing laboratory samples or statistical analysis to examine variables, case study methods involve in-depth, longitudinal assessments of a single instance or group of instances: a case or cases (Flyvbjerg, 2001, 2006). Put another way, the case study method is an investigation of a contemporary phenomenon within its real-life context to explore causation in order to find underlying principles (Yin, 2008), in this case the search for factors which catalyze nuclear power development. Through employing a case study strategy, we endeavored to provide what methodological theorists Alexander George and Andrew Bennet call a "detailed examination of an aspect of a historical episode to develop or test historical explanations that may be generalizable to other events"(George and Bennett, 2004).

In the context of this paper, the intent was to develop "explanations" rather than to "test" previous theory. Consequently, insights were extracted from our research and inductively cobbled into the framework presented in Section 5. In inductive models, some sort of cognitive framework is needed to guide the search for causal factors (Blaikie, 2000; Charmaz, 2006). Accordingly, we elected adoption of a socio-technical systems perspective as a cognitive framework for conducting our analysis. In *Networks of Power: Electrification in Western Society*, Thomas P. Hughes posited that energy supply and use occurs within a "socio-technical" system that extends beyond the domain of science and engineering (Hughes, 1983). Hughes described this socio-technical system as comprising a "seamless web" of technical, social, political, and economic causal factors that support the development of a given technological regime.

Hughes' perspective on socio-technical systems is appealing because it integrates effectively with a number of well-regarded public policy theories. It can be seen as an extension of the behaviorist perspective of path dependence theory which postulates that technological regimes become "locked-in" due to advantages that influential stakeholders increasingly derive from the continued prosperity of the entrenched regime (Pierson, 2004). David provides a clear illustration of social influence on technological path entrenchment in describing how the common "Qwerty" keyboard found on all computers became technologically entrenched despite the existence of another layout which facilitated higher typing speeds (Dvorak keyboard) thanks in large part to the swarms of typists who historically learned to type on Qwerty systems (David, 1985). Hughes' socio-technical systems perspective also conflates with Sabatier and colleague's advocacy coalition studies which contend that the collective influence of groups of stakeholders with common interests can gain control over political agendas causing either policy entrenchment or policy redirection (Sabatier and Jenkins-Smith, 1993; Weible and Sabatier, 2007). A key premise that all these studies agree on is that successful technologies are not arbitrarily designed and built; they must be designed and built *for* and *into* society.

When applied to a theory of socio-political economy influencing nuclear power development, the socio-technical systems approach implies that there might be a set of prominent social, economic, political and technical conditions that support the emergence of nuclear power regimes. Accordingly, the two case studies that follow attempt to track the evolution of nuclear power in Japan and South Korea with a focus on significant socio-technical influences that supported the development of the nuclear sectors in these countries.

In addition to the socio-cultural similarities shared by Japan and South Korea, the appeal of choosing these two nations for comparative purposes also stems from the markedly similar development paths of their respective nuclear power sectors. Both countries have a long history of nuclear power, with Japan's program beginning in 1955 and South Korea's starting in 1956. Both countries currently rely on nuclear power to supply a significant proportion of electricity (30 percent in Japan and 40 percent in Korea) and both countries have ambitious plans to expand their nuclear programs. Japanese policymakers aim to generate 40 percent of electricity from nuclear resources by 2030 and the South Korea aims to enhance contributions from nuclear power to 60 percent by 2030 (Amari, 2006; Jin, 2007).

3. The socio-political economy supporting Japan's nuclear power industry

3.1. Background

Japan ranks third in the world in installed nuclear power capacity with 55 nuclear reactors comprising 49,467 MW amount of installed capacity (see Appendix A). In 2006, these nuclear reactors generated 303 TWh of energy at costs that the government claims were 20 percent cheaper than natural gas and 40 percent cheaper than hydropower (ANRE, 2008). The Japanese "New Energy Strategy" published in 2006 aims to expand the nuclear power program from an already robust 30 percent of total power generation to 40 percent by 2030 because nuclear power is viewed as being indispensable to Japan's CO_2 emission reduction efforts (Amari, 2006). The main obstacle to expansion of nuclear power capacity in such a densely populated country is waste disposal (JAEC, 2008). Consequently, Japan has initiated a program to fortify the nuclear fuel cycle. Construction is underway at Rokkasho-mura on Japan's first uranium reprocessing plant and Japan's first MOX fuel-fabrication plant which are scheduled for completion in 2010 and 2012, respectively (Chanlett-Avery and Nikitin, 2009).

3.2. The guiding hand of the government

Japan was and is a model planned economy. The Liberal Democratic Party (LDP) which was unseated in 2009 governed Japan for all but 2 years since the end of WWII and presided over the nation's emergence as an economic powerhouse through targeted financial subsidies and domestic market protection mechanisms. Since the 1960s, government financial support through grant and subsidy programs for technology research has ranked in the top echelon compared to other nations, and is currently at about 3 percent of Japanese GDP (Nezu, 2007). The result has been the emergence of world-class, technologically savvy firms such as Sony, Honda, Toyota, Toshiba, and Hitachi. In order to protect the fledgling technology firms from foreign competitors, the Japanese government imposed high import tariffs on strategically important goods (i.e. automobiles) and stringent market-entry regulations to insulate the domestic market (Hane, 1992). These policies enabled domestic businesses to utilize domestic profits to subsidize foreign market-building activities (Bartlett et al., 2003).

Given the government's micromanagement of industrial policy, it should come as no surprise that even though Japan's electric utilities were privatized in 1951, the government retained control over strategic issues such as the types of technologies to be promoted and developed (FEPC, 2008). This was well illustrated during the emergence of Japan's nuclear power program. Japan's nuclear power program was officially launched when the Japanese government passed the Atomic Energy Basic Law in 1955, which set out the criteria under which peaceful development of nuclear technology was to be undertaken. Government development funding which commenced that year eventually led to the inauguration of Japan's first nuclear energy plant, the Tokai nuclear power plant in 1966. While development was underway, the government tasked Japan's three largest utilities – Tokyo, Kansai and Chubu – with responsibility for technical training and development of long-term commercialization plans (Byrne and Hoffman, 1996). Without government financial support and centralized coordination, Japan's nuclear power program would likely have been a non-starter.

The Japanese government continues to play a central role in the development of nuclear power technology through strategic management of the financial purse strings. From 1975 to 2001, for example, the Japanese government committed more than US$2 billion annually to nuclear power research (ANRE, 2006; JAEC, 2009). Consequently, the Japanese government has fostered the largest nuclear research program in the world-boasting the largest national per capita number of researchers, scientists, engineers, and technicians (Kitagawa and Schuman, 2007). Furthermore, it has nurtured three of the world's leading nuclear power plant manufacturers (Mitsubishi, Hitachi and Toshiba).

3.3. The quest for economic security

Following World War II defeat, Japan was in ruins. More than 30 percent of the Japanese population was homeless, communication and transport networks were in shambles and industrial capacity had been bombed into insignificance (Hall, 1990). With the support of Occupation funding, Japan embarked on a modernization program that would achieve unprecedented economic success. By the 1960s, Japan boasted the second largest radio and television manufacturing industries in the world and its automotive industry had grown to become the third-largest in the world (Hall, 1990). Accordingly, when the government turned to development of the nuclear power program, most Japanese were already sold on the merits of technological progress.

Japan's nuclear energy program is an offspring of aspirations for enhanced national energy security. The nuclear power program accelerated in the 1970s, when the oil embargoes in 1973 and 1974 convinced many of the political elite that nuclear power was needed to buffer the Japanese economy from energy shocks. National planners also saw nuclear technology as an important export product, a tool to not only free the nation from energy dependence, but to also extend its economic reach into the Pacific and the world at large (Kim and Byrne, 1996). The sheer lack of indigenous energy resources justified a massive expansion of the nuclear program, including commitment to plutonium fueled fast breeder reactors (Byrne and Hoffman, 1996). The Japanese government's support for nuclear technology was and is based on the tenet that a greater national risk is posed by dependence on imported energy than by a network of nuclear power plants. Japan imports more than 95 percent of its energy feed-stocks, and other than Italy (which is inter-connected to the European Union electricity grid) no other country in the OECD exhibits such precarious dependence on imported energy (FEPC, 2008). Japanese policymakers believe this places the economic well-being of the country at the mercy of a highly unstable global energy market (ANRE, 2006).

For decades in Japan, expansion of the nuclear power program has been perceived as a strategic necessity for enhancing domestic energy security while preserving low energy costs. Recently, the challenge of reducing carbon emissions to fulfill

Japan's Kyoto Protocol commitments has bolstered the allure of nuclear power. Accordingly, if there is any lesson to be derived from Japan's ongoing experiment with nuclear power, it is that dominant economic priorities can nullify conditions that may otherwise prevent nuclear power development.

Not only was Japan in ruins following World War II, the nation's dearth of natural resources placed industry in a precarious position for recovery. The only resource that Japan had in sufficient quantity was labor. Accordingly, the key tenets of Japan's modernization strategy lay in supporting technologies that could help industries utilize labor more effectively or add-value to the production process (Inkster and Satofuka, 2000). Such technocratic ideology sired a host of now famous systems for enhancing productivity such as total quality management, just-in-time inventory control and kanban production control (Chase and Aquilano, 1995). In the 1960s, the promise of generating cheap energy through applied nuclear technology meshed perfectly with government aspirations to enhance the international competitiveness of industry. For resource-poor Japan, developing the most technologically advanced energy infrastructure was akin to developing a new type of resource—a technological resource.

3.4. Achieving socio-political economic harmony

Until recently, the LDP's patriarchal lock on power has prompted some to label Japan's political scene as a "one and a half party" system (Hall, 1990). Although the LDP has found it necessary on occasion to form alliances with other political parties in order to gain a majority of seats necessary to form a government, political authority in Japan has been predominantly vested with leading factions of the LDP. One of the LDP's key strategies for mitigating challenges to political authority is to employ a form of political musical chairs in response to crisis. Typically, any serious crisis catalyzes a resignation by a senior official. In this manner, policy failure is diverted away from the party. Bureaucrats who have resigned in this way frequently retain a degree of power by assuming shadow positions within the LDP's internal power networks. Fortunately, during the initial era of nuclear power expansion, no nuclear mishaps occurred to necessitate cabinet level resignations; however, this strategy was illuminated in the late 1990s when the Power Reactor and Nuclear Fuel Development Corporation was restructured as the Nuclear Cycle Development Institute following technical mishaps involving the breeder reactors it had developed.

Another mechanism in Japan that tempers challenges to political authority involves strategic control of Japan's political media. Many mainstream reporters belong to ministerial "reporter's clubs" which give members preferred access to government sources (Pharr and Krauss, 1996). However, it has been asserted that an implicit condition for continued membership is the tempering of public criticism. This tends to relegate stronger critiques to specialized reporters who work from "outside" the system (Pharr and Krauss, 1996). In the 1960s and 1970s when such control over the media was strongest, the public was rarely privy to updates on the nuclear power expansion program because information on such developments was rarely passed to reporters outside of the reporter clubs. In short, during the initial era of nuclear power expansion in Japan, the combination the LDP's majority lock on parliament and this unique form of media control served to keep the dangers of nuclear power development out of the public eye.

From the conclusion of the Pacific War until the 1970s, a prevailing spirit of self-sacrifice for the benefit of the nation (or one's employer or one's children) dominated Japanese society (Hane, 1992). Unless a project or development caused extreme hardship on a local community or special interest group, civic opposition was often negligible (Hasegawa, 2004). This mentality of self-sacrifice helps to explain how nuclear power became entrenched in a nation which has an understandable historical aversion to nuclear technology. Nuclear energy has consistently been promoted as a necessary evil for supporting economic prosperity. To this day, the government continues to appeal to this sense of pragmatism in its nuclear energy expansion activities (JAEC, 2009). In short, the combination of government control over the information that the media publically disseminated and the dedication of Japan's masses to national revitalization induced a high degree of civic apathy toward nuclear power development.

4. The socio-political economy of nuclear power development in South Korea

4.1. Background

The inception of South Korea's nuclear program can be traced back to March 1956 when the South Korean Ministry of Education established the Atomic Energy Department, and its head Pak Ch'ol Chae convinced the government to support an atomic energy development plan. The following year, South Korea joined the International Atomic Energy Agency and by March 1958, an Atomic Energy Act was passed. The country established an Office of Atomic Energy and an Atomic Energy Research Institute in 1959 to manage a slew of basic research programs extending into the 1960s. Their first research reactor, a Triga Mark 2, began operating in 1962. Their first development plan in 1968 focused on justifying the importance of nuclear energy to South Korea's burgeoning economy while the second development plan released in 1976 quantified ambitions in calling for 22 plants to be established by 2000. Subsequent plans upped the target to 46 plants by 2000, enough to supply 50–80 percent of the country's electricity. By the early 1980s, eight reactors were already under construction.[3]

Since that time, the nuclear industry has fallen short of initial growth projections but it has, nevertheless, grown moderately and the government has created a regulatory framework to enhance development of nuclear power. Currently, 40 percent of the electricity produced in South Korea is created by a network of 20 nuclear reactors constituting slightly more than 17,000 MW of installed capacity (see Appendix B) (Jin, 2007). According to the country's Fifth Long-Term Power Development Plan, the industry is expected to reach 25,000 MW of installed capacity delivered by 28 nuclear plants by 2015. The Ministry of Education, Science & Technology's most recent development plan calls for US$100 billion of additional investment in nuclear infrastructure to ensure the development of at least 40 nuclear reactors by 2035, which will be capable of supplying 60 percent of the country's electricity (Jin, 2007).

4.2. The guiding hand of the government

The government has a longstanding history of strong centrally led economic planning, and it has rationalized nuclear power development for the sake of energy security. The country was a military dictatorship from 1961 to 1987. Notably, Presidents Park

[3] For background on the history of the South Korean nuclear program, see the Korea Atomic Energy Commission, 1968. Long-term plan of research, development and use of nuclear energy (1968–1989); Korea Atomic Energy Research Institute, 1990. A history of Korea Atomic Energy Research Institute (1959–1989) (Taejon: KAERI); and Young-Sun Ha, Nuclear proliferation, world order, and Korea (Seoul: Seoul National University Press, 1983).

Chung Hee, and Chun Doo Hwan exerted strong autocratic (and sometimes ruthless) control over the South Korean economy and society. Nuclear power was heralded for its capacity to wean the nation off imported oil and coal while concurrently sustaining South Korea's seemingly insatiable demand for more energy. A dearth of natural resources created a strategic vulnerability for the nation that crystallized during the oil shocks of the 1970s. Since that time the government has treated energy security as synonymous with nuclear power expansion (Kim and Byrne, 1996). Nuclear power was also embraced for its potential to signal a transition to the rest of the world of South Korea moving from developing to developed nation, from militarily weak to strong. In addition, nuclear power was endorsed due to its capacity to consolidate and extend state authority throughout the industrial economy, in the same way that earlier large-scale rural electrification projects had forced the farming population to depend on the state for essential services. Nuclear technology, put another way, went hand in hand with the twin Korean ideologies of capitalism and political centrism (Kim and Byrne, 1996).

Given the country's political structure under dictatorship at the time, it should come as no surprise that nuclear energy planning was highly centralized. When the Office of Atomic Energy was established in 1959, it was placed directly and solely under the oversight of the office of the president. The military backed coup of 1961 quickly consolidated the three former regional electricity companies—Choson Electric Industries, Kyo;ngsong Electric and Namson Electric—into a national entity, the Korea Electric Company, which later became Korea Electric Power Corporation (KEPCO, now the Korea Hydro and Nuclear Power Corporation). KEPCO was delegated responsibility for construction of nuclear power plants, generation and distribution of nuclear electricity, and all planning, financing, training, licensing, and management of foreign technical assistance related to the nuclear program (Kim and Byrne, 1996).

4.3. The ideological allure of nuclear power

Nuclear energy was ideologically linked with visions of military autonomy and strength, as well as economic competiveness. In particular, the nuclear program was closely aligned with creating an image of military strength. Nuclear technology was coveted not only as an electricity technology that would power the economy, but also for enhancing national defense. Desiring to pre-empt the potential social upheaval and economic disruption of a war with North Korea by a show of strength, government leaders embraced technological development in general and the attainment of nuclear weapons in particular as long-term goals. President Park Chung Hee openly announced ambitions to develop indigenous nuclear weapons to ensure that South Korea possessed a strong military deterrent that was independent from US military protection. President Park established a covert Weapons Exploitation Committee in 1969 to obtain highly enriched uranium and negotiate purchases of advanced nuclear weapons components (Siler, 1998). Efforts to intensify the nuclear weapons program were accelerated in the 1970s when Presidents Richard Nixon and Jimmy Carter called on South Korea to bolster its self-defense capacity and announced plans to reduce America's military presence in South Korea (Kang and Feiveson, 2001). The military dimensions of the nuclear power program were only put on hold after 1976, when the United States, shocked over South Korea's decision to bolster self-defense capacity through nuclear rather than conventional means, threatened to suspend export licenses and credits necessary to acquire American nuclear reactor designs unless it forwent plans for nuclear weapon development (Kim and Byrne, 1996). Thus, for at least two decades, nuclear power production was intertwined with the allure of nuclear weapons, deterrence, and Korean military strength.

Nuclear power was also attached to visions of economic modernization and industrialization. With limited natural resources, key political leaders endorsed cooperation between industry and government and promoted advanced technology as a way to achieve economic growth and international sovereignty. South Korea, strongly influenced by the Korean War and Japanese colonization and further conditioned to create a free-standing electricity system after North Korea abruptly cut off supply in 1948, placed a strong emphasis on achieving energy security amidst expanding demand for energy. Government elites saw nuclear power as central to lifting South Korea out of impoverishment after civil war (Byrne and Hoffman, 1996).

4.4. Achieving socio-political economic harmony

As previously mentioned, the Korean nuclear industry was nurtured under a series of dictators who prevented public dissent (sometimes violently), meaning objection to nuclear power was rare and, when it occurred, ineffective. To quell tides of discontent, dictators justified their actions by appealing to the importance of adopting technologies that could best help the populous escape poverty and provide the nation with enhanced defensive capabilities, appeals that persuaded most members of the public (Byrne and Hoffman, 1996). Even today, although fully democratized, the government remains heavily influenced by bureaucrats and military personnel, operating in a sort of "controlled parliamentary system" characterized by a strong conservative coalition with subdued dissent and opposition (Lee, 1993). For the early parts of its history, the parties involved in nuclear development shielded the program from public scrutiny and sought to bolster support through rhetorical appeals to modernization and technological development. It was not until the late 1980s and early 1990s that a moderately influential anti-nuclear movement emerged after 11 plants reported 193 accidents, a nuclear waste storage crisis became public knowledge, and local not-in-my-back-yard (NIMBY) opposition heightened against nuclear power plants (Lee, 1999).

5. Toward a socio-political economic framework for nuclear power expansion

This section draws from our two cases to explicate a framework that might allow analysts to predict the requisite social, political, and economic conditions necessary to catalyze nuclear power development. Six dominant factors appear to be at the core of support for nuclear power development in each country: (1) strong state involvement in guiding economic development; (2) centralization of national energy policymaking and planning; (3) campaigns to link technological progress with national revitalization; (4) influence of technocratic ideology on policy decisions; (5) subordination of challenges to political authority, and (6) low levels of civic activism.

As Table 1 depicts, each of these elements played a highly influential role in allowing nuclear power to develop in Japan and Korea. In both nations, development of nuclear power technology was driven by government funding and centralized through government research institutions. Although the privatization of Japan's utilities in 1951 delegated operation of power grids to private firms, the government employed legislative mechanisms to maintain control over strategic energy resource planning. Nuclear power technology embellished Japan's modernization efforts and technocratic policymakers saw this new form of energy as a way to give a resource poor country access to a secure energy resource. Finally, nuclear power development was insulated from political

Table 1
A socio-political economy theory of nuclear power.

Factor	Examples
Strong state involvement in economic development	• The Liberal Democratic Party was able to exert almost exclusive control over the Japanese economy and politicians were able to micromanage the country's industrial policy. • South Korea was a military dictatorship during the nascent years of its nuclear program allowing the government to control the policy agenda.
Centralization of national energy planning	• In Japan, energy policy was consolidated at the national level and nuclear electricity generation was initially approved for only three utilities, Tokyo, Kansai and Chubu. • In South Korea, the Office of Atomic Energy was placed directly under the President and the nuclear program was structured as a monopoly under the Korea Electric Power Corporation.
Campaigns to link technological progress to national revitalization	• Japanese policymakers perceived nuclear power as an essential component of an independent, energy-secure, economically competitive nation. • South Korean policymakers believed nuclear power presented an allure of military strength and was essential to economic development.
Influence of technocratic ideology on policy decisions	• In Japan, a technocratic ideology of employing new technologies to maximize labor productivity to offset competitive disadvantages in resource availability existed. • In South Korea, confidence existed that Korean engineers and scientists could perfect new and better indigenous reactors and develop technologies to control the entire fuel cycle thereby giving the nation a degree of technologically induced security.
Subordination of challenges to political authority	• Hegemony of the LDP, frequently shuffled cabinet positions and tight government control over the media diluted political and popular opposition to nuclear power development in Japan. • In South Korea bureaucrats supported by the power of the military operated a "controlled parliamentary system" which rendered any challenge to nuclear development plans ineffective.
Low levels of civic activism	• A prevalent ideology of self-sacrifice which placed economic growth above all other outcomes produced a high degree of apathy toward risky technological developments such as nuclear power in Japan. • Opposition to nuclear power in South Korea was constrained by the country's strong bureaucracy centered political system.

challenge by the sheer dominance of the LDP and its control over media critique. Civic opposition was also non-invasive during Japan's rise to economic prominence due to a pervasive mentality of self-sacrifice dedicated toward rebuilding a war-torn nation.

Similarly, in South Korea, a military dictatorship and centralization of the electricity supply enabled policymakers to closely monitor and control nuclear activity. Concerns over maintaining industrial competitiveness and a desire to thwart the threat of North Korean military aggression perpetuated an appeal of nuclear energy as key to the country's continued prosperity and security. National pride in advanced engineering and scientific developments, a parliamentary system which prevented effective political oversight, and faith in bureaucracy have also prompted technocratic values and constrained challenges to political authority and activism in South Korea.

What do these six factors mean for the future of nuclear power in Japan and Korea, readers may ask? Although more than 40 years have passed since Japan's nuclear power program commenced, little has changed in regard to the six elements conducive to nuclear power expansion. The government's heavy hand in guiding industrial policy remains firmly on the rudder of the national economy despite a recent change in the governing regime. Moreover, not only does centralized government control over energy policy still exist, it has been largely fortified by pressures to achieve CO_2 emission reductions to adhere to Kyoto Protocol commitments. As Japan attempts to rebound from the second economic recession in a decade, the role of technology in revitalizing the economy is as crucial today as it was in the 1960s. Moreover, the technocratic ideology which supported nuclear power expansion in the 1960s now exists in a more formal, well-funded form, the New Energy and Industrial Technology Development Organization (NEDO). The government further centralized the nuclear sector in 2005, when they created the Japan Atomic Energy Agency to enable the government to better control nuclear research occurring at government think-tanks—the Japan Atomic Energy Research Institute and the Japan Nuclear Cycle Development Institute (Chanlett-Avery and Nikitin, 2009). Finally, the mechanisms described earlier for tempering challenges to political authority still exist in enhanced forms in Japan.

The only development of significance in regard to the socio-political economy of nuclear power development in Japan is an increase in civic activism which was recently empowered through new legislation. A Public Information Act was enacted in 1999 out of concern over lack of transparency regarding government activities. Nuclear mishaps in the 1990s which included a sodium leak at a Monju reactor in 1995, an explosion at a nuclear waste reprocessing unit in 1997 and a criticality incident at a nuclear fuel fabrication facility played a significant role in the promulgation of this law. Now, all nuclear electricity suppliers in Japan are required to make public the quantity of stored plutonium and a plutonium use plan for each year. Furthermore, all of Japan's facilities are now subject to stringent IAEA safeguards (Chanlett-Avery and Nikitin, 2009). To what extent improved access to information on Japan's nuclear program will influence civic activism is uncertain but the potential for amplified activism exists. Japanese society is rapidly aging; and as a result, the population base is increasingly dominated by elderly citizens who hold ideals which extend beyond economic pursuits and who have time on their hands for participating in activist activities.

Over the past decade, social concern over environmental governance has increased markedly. While there has always been a degree of reverence for the environment stemming in large part from tenets of Japan's indigenous religion, Shinto which attributes spiritual properties to environmental endowments, economic development pressures tended to overshadow all else during Japan's rise to economic prominence (Hane, 1992). The

sacrosanct Japanese perspective on the environment was severely put to the test in the 1960s and 1970s when unfettered economic development severely impinged on environmental salubrity (Barrett, 2005). The proliferation of cases involving arsenic poisoning, mercury poisoning (Minamata disease), semi-acute spinal and optical nervous disorders and hexavalent chromium diseases inspired civil litigation and protest (Tsuru, 2000). Increasingly, Japanese citizens are less inclined to accept developments which impinge on environmental or aesthetic enjoyment (Hasegawa, 2004). Perhaps as precursor of the evolution of civic activism, public pressure following media coverage of falsified safety inspection records played a role in forcing the government to shut down the Kashiwazaki-Kariwa plant in July 2007. When it comes to the issue of nuclear power expansion, one cannot help but think that Japan is one nuclear mishap away from fueling massive public opposition toward further expansion plans.

In South Korea, government control over the nuclear power agenda is a bit more unstable, with environmental groups and the public beginning to challenge the government's plan for nuclear expansion. While the government continues to try and discourage public participation in nuclear power planning by maintaining a veil of secrecy and refusing to release information to inquisitive environmental groups (Kim, 2009), there is some evidence that control is starting to erode. In the past few years, environmental groups have begun to publically and legally challenge the lack of transparency associated with the nuclear power program (Watts, 2009).

That said, the anti-nuclear movement's capacity to actually prevent nuclear expansion is still subordinate to government aspirations. Korea is still an "immature democracy" with a strong bureaucracy-centered political system accustomed to authoritarian policymaking. The anti-nuclear movement has stopped occasional plans for waste facilities, but it has had little success in shutting down existing plants or inhibiting development of new nuclear power plants. In recent years the nuclear industry has taken a pro-environmental posture to deflect and diffuse criticism, a stance picked up by the Korean media, and the environmental threats posed by nuclear power are overshadowed by numerous other environmental problems including the contamination of Siwha Lake, unexplained illnesses at petrochemical industrial complexes, dead fish in major rivers, and air pollution in Seoul (Watts, 2009).

Furthermore, amidst the recent period of wildly fluctuating prices for fossil fuel energy resources, challenges are counterbalanced by the revitalized appeal of nuclear power as an important element to continued economic prosperity and improved national energy security. In fact, nuclear power technology is now seen as a viable and attractive export industry. The Korea Hydro and Nuclear Corporation has recently been marketing its "Optimized Power Reactor" in developing countries such as Indonesia and Vietnam, and the company has signed agreements with Indonesia's PLN for a feasibility study for that country's first nuclear power plant (World Nuclear Association, 2009). Taken to an extreme, some scientists even fantasize about South Korea serving as the inter-connected hub of nuclear electricity supply for all of Asia including not only China and Japan but also Russia (Lee et al., 2004).

6. Conclusions and limitations

Based on a historical analysis of nuclear power programs in Japan and Korea, and adhering to the notion that all new technological regimes are supported by a socio-technical web that aligns social, economic, political, technical, and cultural factors, this article has proposed a framework of nuclear socio-political economy involving six factors that are conducive to the expansion of nuclear energy. These factors are: (1) strong state involvement in guiding economic development; (2) centralization of national energy policymaking and planning; (3) campaigns to link technological progress with national revitalization; (4) influence of technocratic ideology on policy decisions; (5) subordination of challenges to political authority, and (6) low levels of civic activism.

The intricacies involved in developing a framework of socio-political economy for a complex industry renders initial attempts prone to a number of challenges related to predictive validity. Clearly much more research is required in order to arrive at a stage of theoretical development that would enable analysts to apply the socio-political economic framework with a degree of confidence in diverse settings. The main limitation to the emergent framework developed in this paper relates to its external validity. Simply put, are the socio-political economic characteristics attributed to supporting nuclear power development in Japan and Korea evident and equally influential in all nations that have established strident nuclear power programs? The only way to answer this question is to extend the analysis to other nations which have exhibited strident support for nuclear power programs.

There also remains a number of intriguing questions relating to what goes on in nations which Fig. 1 refers to as "ideologically untethered nations". For nations that would be classified as either ideologically opposed to nuclear power or ideologically supportive of nuclear power, there is a clear sense of technological "lock-in" (Ahman and Nilsson, 2008) associated with national nuclear development policies. Consequently, one could argue convincingly that a high degree of path dependency insulates such technological regimes from change (Arthur, 1994). However, for these "ideologically untethered nations", which at different stages of national development alternate between support for and opposition to nuclear power, there is a high degree of uncertainty regarding what causes this phenomenon of extreme policy fluctuation. To investigate this phenomenon, further research is necessary wherein the six socio-political economic factors identified in this work are used to examine the developmental trends within "ideologically untethered nations" in order to identify whether or not changes occurring within in these six realms are responsible for catalyzing these ideological shifts in policy.

Finally, space limitations have prevented adequate investigation into the relative strengths of influence exhibited by the six socio-political economic factors outlined in this article. Clearly, quantitative methodologies need to be applied in order to attempt to quantitatively determine causal power. Furthermore, if certain criteria are more influential in stimulating nations to support nuclear power development programs, it is incumbent on the research community to seek to establish whether or not the same magnitude of influence exists in regard to the six socio-political economic factors across diverse national platforms.

Still, we contend that extending research on the socio-political economy of nuclear energy merits adoption because by extending such an analysis to a comprehensive investigation of all nations, we can gain a better understanding of the future of nuclear power development on a global scale. In doing so, one can begin to predict the economic, environmental and security implications associated with an evolving world order in nuclear power development. Accordingly, in spite of the limitations of our theory, the socio-political economic framework for supporting nuclear power development represents a necessary step forward in better understanding the conditions under which nuclear power surges and ebbs in nuclear capable nations.

Appendix A

See Table A1.

Table A1
Existing Japanese nuclear power plants.

Name	Prefecture	Date commenced	Date operational	Units	Capacity (MW)	Type	Supplier	Operator
Tomari 1	Hokkaido	1984	1989	1	579	PWR	Mitsubishi	Hokkaido
Tomari 2	Hokkaido	NA	1991	1	579	PWR	Mitsubishi	Hokkaido
Higashi-Dori	Aomori	1998	2005	1	1100	BWR	Toshiba	Tohoku
Onagawa 1	Miyagi	1970	1984	1	524	BWR	Toshiba	Tohoku
Onagawa 2	Miyagi	NA	1995	1	825	BWR	Toshiba	Tohoku
Onagawa 3	Miyagi	NA	2002	1	825	BWR	Toshiba/Hitachi	Tohoku
Fukushima Daiichi 1	Fukushima	1967	1971	1	460	BWR	GE	Tokyo
Fukushima Daiichi 2	Fukushima	1969	1974	1	784	BWR	GE/Toshiba	Tokyo
Fukushima Daiichi 3	Fukushima	1970	1976	1	784	BWR	Toshiba	Tokyo
Fukushima Daiichi 4	Fukushima	1972	1978	1	784	BWR	Hitachi	Tokyo
Fukushima Daiichi 5	Fukushima	1971	1978	1	784	BWR	Toshiba	Tokyo
Fukushima Daiichi 6	Fukushima	1973	1979	1	1100	BWR	GE/Toshiba	Tokyo
Fukushima Daini 1	Fukushima	1975	1982	1	1100	BWR	Toshiba	Tokyo
Fukushima Daini 2	Fukushima	1979	1984	1	1100	BWR	Hitachi	Tokyo
Fukushima Daini 3	Fukushima	1980	1985	1	1100	BWR	Toshiba	Tokyo
Fukushima Daini 4	Fukushima	1980	1987	1	1100	BWR	Hitachi	Tokyo
Kashiwazaki Kariwa 1	Niigata	1978	1985	1	1100	BWR	Toshiba	Tokyo
Kashiwazaki Kariwa 2	Niigata	1983	1990	1	1100	BWR	Toshiba	Tokyo
Kashiwazaki Kariwa 3	Niigata	1987	1993	1	1100	BWR	Toshiba	Tokyo
Kashiwazaki Kariwa 4	Niigata	1988	1994	1	1100	BWR	Hitachi	Tokyo
Kashiwazaki Kariwa 5	Niigata	1983	1990	1	1100	BWR	Hitachi	Tokyo
Kashiwazaki Kariwa 6	Niigata	1991	1996	1	1356	ABWR	GE/Toshiba/Hitachi	Tokyo
Kashiwazaki Kariwa 7	Niigata	1992	1997	1	1356	ABWR	GE/Toshiba/Hitachi	Tokyo
Hamaoka 1	Shizuoka	1971	1976	1	540	BWR	Toshiba	Chubu
Hamaoka 2	Shizuoka	1974	1978	1	840	BWR	Toshiba	Chubu
Hamaoka 3	Shizuoka	1983	1987	1	1100	BWR	Toshiba	Chubu
Hamaoka 4	Shizuoka	1989	1993	1	1137	BWR	Toshiba	Chubu
Hamaoka 5	Shizuoka	2000	2005	1	1267	ABWR	Toshiba	Chubu
Shika 1	Ishikawa	1988	1993	1	540	BWR	Mitsubishi	Hokuriku
Shika 2	Ishikawa	1999	2006	1	1358	ABWR	Hitachi	Hokuriku
Mihama 1	Fukui	1967	1970	1	340	PWR	Westinghouse	Kansai
Mihama 2	Fukui	1968	1972	1	500	PWR	Westinghouse/Mitsubishi	Kansai
Mihama 3	Fukui	1972	1976	1	826	PWR	Mitsubishi	Kansai
Takahama 1	Fukui	NA	1974	1	826	PWR	Westinghouse	Kansai
Takahama 2	Fukui	NA	1975	1	826	PWR	Mitsubishi	Kansai
Takahama 3	Fukui	NA	1985	1	870	PWR	Mitsubishi	Kansai
Takahama 4	Fukui	NA	1985	1	870	PWR	Mitsubishi	Kansai
Ohi 1	Fukui	1970	1979	1	1175	PWR	Westinghouse	Kansai
Ohi 2	Fukui	NA	1979	1	1175	PWR	Westinghouse	Kansai
Ohi 3	Fukui	NA	1991	1	1180	PWR	Mitsubishi	Kansai
Ohi 4	Fukui	NA	1993	1	1180	PWR	Mitsubishi	Kansai
Shimane 1	Shimane	1967	1974	1	460	BWR	Hitachi	Chugoku
Shimane 2	Shimane	NA	1989	1	820	BWR	Hitachi	Chugoku
Ikata 1	Ehime	1971	1977	1	566	PWR	Mitsubishi	Shikoku
Ikata 2	Ehime	NA	1982	1	566	PWR	Mitsubishi	Shikoku
Ikata 3	Ehime	NA	1994	1	890	PWR	Mitsubishi/Westinghouse	Shikoku
Genkai 1	Saga	1970	1975	1	559	PWR	Mitsubishi	Kyushu
Genkai 2	Saga	NA	1981	1	559	PWR	Mitsubishi	Kyushu
Genkai 3	Saga	NA	1994	1	1180	PWR	Mitsubishi	Kyushu
Genkai 4	Saga	NA	1997	1	1180	PWR	Mitsubishi	Kyushu
Sendai 1	Kagoshima	1975	1984	1	890	PWR	Mitsubishi	Kyushu
Sendai 2	Kagoshima	NA	1985	1	890	PWR	Mitsubishi	Kyushu
Tokai Daini	Ibaraki	1973	1978	1	1100	BWR	GE	JAPC
Tsuruga 1	Fukui	1966	1970	1	357	BWR	GE	JAPC
Tsuruga 2	Fukui	1982	1987	1	1160	PWR	Mitsubishi	JAPC

Note on "Type" column: PWR=pressurized water reactor, BWR=boiling water reactor, ABWR=advanced boiling water reactor. Note on "Operator" column: JAPC=Japan Atomic Power Corporation.

Table B1
Existing South Korean nuclear power plants.

Name	Location	Date commenced	Date operational	Units	Capacity (MW)	Type	Supplier	Operator
Kori Nuclear Power Plant	Gori, Busan	1972	1978, 1983, 1985, 1986	4	3075	Pressurized water reactor	Westinghouse (United States) and General Electric (United States)	Korea Hydro and Nuclear Power Corporation
Ulchin Nuclear Power Plant	Uljin-gun, Gyeongbuk	1983	1988, 1989, 1998, 1999	6	5900	Pressurized water reactor/ Korean standard nuclear plant	Framatome (France), Bechtel (United States), and Korea Heavy Industries and Construction (South Korea)	Korea Hydro and Nuclear Power Corporation

Table B1 (*continued*)

Name	Location	Date commenced	Date operational	Units	Capacity (MW)	Type	Supplier	Operator
Wolsong Nuclear Power Plant	Gyeongju, North Gyeongsang	1972	1983, 1997, 1998, 1999	4	2579	CANDU	Atomic Energy Canada Limited (Canada)	Korea Hydro and Nuclear Power Corporation
Yonggwang Nuclear Power Plant	Yonggwang, South Jeolla	1979	1986, 1987, 1995, 1996, 2002	6	5900	Pressurized water reactor/ Korean standard nuclear plant/ System 80 advanced pressurized water reactor	Korea heavy industries and construction (South Korea)	Korea Hydro and Nuclear Power Corporation

Appendix B

See Table B1.

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