



PUBLIC ACCEPTANCE OF NUCLEAR ENERGY: INTERNATIONAL COMPARATIVE PERSPECTIVE

19TH INPRO DIALOGUE FORUM

DEC. 7. 2021

PROF. WONJOON KIM

HEAD, GRADUATE SCHOOL OF INNOVATION AND TECHNOLOGY MANAGEMENT

KAIST

OVERVIEW

- **Key findings to consider in Nuclear Public Acceptance (NPA) Policy**
 - A country's accumulated social acceptance of nuclear energy is important
 - County dependent factors, such as geography, history, and environment significantly moderate the NPA differently
 - Fukushima Nuclear disaster has changed NPA significantly, but not as much as Chernobyl
 - Integrated Model of Nuclear Energy Development is important
 - NPA Policy – Energy Mix Policy - Nuclear Power Development Policy

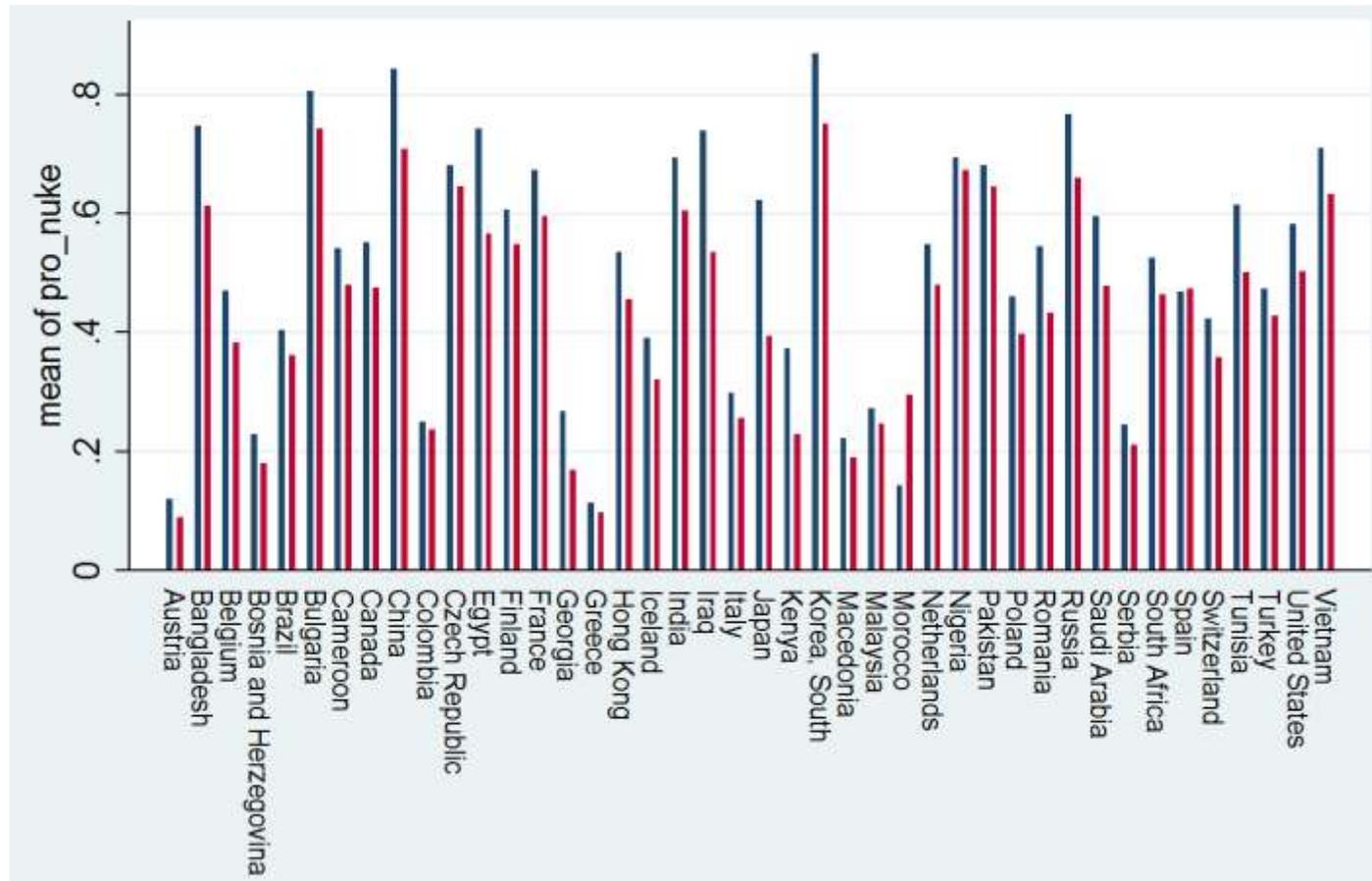
PURPOSE OF THE STUDY

■ Purpose of the Study

- Understand how this nuclear disaster has changed public attitudes toward nuclear power in different countries before they revise existing nuclear policies
- Examines critical factors that affected public acceptance of nuclear energy by closely examining changes in public opinion in 42 countries after the Fukushima accident
- To understand in what way a historical disaster such as the Fukushima accident affects public acceptance of nuclear energy
 - Findings will enable governments to establish comprehensive and rational nuclear policies rather than ad-hoc and spontaneous responses.

EFFECT OF FUKUSHIMA ACCIDENT ON NPA

■ Effect of Fukushima Accident on Nuclear Public Acceptance



*Blue bar and red bar in the graph represents the public acceptance rate before and after Fukushima accident, respectively.

NUCLEAR ACCIDENT AND NUCLEAR PUBLIC ACCEPTANCE

■ Direct and Indirect Effect of Nuclear Accident

■ Direct Effects

- Damages from Radioactive materials

■ Indirect Effects

■ Stigma Effects

- Although nuclear accidents are rare, they produce severe damage and therefore generate a strong signal that there is an unusual risk in nuclear power generation (Slovic, 1987).
- This signal helps to perpetuate a negative image or stigmatization of nuclear energy (Gregory et al., 1995).

NUCLEAR ACCIDENT AND NUCLEAR PUBLIC ACCEPTANCE

- **Heterogeneous Stigma Effects of Nuclear Accidents**
 - **Proximity Effects**
 - An inverse relationship between distance from an accident site and the level of public acceptance.
 - The closer an area is to the site of an accident, the lower public acceptance is for the source of the accident (Rosa and Dunlap, 1994)
 - **Distance Effects:**
 - People farther away from the site of an accident have less information about it, and this may amplify their fears and reduce their acceptance of nuclear energy (Coval and Moskowitz, 1999; Garmaise and Moskowitz, 1999; Grinblatt and Keloharju, 2001)

NUCLEAR ACCIDENT AND NUCLEAR PUBLIC ACCEPTANCE

■ Other Effects of Nuclear Accidents

- Country's Dependency on Nuclear Energy
 - Whether nuclear power reactors are in operation
 - The proportion of nuclear power reactors in operation
 - The proportion of the country's entire electrical supply that is generated by nuclear power
- Country's Media Environment
 - If the media have a high level of independence from the government, they can deliver accurate information about the potential risks of nuclear energy and damages from a nuclear accident in a timely manner

DATA

- **Data**

- Global Snap Poll
- March 21 to April 10, 2011
- 47 countries

- **Measures (Dependent Variables)**

- Public Acceptance of Nuclear energy before and after the Fukushima nuclear accident

METHODS

- **Method**

- **Logistic Model**

$$\text{logit}(p_{irt}) = \log\left(\frac{p_{irt}}{1-p_{irt}}\right) = \alpha_1 + X_{1r}\beta_1 + Z_i\gamma_1 \\ + F_t(\alpha_2 + X_{1r}\beta_2 + D_r X_{2r}\lambda + Z_i\gamma_2)$$

- The logit probability p_{irt} that person i of country r supports the use of nuclear energy at time t (t =before and after the earthquake and tsunami in Japan)

MEASURES

■ Measures (Independent Variables)

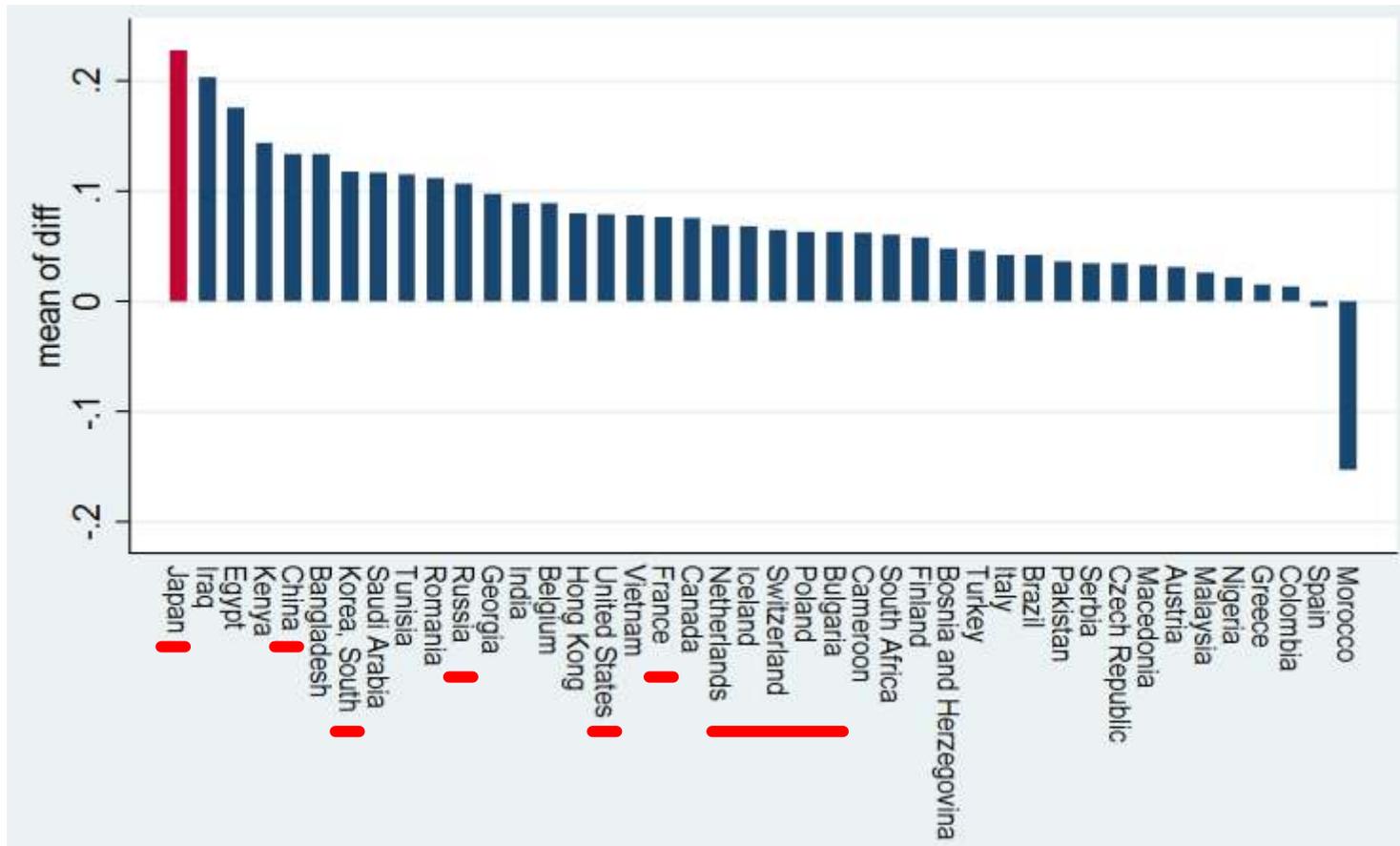
Variables	Description	Year	Unit	Source
pro_nuke	Individual acceptance of the use of nuclear energy to provide electricity for the world before and after Fukushima accident (Individual level), Strongly and somewhat favor: 1; Strongly and somewhat oppose: 0	2011	Binary	ICPSR ^a
distance	Natural log of distance as the crow flies from Fukushima power plants to the capital of each country (national level)	-	km	Free Map Tools ^b
binnpr	Whether or not nuclear power reactors are operated (national level)	2010	Binary	IAEA ^c
num_npr_area	Number of nuclear power reactors in operation in 100,000 sq. km of national surface area (national level)	2010	Number	IAEA, World Bank
per_npg	Proportion of nuclear power generation in the entire nation's power supply (national level)	2009	Percentage	IAEA
toe	Natural log of total operating experience of nuclear power generation in history (including shutdown nuclear power reactors) (national level)	~2010	Year	IAEA
pol	Freedom of the press in political environment (Political pressures and controls on media content, 0 indicates more freedom) (national level)	2011	0-40 scale	Freedom House ^e
earthquake	Number of significant earthquakes (the earthquakes that caused moderate damage (approximately \$1 million or more), 10 or more deaths, Modified Mercalli Intensity X or greater, the earthquakes generated a tsunami among the earthquakes whose magnitude are 6.0 or greater, or earthquakes whose magnitude are 7.5 or greater) happened over the last 30 years (national level)	1981	~2010	Number
USGS ^d				
accident	Number of nuclear power station accidents and incidents since 1952 (national level)	2011	Number	IAEA
GDP	Natural log of per capita GDP at current prices in US dollars (national average)	2010	Dollars	World Bank
male	= 1 if so, otherwise coded 0 (individual level)	2011	Binary	ICPSR
age	Age (individual level)	2011	Year	ICPSR
income	Level of monthly household income (individual level), Bottom and second quintile: low_income; Third quintile: mid_income; Top and fourth quintile: high_income	2011	Categorical (2 binary)	ICPSR
education	Level of educational attainment (individual level), No education/only basic education: low_edu; Secondary school: mid_edu; High level education (e.g. university): high_edu	2011	Categorical (2 binary)	ICPSR

RESULTS

Variables	Public Acceptance (pro_nuke)			
	Model 1	Model 2	Model 3	Model 4
<i>Original effect</i>				
Intrinsic preference for nuclear energy	-0.837**	-0.837**	-0.837**	-0.837**
binnpr	0.656**	0.656**	0.656**	0.656**
num_npr_area	0.019**	0.019**	0.019**	0.019**
per_npg	1.141**	1.152**	1.153**	1.140**
toe	0.047**	0.047**	0.047**	0.047**
pol	0.025**	0.025**	0.025**	0.025**
earthquake	0.006**	0.006**	0.006**	0.006**
accident	0.011	0.010	0.011	0.011
GDP	-0.244**	-0.244**	-0.244**	-0.244**
male	0.528**	0.528**	0.528**	0.528**
age	-0.002*	-0.002*	-0.002*	-0.002*
mid_income	0.224**	0.225**	0.225**	0.225**
high_income	0.528**	0.529**	0.529**	0.529**
mid_edu	0.027	0.025	0.026	0.025
high_edu	0.148**	0.146**	0.146**	0.146**
<i>Fukushima effect(Interactions)</i>				
after_tsunami (main effect)	-0.261**	-0.277**	-0.267**	-0.263**
distance	-0.625**	-0.634**	-0.664**	-0.620**
binnpr	0.157	0.174	0.186*	0.164
num_npr_area	-0.046**	-0.053**	-0.051**	-0.047**
per_npg	0.380*	0.467**	0.469**	0.423**
toe	-0.058**	-0.063**	-0.061**	-0.058**
pol	-0.008*	-0.008**	-0.008*	-0.007*
earthquake	-0.017**	-0.019**	-0.014**	-0.015**
accident	0.134**	0.162**	0.124**	0.118**
GDP	0.049*	0.048*	0.050*	0.052*
male	0.047	0.046	0.043**	0.047*
age	-0.002	-0.002	-0.002	-0.002
mid_income	-0.149**	-0.143**	-0.143**	-0.150**
high_income	-0.148**	-0.144**	-0.142**	-0.150**
mid_edu	-0.013	-0.008	-0.012	-0.011
high_edu	-0.046	-0.050*	-0.045	-0.041
toe*distance		-0.042**		
pol*distance			0.015**	
earthquake*distance				0.003
Log-Likelihood	-31,024.338	-31,020.483	-31,018.021	-31,023.753
BIC	62,383.534	62,386.625	62,381.701	62,393.165

RESULTS

■ Effect of Fukushima Accident on Nuclear Public Acceptance



* Positive value of 'mean of diff' means that the public acceptance rate after Fukushima accident is smaller than before.

RESULTS

- **Fukushima Effects on NPA of Countries – Distance Effects**
 - The distance effect was greater than the proximity effect on public acceptance of nuclear energy after the Fukushima accident (Assefa and Frostell, 2007)
 - Public concern and fear increased with greater distance from the site
- **Fukushima Effects on NPA of Countries – Nuclear Energy Experience**
 - The greater the experience of nuclear power generation, the higher the public acceptance of nuclear energy
 - Distance from the Fukushima accident site strengthens the negative effect of the operational experience of nuclear power generation on NPA after the accident

RESULTS

- **Fukushima Effects on NPA of Countries – Nuclear Energy Experience**
 - The greater the experience of nuclear power generation, the higher the public acceptance of nuclear energy.
- **Fukushima Effects on NPA of Countries – Density of Nuclear Power Reactor**
 - NPA sharply decreased after the accident in countries with a high density of nuclear power reactors
 - Operational experience of nuclear power generation does not lessens the decrease

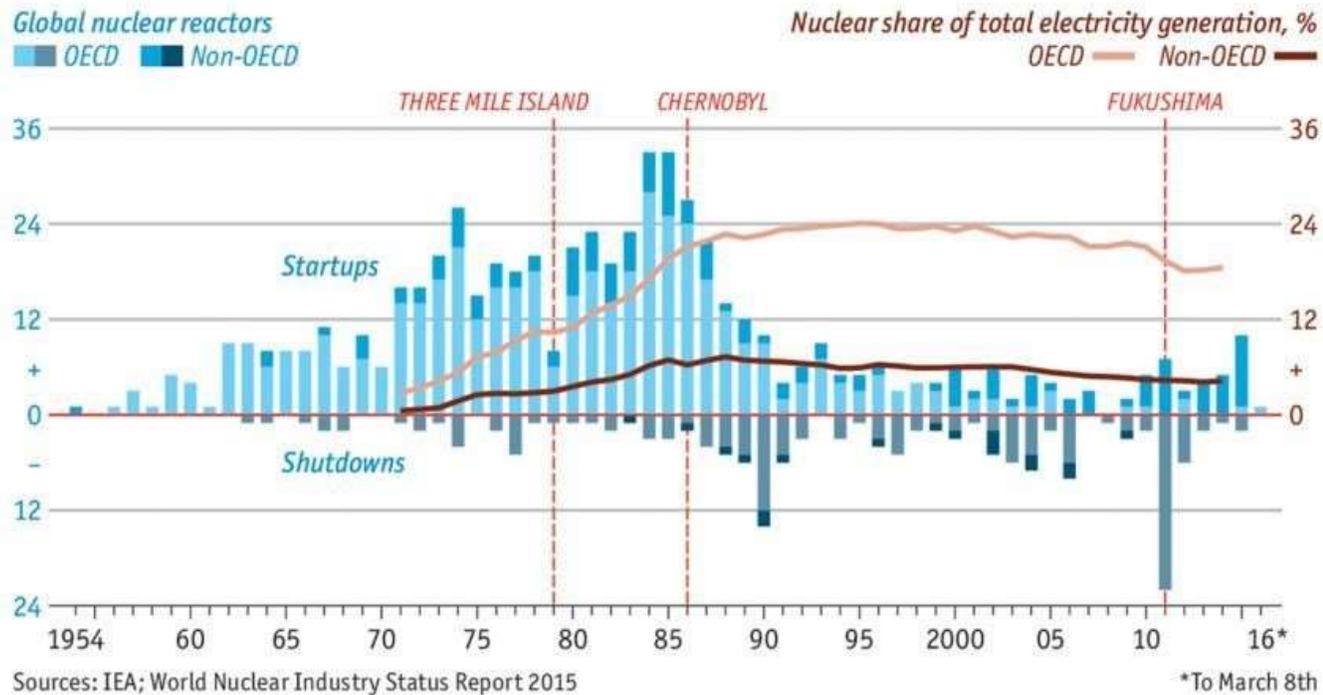
RESULTS

- **Fukushima Effects on NPA of Countries – Media Environments**
 - Political pressure on and control of media content contributed to a further decrease in public acceptance of nuclear energy after the Fukushima nuclear accident
 - If the media loses credibility, this can also magnify the concern of the public and reduce public acceptance of nuclear energy
- **Fukushima Effects on NPA of Countries – Experience of Nuclear Power Accidents**
 - The number of nuclear power station accidents and incidents has no significant relationship with public acceptance of nuclear energy
 - While the number of significant earthquakes is positively related to public acceptance

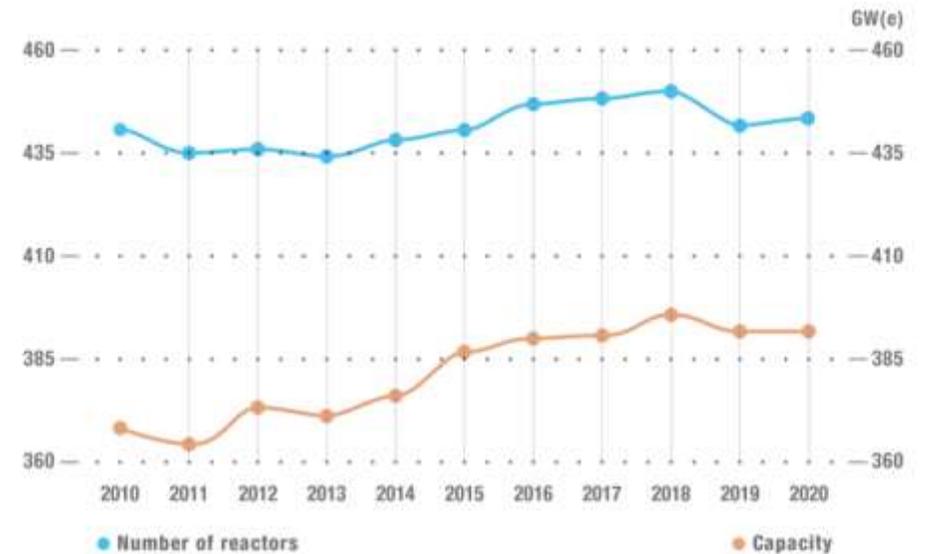
EFFECT OF FUKUSHIMA ACCIDENT ON GLOBAL NUCLEAR REACTOR

- Global Nuclear Reactors before and after Fukushima, Chernobyl, Three Miles Island

Meltdown

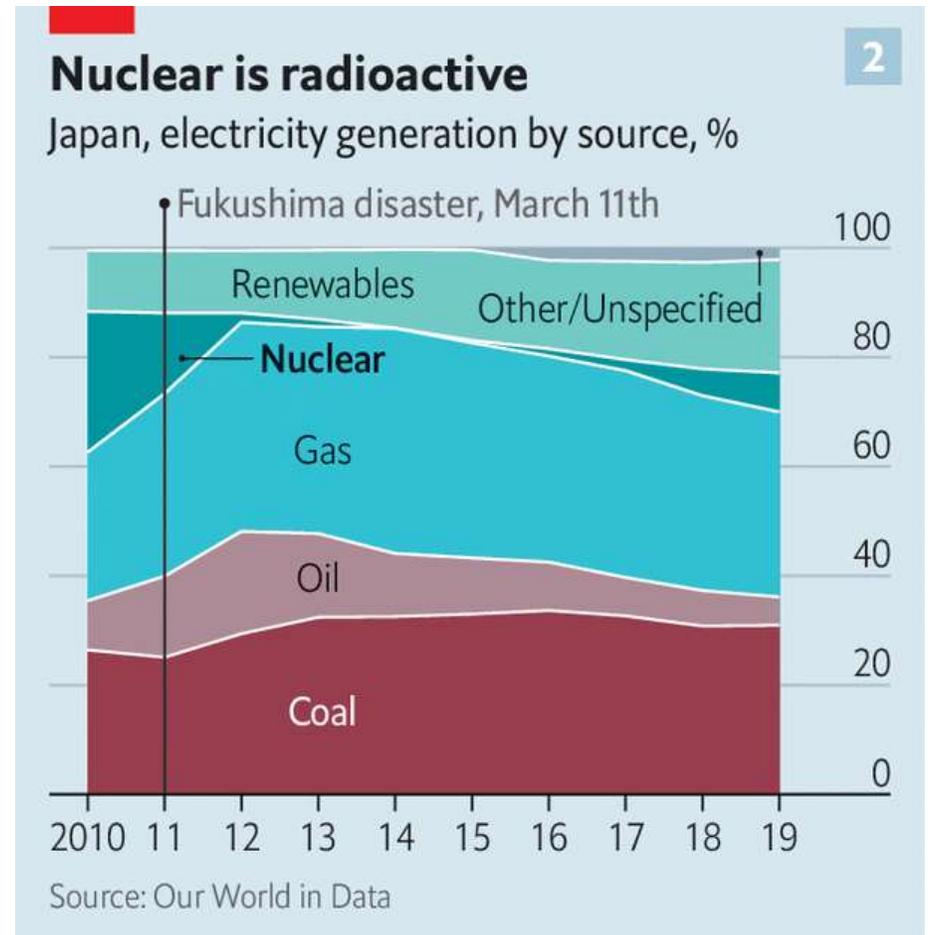


NUCLEAR POWER CAPACITY TREND



EFFECT OF FUKUSHIMA ACCIDENT ON JAPAN'S ENERGY MIX

- The Fukushima disaster was not the turning point
- Nuclear is coming back and it is back on track again

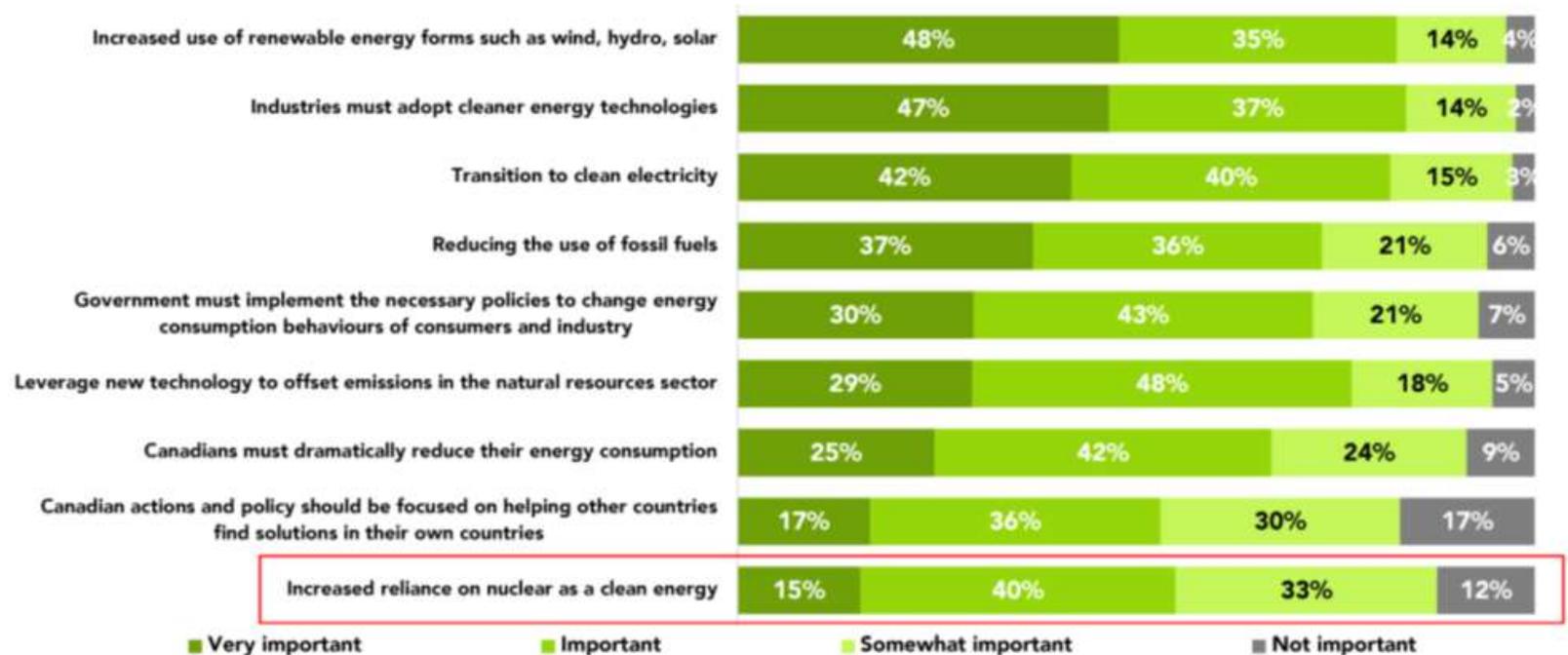


The Economist

CLIMATE CHANGE AND NUCLEAR ENERGY

- Not high priority, but an important alternative

IMPORTANCE OF SOLUTIONS TO CLIMATE CHANGE



When it comes to climate change, how important are these possible solutions to addressing climate change?

ABACUS DATA

2020 study from the Canadian Nuclear Association

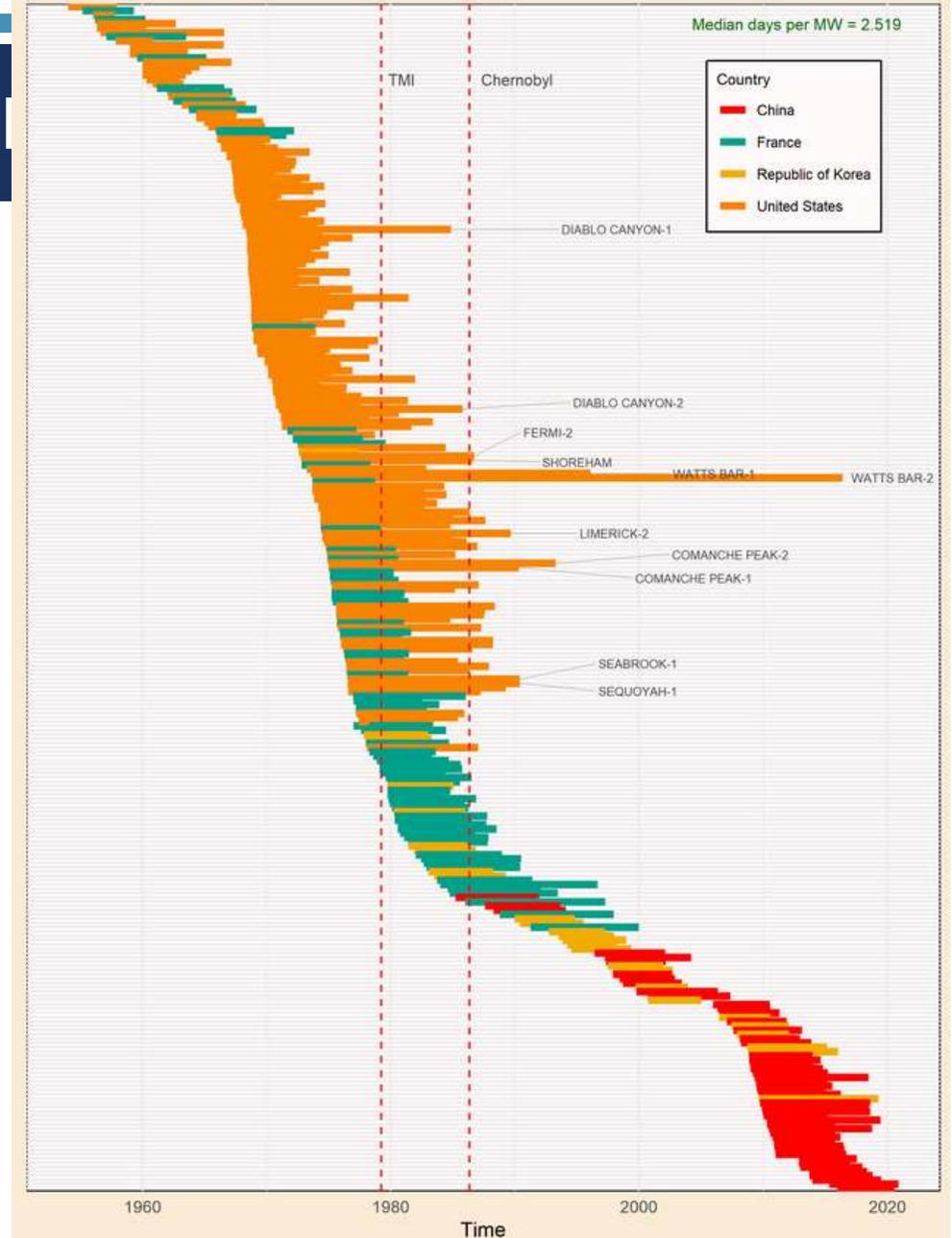
EFFECT OF FUKUSHIMA ACCIDENT ON

- Fukushima made the construction of nuclear power plants delayed or abandoned
- But, China keep pushing it

Nuclear reactor constructions

Nuclear Reactor Construction (first concrete to grid connection)

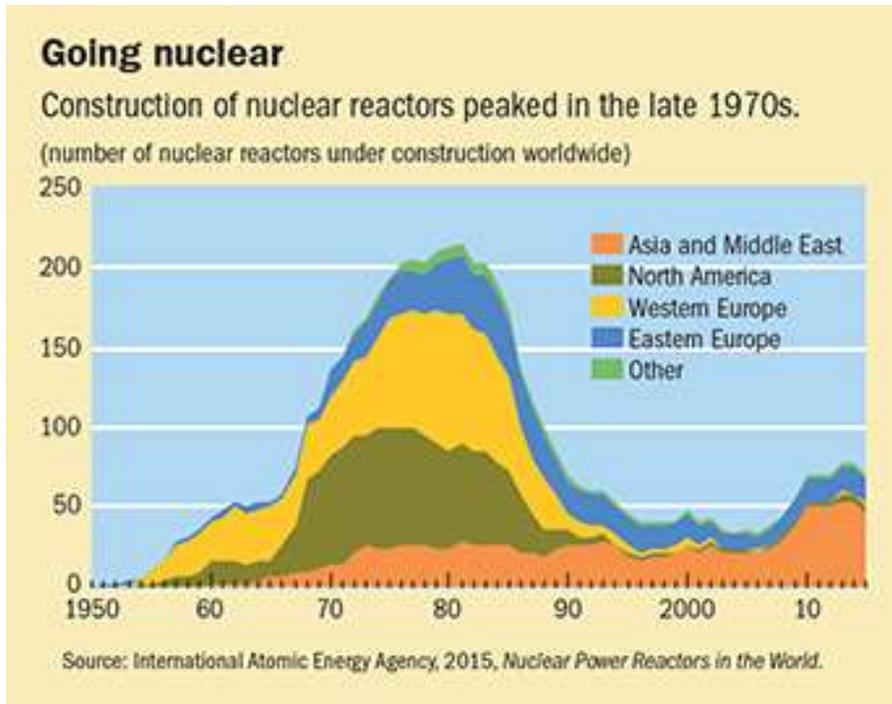
Labelled reactors took longer than 5,000 days, sorted by first concrete, TMI = Three Mile Island



Dataviz: @GrantChalmers | Source: <https://pris.iaea.org>

EFFECT OF FUKUSHIMA ACCIDENT

- Construction of most nuclear-power reactors is behind schedule



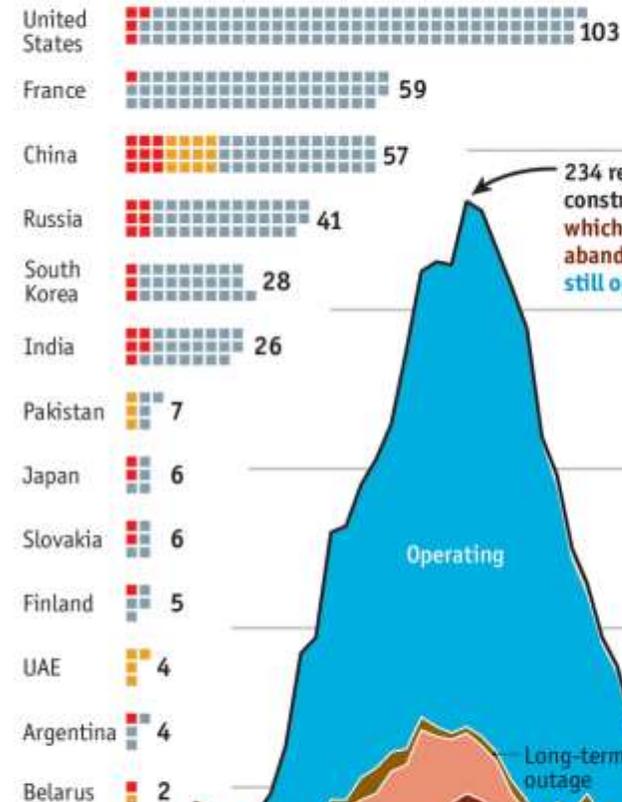
Nuclear reactors under construction

Current situation, January 1st 2017

By location

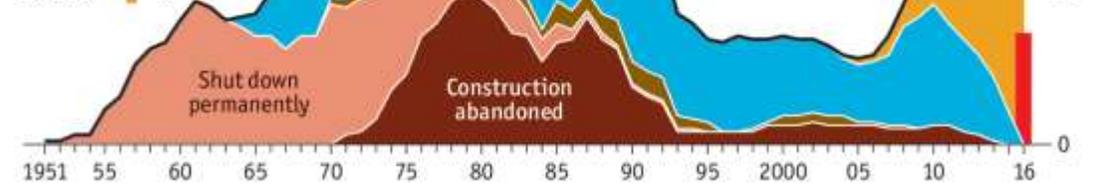
Under construction* In operation

of which: behind schedule



234 reactors were under construction in 1979, of which 48 were later abandoned and 165 are still operating

Of the 55 reactors currently under construction 35 are behind schedule



Source: World Nuclear Industry Status Report, Global Nuclear Power Database, January 2017

*Only countries with active construction projects

DISCUSSION

- **Considering country's unique technological, industrial, and safety status regarding nuclear energy is important for NPA policy**
 - **Credibility for Media and Government is important**
 - **Density and experience of nuclear energy is also important**
- **Fukushima Nuclear disaster has changed NPA significantly, but not as much as Chernobyl**
- **It seems there is tension between the needs and the concerns for Nuclear Energy currently**



Thank you