

# Uranium and Nuclear Power: Past, Present and Future

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# Déjà vu All Over Again

- ▶ At end of WWII, US government wanted to encourage new uranium industry
- ▶ various incentives, including strong price signals
- ▶ that era ended in mid-1960s, whence nuclear power industry took root
- ▶ strong growth in uranium market followed, up to Three Mile Island incident (28 March, 1979)
  - ▷ conventional wisdom: TMI sealed Nuclear power's fate
    - no new Nuclear plant built from that date forward\*
  - ▷ “beginning of the end” for Nuclear power?

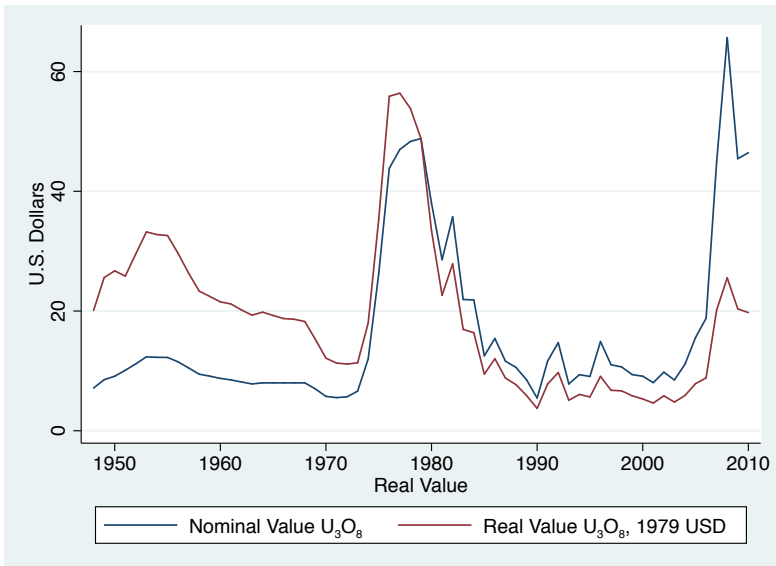
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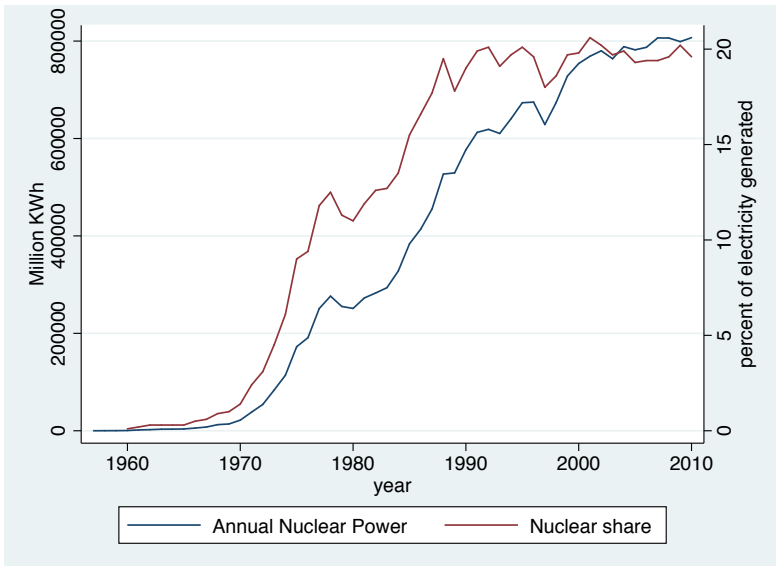
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- ▶ fast-forward ... to 21<sup>st</sup> Century
- ▶ solid growth in nuclear energy
- ▶ until Fukushima Daiichi reactor meltdown, 11 March 2011
- ▶ “beginning of the end” for Nuclear power?

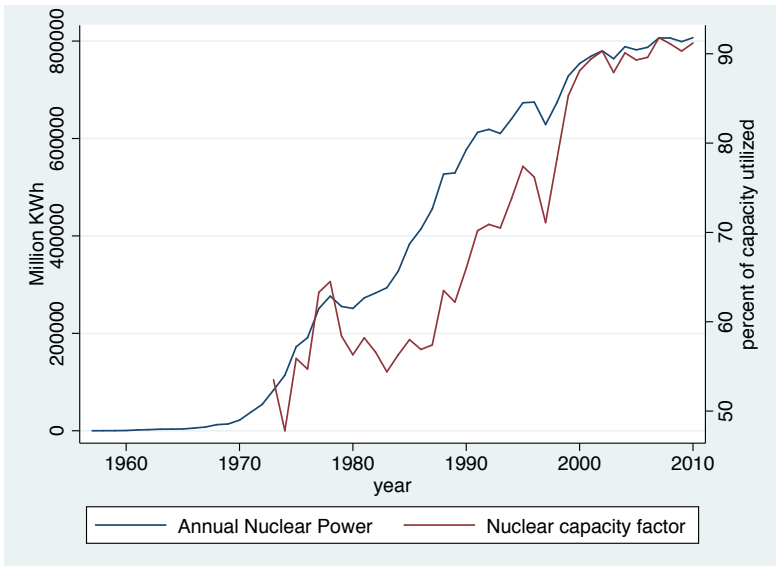
# Time path: price of uranium



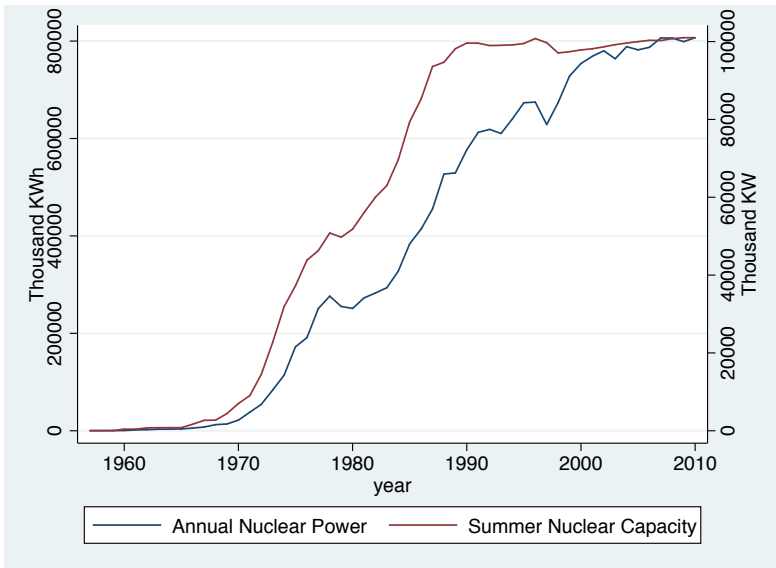
# Time path: Nuclear Power



# Time path: Nuclear Power, Capacity Utilization

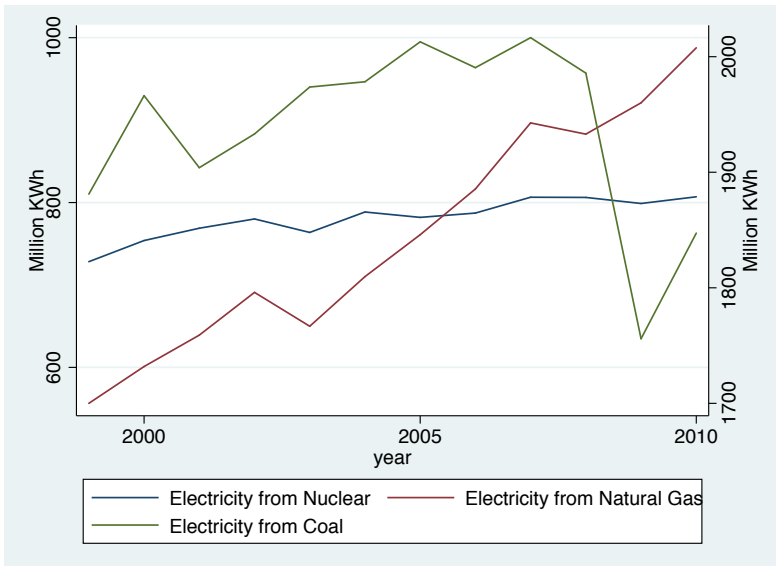


# Time path: Nuclear Power, Summer Capacity

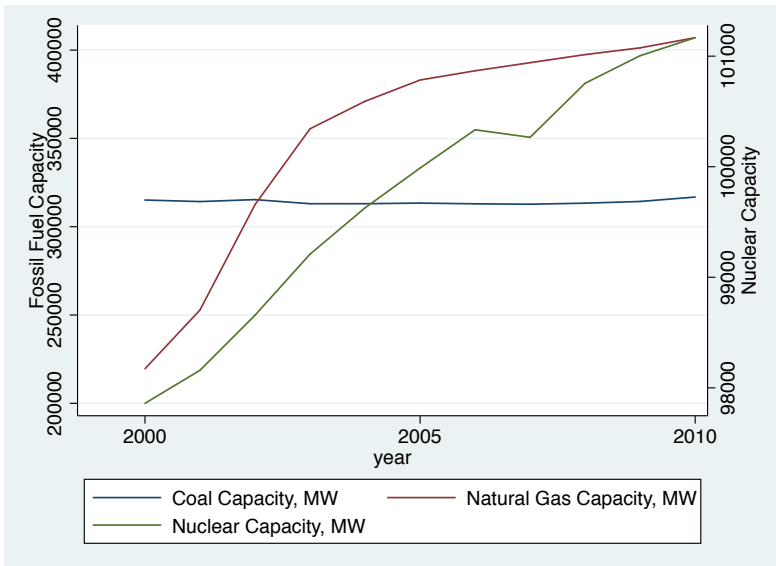




# Time path: Electricity Production, Various Fuels

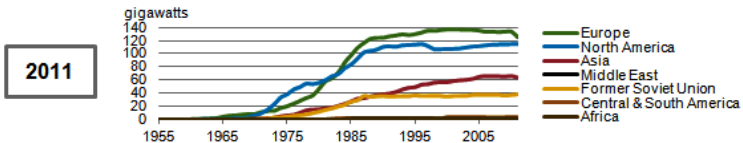
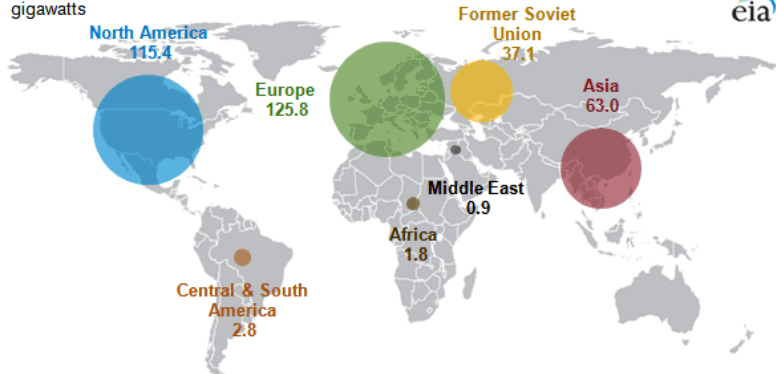


# Time path: Various Fuels, Summer Power Capacity

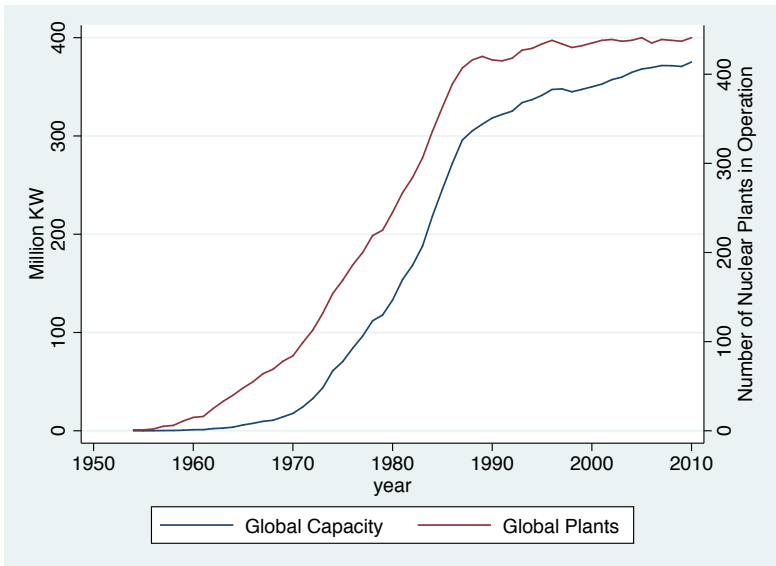


# Nuclear Power: Global Role

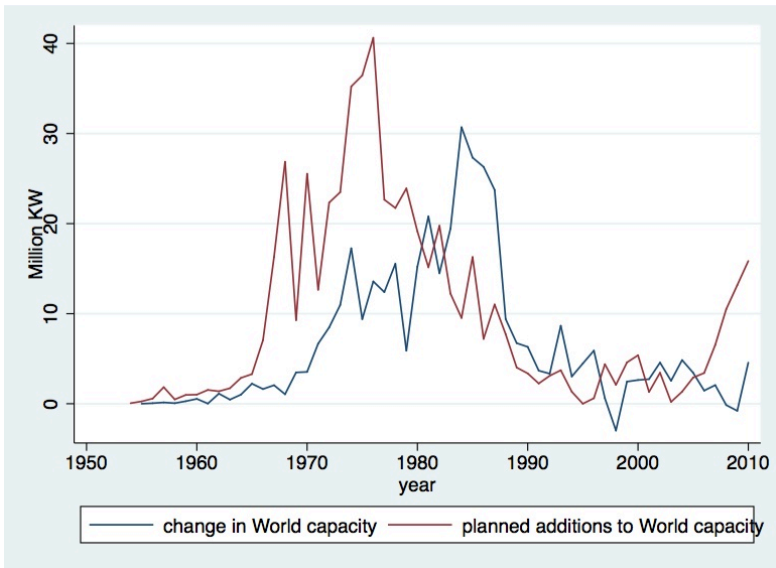
World nuclear electricity generating capacity by region, 1955-2011  
gigawatts



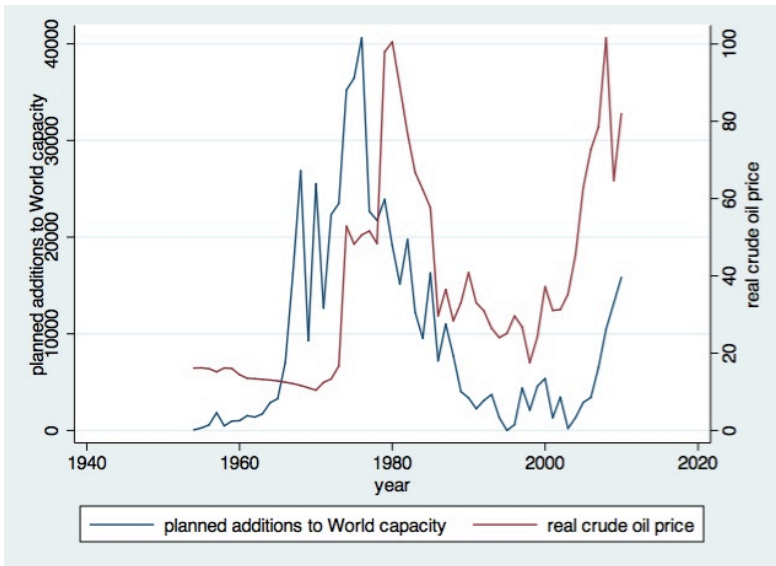
# Time Path: Global Nuclear Capacity



# Nuclear Power: Historical Global Expansion



# Why Nuclear Expansion?



# Carbon Policy and Nuclear Power

- ▶ 1.020 kg CO<sub>2</sub> per kWh for coal
- ▶ 0.515 kg CO<sub>2</sub> per kWh for natural gas
- ▶ plausible impact: pressure towards reduced use of both fuels as inputs into electricity
- ▶ then increased pressure for usage of Nuclear energy
  - ▷ In North America and Europe
  - ▷ also in FSU, BRIC countries
- ▶ induces increased demand for Uranium

# Implications

- ▶ Coal is faltering
- ▶ Natural Gas is rising rapidly
- ▶ Nuclear continues steady growth, particularly if
  - ▷ oil prices continue to rise
  - ▷ meaningful carbon policy is enacted
- ▶ huge new deposits of Natural Gas apparently at hand
- ▶ what about Uranium?
  - ▷ likely push towards new exploration, new development



# Optimal behavior: resource extracting firms

- ▶ privately optimal rate of extraction sets current rents equal to discounted future expected rents
- ▶ expectation depends on current beliefs
- ▶ but also manifest anticipated extraction next period
- ▶ in this way, current production is indirectly influenced by current exploration
  - ▷ if current exploration rises, this increases expected future finds, which in turn motivates larger production today

# What do we know?

- ▶ privately optimal exploration balances current marginal exploration cost against future expected benefits
  - ▷ value of expected finds
  - ▷ (negative?) impact of current exploration on future find rate, which will adversely impact payoffs two periods hence
  - ▷ expected value of information
    - current exploration yields inform'n, changes future beliefs
    - this is true for other firms as well
    - possibility of public good aspect to information
    - also possibility of using information for speculative purposes
- ▶ evidence suggests speculation governed past exploration
- ▶ increases in  $D$ , associated sharp increases in production and exploration would seem to reinforce this conclusion
- ▶ similarity to first decade of 21<sup>st</sup> century striking
- ▶ likely implication: over-exploration continues
  - ▷ on a global scale?

## What can we learn from the past experience?

- ▶ strong price signals lead to over-exuberant exploration
- ▶ this excess exploration likely motivated by speculation
- ▶ excess exploration spills over into extraction levels, yielding social over-production
- ▶ attendant welfare losses from over-exploration, over-production
- ▶ can we draw useful insights from the record of solid prices in 1950s, strong run-up in prices in early 1970s to guide policy going forward?
- ▶ evidence suggests a role for (international) governmental intervention
  - ▷ tax on exploration?
  - ▷ (larger) severance tax on produced ore?