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Analysis

Measuring the impact of nuclear accidents on energy policy

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ABSTRACT

This paper investigates the effects of nuclear accidents on energy policy with the help of a panel dataset of 31 countries from 1965 to 2009, using annual data on the capacity of reactor construction starts, as well as the timing of three nuclear accidents scaled five or higher on the International Nuclear and Radiological Event Scale. After determining the extent of the accident impact in the different countries, I find that neither the Three Mile Island (TMI) nor the Lucens accidents had a worldwide negative effect on construction starts, while Chernobyl did. Three Mile Island had a lasting impact in the United States, however. I show that the effect of Chernobyl wore off in certain geographical clusters, after ten to thirty years. An accident is likely to have a negative and long lasting impact in the country where it happened, and possibly in countries affected by the direct consequences. I find that nuclear capacity enlargement shows a significant lock-in effect, but it was also driven by primary energy consumption and energy security considerations in the past five decades.

1. Introduction

In the first decade of the 21st century, until the accident at the Fukushima Dai-ichi nuclear power plant occurred, the notion of a nuclear renaissance emerged (Ahearne, 2011; Goodfellow et al., 2011) and many, mostly Asian countries started large-scale civilian nuclear programs. The Fukushima accident in 2011 however, was followed by immediate policy reactions against nuclear energy in a number of countries, though many other countries decided to continue with their nuclear programs. For example, while Germany chose to phase out nuclear power (Wittneben, 2012), the Chinese government decided to proceed following a short moratorium.

Already in a 2009 study, Joskow and Parsons (2009) claimed that another significant accident at an existing nuclear power plant anywhere in the world could have very negative consequences for any hope of a nuclear renaissance. However, the true impact of this accident on reactor constructions will be visible only in a few years. The goal of this paper is to quantify the effect of past nuclear accidents, in order both to understand how long and how severely nuclear accidents reduce the construction of new reactors and to gain a clearer picture about the possible extent of the aftermath of the Fukushima accident. While the effects of nuclear accidents on energy policy have been discussed in a number of studies, among others in Ebinger (2011), Nohrstedt (2005, 2008), Joskow and Parsons (2012), Thomas (2012) and in Goodfellow et al. (2011), most of these articles dealt with the psychology or the politics of post-accident policy making, rather than quantifying the effects on reactor construction.

There are only a handful of econometric studies, such as Fuhrmann (2012) and Gourley and Stulberg (2013) examining the driving forces of reactor construction. Furthermore, the impact of accidents in this context is rarely measured. Fuhrmann (2012) investigates the motives of nuclear power plant construction using a logit model to test the significance of nuclear accidents, economic development, nuclear proliferation, energy security, the supply of nuclear technology and of norms as the determinants of nuclear power plant construction. He comes to the conclusion that economic development and energy insecurity are positively and significantly influencing reactor construction. Fuhrmann (2012) does not find the nuclear weapons or nuclear non-proliferation treaty variables significant, implying that enrolling in a civilian nuclear program does not mean sinister intentions from the beginning, although there is no evidence that these intentions might not change. Unlike the Chernobyl and TMI accident dummies, the supply side variable is insignificant. Fuhrmann (2012) concludes that nuclear power plant construction is likely to continue in countries which had invested in nuclear technology and infrastructure before the Fukushima accident, but the probability that new countries will enrol in civilian nuclear programs is drastically lowered.

Gourley and Stulberg (2013) investigate the correlates of nuclear energy using a binary logistic regression on the occurrence of construction starts. They investigate the characteristics systematically shared by existing nuclear power states that distinguish them from non-nuclear

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states. They find that energy insecurity and real income are positively correlated with nuclear energy, however they do not find evidence for common traits in economic growth, political governance, regime duration, or strategic considerations such as enduring rivalries (hostilities). They note that aspirant nuclear states tend to be either large emerging market economies or smaller, but fast growing nations. Nelson (2010) conducted a stepwise regression on nuclear reliance (defined as the fraction of national electricity generated from nuclear energy). He found that coal reserves and the state of the fuel cycle are negatively correlated, while international commerce and polity and energy insecurity are positively correlated with nuclear reliance. Gross domestic product, gas reserves or electricity generation were not found significant. The methodology applied was questioned however by Gourley and Stulberg (2013).

Guidolin and Guseo (2012) examine the existence of a nuclear renaissance using innovation diffusion models, and investigate among others shocks to reactor grid-connections. The authors identify a negative shock in 1987 corresponding to the Chernobyl accident, followed by a consistent decline. Especially in the wake of Fukushima, they foresee a declining future pattern for reactor startups. Guidolin and Guseo (2012) also note that nuclear expansion presently is a phenomenon in countries with highly centralised government structures.

This study contributes to closing the gap in the empirical literature by examining the statistical impact of the main accidents on reactor construction starts worldwide, while controlling for energy consumption, and for a number of economic and strategic factors. The method is novel, as the length of impact of each accident is allowed to vary country by country, thus accounting for their diminishing impact, where appropriate. Previous studies used accident variables running uniformly from the date of the accident to the end of the examined period, or for a uniform number of years. Also, no other study has utilised the capacities of construction starts before, which allows for a more accurate investigation of the subject and a different econometric approach. Earlier papers used a binary variable approach to account for construction starts.

Of the three accidents examined in this paper, only Chernobyl had a significant negative worldwide impact on nuclear power plant construction, while the effect of TMI was significant primarily in the United States. I find that the effect of nuclear accidents can, but need not wear-off in a time span of ten to thirty years. Thus, an accident is likely to have a long lasting negative impact in the country where it happened, and possibly in regions most affected by the nuclear fallout. I also find that next to energy consumption and energy security, the lock-in effect is a very strong driving factor in the nuclear industry. This paper is organised as follows: Section 2 examines the economic and policy environment of nuclear energy during the past five decades. Section 3 discusses the data and the methodology used, Section 4 explains the empirical results, and Section 5 presents the conclusions.

2. Five Decades of Commercial Nuclear Energy

This section looks closely at the historical and economic factors that shaped the nuclear industry as well as the surrounding energy policy during the last fifty years. In the wake of the Second World War, civilian reactor technology was initially developed from the military applications of nuclear power. The International Atomic Energy Agency (IAEA) was established in 1957 to promote the safe, secure and peaceful uses of nuclear technologies. The first commercial reactors appeared in the first half of the 1950s in the US, in the USSR, and in West Europe. Arising from the novelty of the technology, many different reactor designs were experimented with, in this decade (Lester and Rosner, 2009), a number of which either did not prove economically viable, or other technically better designs were favoured instead. This was the era of the Cold War, when nuclear armament was a strategic priority for both the West and the Eastern Bloc.

A rapid worldwide commercial expansion of nuclear reactors followed at the end of the 1960s, irrespective of the ownership structure of the plants (state vs. privately owned plants). However, the 1970s brought a significant change to the international energy landscape. The oil crisis of 1973–74 sent the inflation and interest rates skyrocketing in the Western World. As a result of high energy prices, the demand for end user energy services broke in considerably, while energy efficiencies began to kick-in. This phenomenon at the time was not observable in the countries of the Eastern Bloc, as the USSR not only had large own oil and gas reserves, but also regulated resource and energy prices. It is argued that in an environment of high interest rates and high inflation, large base load power plants with significant initial investment costs became especially uncompetitive. According to Ebinger (2011), the US demand for large base load plants was growing annually 6–7% in the 1960s, but started falling 1–2% after the first oil crisis. Apart from this, a very complicated authorisation process evolved, with the federal and state regulators all doing their independent reviews on construction and operational licenses that also increased the time needed to build a nuclear plant (Ebinger, 2011).

By 1979 the nuclear industry was already fighting with overcapacity in the United States, high investment costs and inflation, growing public, environmental, and proliferation concerns. It was in this year that the Three Mile Island accident happened. The release of radioactivity was well under the health safety limits, and even after thirty years, no deaths or illnesses are attributable to TMI (Van Roey, 2009). The accident however received tremendous media attention, and a local public panic ensued. Contributing factors could have been the release of the film “China Syndrome” two weeks before the event, or an evacuation order given by the nuclear regulatory body – based on false information regarding the measurement of released radioactivity – that was later withdrawn. According to Ebinger (2011), after TMI nearly 100 orders for nuclear reactors were cancelled in the United States, and only one reactor was finished. Many investments were scrapped, among others nearly-ready plants (Joskow and Parsons, 2009). It is argued that TMI, although it had a large echo, has just finished off what the stagflation and high interest rates of the decade have started (Cohen, 1990). The worldwide number of nuclear power plant construction starts had fallen already starting with 1977. TMI also likely triggered the Swedish referendum on nuclear energy (Nohrstedt, 2005), which resulted in a long-term nuclear phase out decision.

The beginning of the 1980s was marked once again by a severe oil crisis, resulting in significant reductions in end-energy use, as well as in primary energy consumption. The effects were again not visible in the Eastern Bloc, for the reasons outlined above. Oil prices broke in however considerably in 1986. It was in these circumstances that the most severe nuclear accident of all times happened in Ukraine. The disaster at Chernobyl was due not only to a bad reactor design, but also to enormous human errors, and to the complete disregard of safety procedures (Villa, 2008). The accident contaminated significant areas of Europe, and caused a large public outcry against nuclear energy. Apart from a few countries that kept their nuclear programs, in most parts of the world, new construction starts fell dramatically.

The last twenty years were characterized worldwide by the wide spreading of small and medium capacity gas and coal plants (Joskow and Parsons, 2009), and by the remarkable increase in commodity prices starting in the early 2000s until the great financial depression of 2008. Liberalisation and quasi-liberalisation of electric markets sped up not only in Western but also in Eastern Europe and in the former USSR. Especially in the Eastern Bloc, the adjustment to market prices caused drastic increases in energy prices, along with a very strong downward pressure on energy consumption. The primary energy consumption of the former Eastern Bloc decreased by 2010 to the level of the 1970s, after a peak around 1990. In the US, deregulation marked the 1990s, but these efforts suffered considerably as a result of the California Electricity Crisis in 2000–2001.