Industrial Policy and Decarbonization: The Case of Nuclear Energy in France

Julius J. Andersson[1*] Jared J. Finnegan[2]

[1]Stockholm School of Economics

[2]University College London

October 23, 2026

Abstract

We assess industrial policy's role in decarbonization by examining the expansion of nuclear energy in France following the 1973 oil crisis. Within a decade, France initiated construction of 51 new reactors. This resulted in more than a 60% reduction in carbon dioxide emissions from electricity and heat production, and around a 20% reduction in total CO_2 emissions. Emission reductions began six years after the policy was announced, with an average abatement cost close to zero per metric ton of CO_2 reduced. We show that the government's ability to insulate the policymaking process from opponents was crucial for the political success of the reform.

JEL classification: O25; Q54; Q58

Keywords: industrial policy, decarbonization, nuclear energy, climate change, political economy

*Contact: julius.andersson@hhs.se and j.finnegan@ucl.ac.uk. This research did not receive any specific funding, and the authors have no financial relationships or conflicts of interest to disclose. We would like to thank Celina Tippmann and Ann-Charlott Pahl for excellent research assistance.

1 Introduction

The last few years have witnessed a dramatic shift in climate policymaking. Governments around the world have embraced industrial policy as a key strategy for reducing carbon emissions and promoting domestic economies. They are turning to subsidies, loan guarantees and local content requirements, in addition to, and in many cases instead of, conventional policies like carbon pricing. A recent example is the Inflation Reduction Act – "the largest climate bill in U.S. history" (Thompson, 2022) – which allocates over $390 billion toward decarbonization via industrial policy. However, despite this political shift, we know surprisingly little about the environmental and economic effectiveness of green industrial policy, as well as its political economy (Rodrik, 2014; Mckenzie, 2023).

We study the case of the Messmer Plan in France to provide insight on the effect of large-scale industrial policy on carbon emissions and abatement costs, as well as on the conditions that make such a reform politically feasible. Adopted in 1974 in response to the oil price shock of 1973, the Messmer Plan sought to transform the French electricity sector by rapidly and dramatically expanding nuclear energy. The government used loan guarantees, public financing, contracts with suppliers and streamlined planning procedures to enable the state-owned utility Électricité de France (EDF) to secure large amounts of capital and construct reactors at scale and speed (Campbell, 1986; Lucas, 1979). EDF ordered and began construction on 51 new reactors in the decade after the Plan's announcement. As a result, the share of nuclear power in electricity production rose from 8% in 1973 to 80% in 1990, while the share of fossil fuels declined from 65% to 7% (IEA, 2022a).

While the Messmer Plan was not originally aimed at carbon reduction, we analyze it as an early form of green industrial policy due to the resurgence of nuclear energy in modern climate policy discourse. In 2022, the European Commission endorsed nuclear energy as a "green investment", underscored by Thierry Breton, the Commissioner for the Internal Market in the EU, who emphasized nuclear's "fundamental role" in the transition away from fossil fuels (Gröndahl, 2022). In parallel, French President Emmanuel Macron has championed a "nuclear renaissance" as part of his vision for Europe's low-carbon future (Alderman, 2022). France itself aims to build six new reactors, with the potential for an additional eight (Nuclear Engineering International, 2026). In Sweden, historically a frontrunner in the use of carbon pricing, the government's new climate policy advocates for a large-scale expansion of nuclear energy, with a stated goal of 10 new reactors (Government Offices of Sweden, 2023). Adjusted for differences in population size, this expansion matches the scale of France's Messmer Plan. On the other side of the Atlantic, the US included production tax credits for nuclear energy as part of the climate provisions of the Inflation Reduction Act (Bistline, Mehrotra, and Wolfram, 2023). That said, nuclear's role in climate policy remains divisive. Critics contend it is too slow

and costly to build, and thus not as effective as renewables in addressing climate change (Schneider and Froggatt, 2021; Haywood, Leroutier, and Pietzcker, 2023). This skepticism is exemplified by Germany, which has been decommissioning its nuclear reactors since 2011 and closed its last reactors in 2023.

Using a comparative case study design, we evaluate the effects of the Messmer Plan based on four pillars of effective climate policy: emissions reductions, timeframe for achieving reductions, cost of abatement, and political feasibility. In the context of climate change, delays between policy implementation and realised emission reductions are crucial, as the accumulating atmospheric stock of greenhouse gases exacerbates future warming. Additionally, abatement costs and political feasibility are factors that significantly influence the content, design, stringency, adoption and implementation of climate policies.

In the first part of the paper, we empirically estimate carbon emission reductions, the duration from project announcement until emission reductions began and the associated abatement cost. To achieve this, we employ the synthetic control method (Abadie, Diamond, and Hainmueller, 2010, 2015) to construct a credible counterfactual – a weighted average of other OECD countries that represents the outcome in France if the Messmer Plan had not been implemented. Comparing the outcome in France to this counterfactual scenario, we find that the extensive push for nuclear energy led to a more than 60% reduction in carbon dioxide (CO_2) emissions from electricity and heat production and around a 20% reduction in total CO_2 emissions in an average year between 1980-2005. Importantly, we find substantial emission reductions outside of electricity and heat production, in the industrial, residential and services sectors, which we attribute to fuel-switching. Furthermore, we find that six years elapsed from the announcement of the Messmer plan until emission reductions commenced and compute an average abatement cost of -$0.9 per metric ton of CO_2 reduced, indicating that the policy reduced carbon emissions at approximately zero net cost. These results show that rapid and substantial decarbonization is possible through active state intervention, and that ambitious industrial policy in the energy sector can be an environmentally and economically efficient climate policy.

While a large-scale expansion of nuclear energy may appear as a straightforward means to reduce CO_2 emissions, the underlying dynamics are more complex. A simple "back-of-the-envelope" calculation risks both over- and underestimating emission reductions, and overlooks policy-relevant issues such as substitution between nuclear and fossil fuels and the timing of abatement.

For instance, a simple difference-in-differences benchmark comparing France to the OECD average implies substantially larger emission reductions in the electricity and heat sector than our synthetic control estimate. A similar overestimation arises from a mechanical "engineering" calculation that assumes that, absent the Messmer Plan, the nuclear share of electricity generation would have remained low and the combustible-fuel

share high – at roughly their levels in France during the 1970s. Such assumptions ignore both the nuclear expansion already underway in France before 1974 and changes over time in the mix of combustible fuels, which alter the emissions factor of electricity and heat production. At the same time, a narrow focus on electricity generation alone would understate the total effect of the plan, since the Messmer Plan also induced additional emission reductions outside the electricity and heat sector through increased electrification and fuel switching in residential, services, and industrial activities.

Providing a credible estimate of the Plan's overall impact therefore requires a counterfactual that captures both France's pre-existing nuclear energy expansion and its broader energy-system characteristics. France in the early 1970s was characterized by high dependence on imported oil and a small but declining domestic coal industry, whereas countries such as the United States, Canada, and several other non-European OECD members had markedly different energy profiles. By assigning country-specific weights, the synthetic control gives greater importance to countries with energy structures more similar to France's, allowing us to construct a counterfactual that more closely reflects the constraints and adjustment margins France faced during the oil crises.

Additionally, it remains critical to determine whether the added nuclear capacity displaced fossil fuel generation or merely supplemented it (York, 2012). This distinction is crucial, as only net reductions contribute to meeting the climate targets set by the Paris Agreement. It is particularly salient in the context of France at that time, where no carbon pricing mechanisms or other mitigation policies existed to discourage continued fossil fuel use. Relatedly, understanding when abatement effects materialize is essential, especially given the lengthy construction periods associated with modern nuclear reactors and the urgency to achieve net-zero emissions within the next two to three decades (Masson-Delmotte et al., 2018).

Finally, the broader economic and distributional costs of such ambitious climate policies are frequently debated and cited as reasons to weaken current climate initiatives (e.g., Finnegan, 2023). In this context, employing a rigorous comparative case study design and establishing a credible counterfactual is essential for accurately assessing the scope, timing and costs of emission reductions across various sectors of the economy.

However, even though the Messmer Plan eventually led to substantial emission reductions, at a time delay of only six years and at a near-zero abatement cost, it should not be taken as a foregone conclusion that the adoption and implementation of the Plan would be politically successful. In the latter part of our paper, we examine the political economy of the Messmer Plan. We show how France's *dirigiste* policy style during this period - characterized by an autonomous and technocratic bureaucracy, policymaking centralized around a powerful executive, state-ownership of key firms and control over capital allocation - enabled the government to insulate the policymaking process and prevent the Plan's opponents from obstructing decision making. The analysis points to the

key role that insulation plays in enabling governments to overcome opposition to adopt and implement large-scale reforms that upset incumbent interests (Finnegan et al., 2025; Meckling et al., 2022).

Our study contributes to existing literature in several ways. First, by analysing emission reductions relative to a counterfactual scenario, it provides causal estimates of the environmental effects of nuclear energy policy. Existing empirical research on potential emission reductions from nuclear energy deployment relies primarily on time-series data from individual countries, using Granger causality tests to estimate the causal relationship between nuclear energy and CO_2 emissions (Iwata, Okada, and Samreth, 2010; Menyah and Wolde-Rufael, 2010; Apergis et al., 2010). Although these studies generally conclude that increased nuclear energy usage leads to reduced CO_2 emissions, the lack of a counterfactual inhibits our ability to make causal inferences.

Second, this paper extends the empirical literature evaluating climate policies. A growing body of research has analysed the environmental effect of carbon pricing, finding that it effectively reduces carbon emissions (see, for example: Andersson, 2019; Colmer et al., 2025; Leroutier, 2022). However, fewer studies have explored the environmental effectiveness of green industrial policy and findings have been mixed. Research on the effect of Germany's nuclear energy phase-out and simultaneous support of renewable energy as part of the *Energiewende* has found that it has increased carbon emissions (Knopf et al., 2014; Jarvis, Deschenes, and Jha, 2022). In contrast, evaluations of China's green industrial policy, which promotes initiatives like electric vehicle and solar panel production and adoption, have found a decrease in carbon emissions and other air pollutants (Zhang et al., 2022; Song and Zhou, 2021). Additional causal analysis of green industrial policy across contexts is needed to better understand the effects of this important and increasingly utilized policy instrument.

Third, we add to the empirical literature on expansive industrial and research and development (R&D) policies, commonly termed as "moonshot" or "big push" initiatives. These policies, like the Messmer Plan, are distinguished by their targeted focus on specific technologies or regions, substantial public investments, and their aspiration for transformational outcomes (Juhász, Lane, and Rodrik, 2023). Most empirical research indicates prolonged positive economic impacts in the regions directly affected by these policies.[1] Our work extends this literature by examining the environmental consequences of large-scale initiatives.

Fourth, we contribute to the emerging literature in political science on the politics of green industrial policy. Scholars have shown how the ideas underpinning green industrial policy have risen to prominence over the past three decades (Meckling and Allan, 2020),

[1]Examples include analysis of the attempt to modernize the economy of the Tennessee Valley region in the US in the 1930s (Kline and Moretti, 2014); the massive spending on R&D by the US during WWII (Gross and Sampat, 2023); and the US space program in the 1960s (Kantor and Whalley, 2023).

as well as provided clear conceptualizations of green industrial policy and theorized its political dynamics both domestically and internationally (Allan, Lewis, and Oatley, 2021; Allan and Nahm, 2025; Cullenward and Victor, 2020; Kupzok and Nahm, 2024; Meckling, 2021). Moreover, work has shown the institutional underpinnings of national patterns of industrial specialization and innovation (Nahm, 2021). We add to this effort by uncovering the political conditions that foster large-scale industrial reform. Specifically, we identify one key mechanism for reform - insulation - and trace how it enabled the French government to adopt and implement expansive nuclear energy policy.

Last, our paper intersects with the literature on directed technical change (Acemoglu, 1998, 2002; Popp, 2019). One objective of the Messmer Plan was to actively shape the technological development of nuclear energy. A seminal paper by Acemoglu et al. (2012) explores directed technical change and climate mitigation policies, advocating for an optimal strategy that employs both carbon pricing and research subsidies for green technologies. Notably, carbon pricing affects the variable (fuel) costs of energy production, which are crucial for fossil fuels, while industrial policy reduces the fixed (capital) costs, which enhances the competitiveness of zero-carbon alternatives. Consequently, carbon pricing and industrial policy emerge more as complements than substitutes within climate policy in the energy sector, and empirical research should focus on both (Andersson and Finnegan, 2025).

The remainder of the paper is organized as follows. Section 2 discusses the concept of green industrial policy. Section 3 provides background on the Messmer Plan. Section 4 describes the data and method used to estimate emission reductions. Section 5 presents the main results, including impacts on emissions, abatement costs, and the timing of reductions. Section 6 analyzes the political economy of the policy. Section 7 evaluates what we learn from the French case for contemporary green industrial policy debates. Finally, Section 8 concludes.

2 Industrial Policy to Address Climate Change

One key way to mitigate climate change is to reduce the relative price of zero-carbon technologies. This can be done by either increasing the price of fossil fuels or by reducing the price of zero-carbon alternatives. While a variety of policy instruments can achieve these goals, economists have tended to focus on carbon pricing (Akerlof et al., 2019; Nordhaus, 2008). We turn attention to another instrument: industrial policy.

Industrial policy refers to government measures aimed at promoting the growth and transformation of sectors that it views as essential to future economic growth, employment and innovation (Krugman and Obstfeld, 2009). More recently, green industrial policy has emerged as a tool to address climate change (Rodrik, 2014; Meckling, 2021). Its purpose is twofold: environmental and economic. It seeks to mobilize government efforts towards

decarbonization and to foster the development of zero-carbon technologies and domestic firms to increase employment, innovation and growth in green sectors. Governments can employ a range of tools to achieve these aims, including subsidies, direct loans, loan guarantees, local content requirements, tax credits and research grants to support and facilitate research and development (R&D). In this way, green industrial policy operates on a larger scale and encompasses broader objectives compared to carbon pricing or regulatory (command and control) approaches that focus solely on emissions.

Recent examples of green industrial policy include the Inflation Reduction Act passed in the US in 2022. The IRA involved more than $390 billion in government expenditure towards energy security and climate change mitigation, using tax credits, grants, loans and local content requirements to promote low-carbon energy production, the electrification of transport and support of domestic employment and manufacturing in low-carbon sectors (Bistline, Mehrotra, and Wolfram, 2023); though more recently the Trump administration has weakened various parts of the legislation. China has also relied on green industrial policy to reduce emissions and grow its market share in zero-carbon technologies (Altenburg and Assmann, 2017; Harrison, Martin, and Nataraj, 2017). At the European Commission, green industrial policy is being pursued through policies like the Net-Zero Industry Act, the Green Deal Industrial Plan and relaxed state aid rules. Given its increasing use by policymakers, it is crucial to know whether implementing large-scale green industrial policies is indeed an effective climate mitigation policy.

The argument for green industrial policy stems from the existence of market failures caused by both positive and negative externalities, for which traditional market mechanisms often fail to account (Acemoglu, 2023; Rodrik, 2014). The further development of low-carbon technologies by one firm creates positive spillover effects on other firms in the sector, such as technological innovation that reduces manufacturing costs and knowledge sharing, and the value of these spillovers are not fully captured by investors in the developing firm. Without government support, the amount of private expenditure on R&D would thus be below the socially optimal. Furthermore, low-carbon technologies directly compete with fossil fuels, and in most markets, the social costs associated with carbon emissions from fossil fuel combustion are either insufficiently priced or not priced at all. Due to this market failure, the market equilibrium will allocate too many resources towards fossil-fuel technologies, and therefore the "second-best" policy of government support for low-carbon substitutes is warranted and justified. Lastly, there are local co-benefits of improved health from switching from fossil fuels to low-carbon alternatives in the transport and energy sector, by a reduction in air pollutants such as nitrogen oxides and particulate matter (Parry, Veung, and Heine, 2015). As with carbon emissions, the market typically does not price the damages caused by these local air pollutants.

Economists commonly object to industrial policy on two main grounds (Pack and Saggi, 2006; Rodrik, 2008, 2014). First, they argue that policymakers lack the necessary

information to accurately identify the industries or firms most deserving of support. Put differently, governments are bad at picking "winners". And there are indeed numerous examples of government support for specific firms that have later failed (Hufbauer and Jung, 2021). Second, they caution that government support can stimulate rent-seeking behavior and potentially foster corruption. In defense of industrial policy, Rodrik (2014) responds that with well-designed industrial policy we should see some supported firms fail, otherwise the government is underperforming by not taking on enough risk and thereby reducing their average return on investments. Furthermore, Rodrik points out that rent-seeking is a potential issue with all government policies, not only for industrial policy, and can be overcome with appropriate institutional designs. Lastly, Acemoglu (2023) emphasizes that green industrial policy differs from traditional industrial policy because it responds to a measurable market failure: the negative externalities from fossil fuel use. As a result, the case for intervention does not rest primarily on the government's ability to identify future commercial winners, but on its ability to correct a known distortion that systematically disadvantages cleaner technologies.

3 Background to the Messmer Plan

In less than a year, from October 1973 to March 1974, the global price of oil quadrupled from around $3 to almost $12 per barrel (Davenport and Wayth, 2023). This first oil crisis resulted from production cuts and embargoes by the Organization of Arab Petroleum Exporting Countries (OAPEC) in retaliation for the West's support of Israel in the Yom Kippur War – an armed conflict in October of 1973 between Israel and a coalition of Arab nations led by Egypt and Syria.

On the eve of the price shock, oil supplied nearly 70% of France's total energy needs, with the vast majority of that oil being imported (IEA, 2022c).[2] As a result, the country was economically vulnerable to rapid changes in the oil price. In response to the price shock, Prime Minister Pierre Messmer announced an ambitious nuclear energy program on March 6th, 1974 that would reduce France's reliance on imported oil and increase energy security (Wade, 1980; Ikenberry, 1986; Jasper, 1990).

At the same time, the Messmer Plan had economic aspirations. It aimed to generate growth, innovation, competitiveness and employment in the nuclear sector. In the period after the Second World War, the French state sought to restructure industries across a range of sectors into larger units, or "national champions", that would be leaders in their sectors at home and abroad (Hall, 1986; Hall, Hayward, and Machin, 1994; Schmidt, 1996). In the case of nuclear, the goal was for the country's firms to be internationally competitive and capture export markets along the entire supply chain (Lucas, 1979, 1985;

[2]In 1973, France's oil self-sufficiency was just 1.7%, defined as the share of indigenous oil production in the total energy supply of oil.

Thomas, 1988). French firms would be world leaders in reactor design and manufacturing, plant engineering, operator training, fuel enrichment and waste disposal and reprocessing, and over the longer term, have the technological lead in fast breeder reactors.

The government relied on a variety of policy instruments to implement the Messmer Plan. First, it channeled large amounts of capital to the nuclear sector using public finance and loan guarantees.[3] Public funding and loans to nuclear power approximately tripled between 1975 and 1976 (Lucas, 1979, Ch. 3). At the same time, the government used loan guarantees to underwrite the debt that EDF took on, which enhanced the company's credit rating and reduced its borrowing costs. Of all sources of capital, loans constituted the largest form of investment (Jasper, 1990, Ch. 9; Lucas, 1979, Ch. 3). Around half of lending came from the French nationalized banking sector and half from foreign investors, especially the US. EDF was the third largest borrower on US capital markets in 1976, just after Ford and General Motors.

Second, the government used multiannual contracts with Framatome, the main reactor manufacturer (Lucas, 1979, Ch. 3). Framatome and its suppliers needed demand guarantees to make the large investments necessary for increasing production capacity in 1974-76 to meet the Plan's goals. In addition to contracts, the state also expressed a political commitment to purchase reactors via its five-year economic plans, which set ambitious targets for nuclear power.

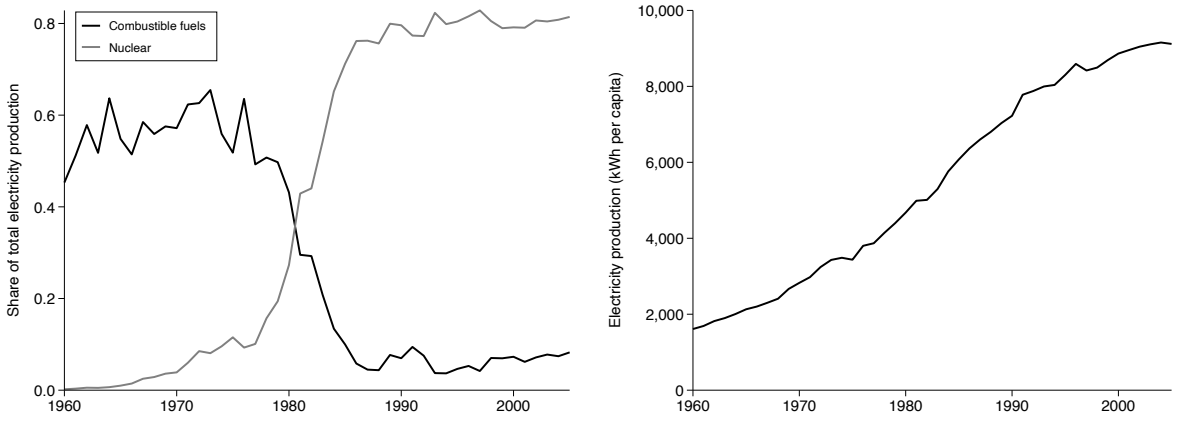
Last, the Ministry of Industry designed siting and authorization procedures to allow for a large program of rectors to be completed on time (Thomas, 1988, Ch. 8). The process was simple and requirements were specified in general terms to enable flexibility. Moreover, nuclear authorization decisions had the status of government decrees and were therefore practically immune from legal challenge (Campbell, 1988, Ch. 8).

Perhaps surprisingly, government civil nuclear R&D expenditures did not significantly increase after the Plan's adoption. Data from the French Court of Audit's (Cours des comptes) 2012 report shows that annual R&D spending was around €1.1 billion (2010 euros) from 1957 to 1969 (Cour des Comptes, 2012, 37-39). For the 1970-1989 period, it was estimated to be €1 billion (2010 euros). The Court of Audit itself noted that spending during the 1970s and 1980s was "equivalent to that of the previous period" (Cour des Comptes, 2012, 39).[4]

With the capital, contracts and planning procedures in place, EDF ordered 16 new reactors in 1974, matching the total number of all reactors ordered before the Messmer Plan. These new reactors had a combined output of 14,400 MWe (megawatt electric).

[3]State loans and loan guarantees are among the most frequently used types of industrial policy, especially in high- and middle-income countries (Juhász, Lane, and Rodrik, 2023).

[4]Ideally, the Court of Audit report would also include data on the costs of the Messmer Plan to the government. Although Chapter 1 of the report includes information on costs related to construction, engineering, fuel and other aspects of nuclear power, these costs are not separated for government versus firms, unfortunately.



(a) Combustible fuels and nuclear

(b) Total production

Figure 1: Electricity Production in France: 1960-2005.

Note: The left panel show the shares of total electricity production coming from combustible fuels and nuclear energy between 1960-2005. Included in the right panel is electricity production from both main activity producers and autoproducers.

For comparison, the previously ordered reactors totaled less than 9,000 MWe (Thomas, 1988, Ch. 8). In 1976, EDF ordered an additional 12 reactors, and a total of 51 reactors were ordered and began construction in the decade following the announcement of the Messmer Plan (Thomas, 1988; IAEA, 2023a). The work on the first three plants – Tricastin, Gravelines, and Dampierre – started in late 1974, and they were connected to the grid in 1980. Of the 51 reactors ordered, 43 came into commercial operation in the 1980s, six in the first half of the 1990s and two in the year 2000 (IAEA, 2023a).

Figure 1a illustrates the proportions of combustible fuels and nuclear energy used in electricity production in France. Before the announcement of the Messmer Plan, between 1960 and 1973, combustible fuels accounted for approximately 50%-60% of total electricity production. The share of oil increased in the early 1970s and reached a peak of 40% in 1973, making oil the primary energy source for electricity production at the time of the first oil crisis. Then, from 1980 onwards, there is a significant decline in the use of combustible fuels and a simultaneous rapid increase in the use of nuclear energy. Since the late 1980s, nuclear energy has consistently provided around 80% of total electricity production in France, while combustible fuels contribute less than 10%, and the remainder is supplied by hydropower (IEA, 2022a).

Total electricity production also increased from 1960 to 2005. Figure 1b demonstrates this trend. In 1960, annual electricity production per person was approximately 1,600 kilowatt hours (kWh). By 2005, production had multiplied more than five times, exceeding 9,000 kWh per person. Hence, not only did electricity supply undergo significant fuel switching, but there was also a simultaneous increase in overall electricity production. This large increase in production will play a key role in the later analysis of emission reductions in sectors outside of electricity and heat production.

4 Data and Method

4.1 Data

To assess the environmental impact of the Messmer Plan, we employ annual panel data on CO_2 emissions for France and 23 other OECD countries, spanning the years 1960 to 2005.[5] While our primary analysis concentrates on emissions originating from the electricity and heat sector, we also examine total emissions and explore additional relevant sectors such as industry, residential and services. The data is gathered from the International Energy Agency (IEA, 2022b), and emissions from electricity and heat production contains the sum of emissions from plants that produce either electricity, heat or both (cogeneration plants). Included in the emissions data are CO_2 emissions from combustible fuels.[6] Energy produced using nuclear power plants is classified as a zero-carbon source. Last, CO_2 emissions are measured in metric tons per capita.

In our main analysis, we focus on emissions from *main activity producers*, plants that supply energy to the public, and exclude emissions from *autoproducers*. Autoproducers are private plants that produce electricity and heat on-site for their own use to support their primary activity (e.g. a paper mill or a steel plant). As such, these emissions are commonly allocated elsewhere. In line with the IPCC guidelines on greenhouse gas inventories (IPCC, 2006), we allocate autoproducers' emissions to the industry sector in our analysis of total emissions.

It is important to note that for 1960-1973, the IEA data on emissions from electricity production cannot separate emissions from main activity producers and autoproducers (IEA, 2021). As a result, the apparent drop in emissions in 1974 (see Figure 2) is partly mechanical, reflecting the shift to reporting only main activity producers. Regardless, all countries in the sample are treated identically in terms of how the emissions data is computed over time, and autoproducer emissions are relatively minor – averaging just 13% of total electricity and heat emissions in our OECD sample during 1974–2005. Given this, we do not expect that combining the two emission sources before 1974 will create issues for our identification strategy. We present evidence in support of this assertion later on.

Our analysis ends in 2005. We chose this year because it marks the start of the European Union Emissions Trading System (EU ETS), which is a potential confounder for our study since it incentivized fuel switching in the electricity sector by putting a price on CO_2 emissions from electricity and heat production within the EU. In total, our sample period of 1960-2005 offers us 14 years of pretreatment data and 32 years of posttreatment data.

[5] We include all countries that were OECD members in 1973.

[6] In our dataset, CO_2 emissions primarily stem from fossil fuel combustion – oil, coal (including peat) and natural gas – with minor contributions from biofuels and waste in later years of the sample period.

From the original donor pool of OECD countries we exclude Luxembourg and Turkey. Luxembourg is excluded due to missing data on CO_2 emissions from electricity and heat production in the years 1974-1976 and we exclude Turkey to avoid interpolation bias. Interpolation bias can occur when we include countries in the donor pool that are too dissimilar to the treated unit – especially on important predictors of the outcome variable (Abadie, Diamond, and Hainmueller, 2015). In 1973, GDP per capita – a key predictor of CO_2 emissions – is much lower in Turkey compared to other OECD countries. For example, it is around a third of the level for France. Similarly, CO_2 emissions per capita from electricity and heat in Turkey are less than one seventh of the level in France. That said, excluding Turkey has no impact on our main results since, when included in the sample, Turkey obtains zero weight in synthetic France – our constructed counterfactual.

4.2 The Synthetic Control Method

To establish the causal impact of the Messmer Plan on CO_2 emissions from electricity and heat production we contrast France with a selection of countries similar to it in relevant aspects but unaffected by a "treatment" equivalent to the Messmer Plan.

Let $J+1$ be the number of countries in our sample, and let $j = 1$ denote France. The countries are observed for time periods $t = 1, 2, \ldots, T$ with periods both prior to treatment $1, 2, \ldots, T_0$ and after $T_0+1, T_0+2, \ldots, T$. The counterfactual, *synthetic France*, is constructed as a time-invariant weighted average of the unaffected control countries and represented by a vector of weights $W = (w_2, \ldots, w_{J+1})'$. The weights are restricted to be non-negative $0 \leq w_j \leq 1$ and sum to one $w_2 + \cdots + w_{J+1} = 1$.

Our selection of W is designed to minimize the difference between France and the control units on key predictors of the outcome variable, as well as on the outcome variable itself during the pretreatment period. We use four key predictors: two economic indicators – GDP per capita and degree of urbanisation – and two emission-related indicators – electricity production using combustible fuels and domestic oil and coal production.[7] Electricity production from combustible fuels is included to match with countries with a similar reliance on fossil fuels before treatment, while domestic production is an indirect measure of the ability to switch from imported to domestically produced fossil fuels.

With a long pre-intervention period, an accurate match on the outcome variable indicates that both observed predictors and unobserved factors with possibly time-varying effects impact France and its synthetic counterpart similarly (Abadie, Diamond, and Hainmueller, 2015). We have 14 years of pretreatment data (1960-1973) and an additional 6 years (1974-1979) before the first new nuclear reactors became operational. A close fit on CO_2 emissions between France and its counterfactual during this 20-year period suggests successful matching on all relevant variables.

[7] More details and data sources are available in Online Appendix A.

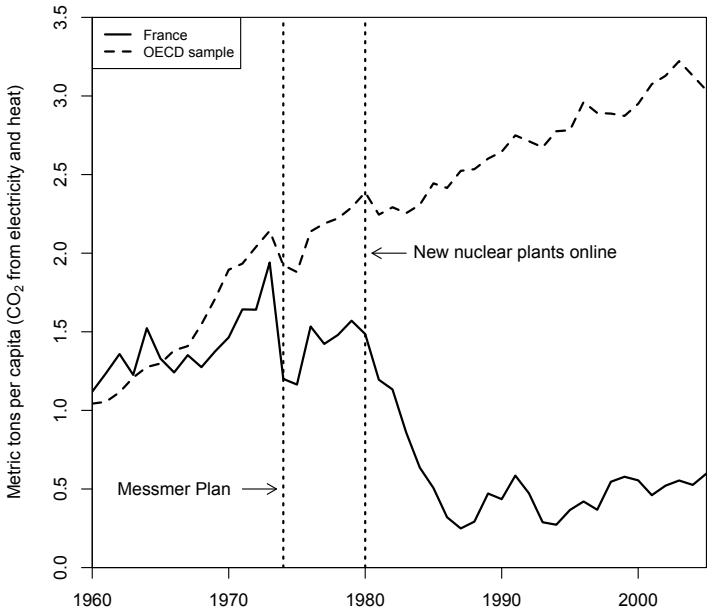


Figure 2: Path Plot of per capita CO_2 Emissions from Electricity and Heat during 1960-2005: France versus OECD average.

5 The Environmental Effect of the Messmer Plan

Figure 2 compares per capita CO_2 emissions from electricity and heat production in France with the unweighted average of the 21 OECD countries in our donor pool. The figure illustrates why we prefer the synthetic control method over a difference-in-differences approach for our analysis.[8] Specifically, the growth rate in emissions differs substantially in the pretreatment period. From 1960 to 1973, per capita emissions in the OECD sample increase by an average of 0.088 tons per year, compared to only 0.041 tons in France, a difference that is statistically significant. With synthetic control, we can assign weights to minimize the influence of countries that either heavily relied on fossil fuels or had minimal fossil use in the pretreatment period. This targeted weighting reduces both over- and underestimation of emission reductions in the posttreatment period. Furthermore, we can give greater weight to countries with energy profiles similar to France's prior to treatment. In the 1960s and early 1970s, France became increasingly dependent on imported oil and had a small but declining domestic coal industry – unlike the US and many other non-European OECD countries. While France and the OECD average had similar levels of energy self-sufficiency in the early 1960s, above 50%, by 1973, France had fallen below 25%, whereas the OECD average was around 43% and rising. By emphasiz-

[8] A simple difference-in-differences estimate, comparing the change in France to the change in the OECD average between the transitional period (1974–1979) and the posttreatment period (1980–2005), yields an estimated emission reduction of 1.43 tons of CO_2 per capita in an average year. A similarly simple "engineering" benchmark – computing the counterfactual by applying the average emissions factor in electricity and heat production during the transitional period to total electricity and heat production in France during the posttreatment period – yields an emission reduction of 2.45 tons of CO_2 per capita in an average year.

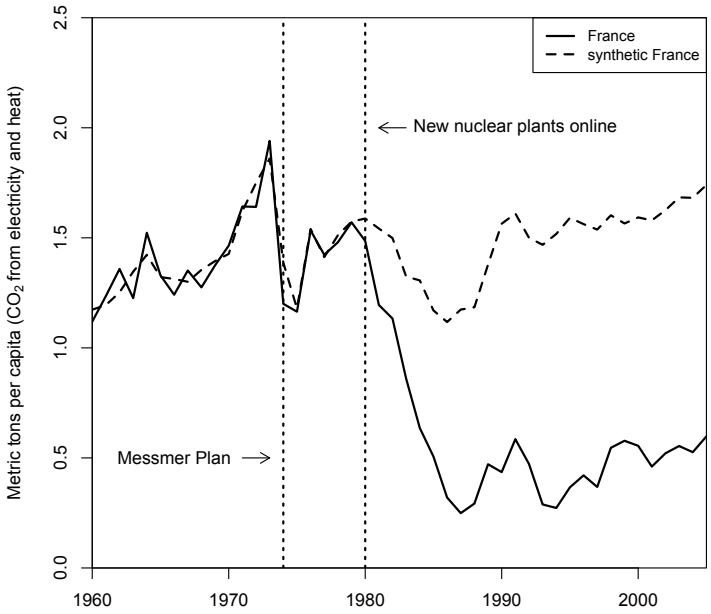


Figure 3: Path Plot of per capita CO_2 Emissions from Electricity and Heat during 1960-2005: France versus Synthetic France.

ing countries with similar import dependence, we construct a counterfactual that better reflects France's exposure to the two 1970s oil crises and their impact on emissions.

5.1 France and its Synthetic Counterfactual

Figure 3 shows the evolution of CO_2 emissions per capita from electricity and heat production in France and its synthetic (weighted) counterfactual from 1960-2005. The two series closely track each other in the pretreatment period of 1960-1973 and in the transitional period of 1974-1979. There are rather large movements in the outcome variable during this time frame, but the tight co-movement between France and synthetic France indicate that the volatility is due to common factors, such as the oil price shock in 1973. Then, as newly commissioned reactors come online in 1980 and onward, there is a sharp drop in emissions in France, which is not matched by a similar emissions trajectory in the counterfactual scenario. Interestingly, there is a drop in emissions in synthetic France in the first half of the 1980s, that is later reversed by the end of that decade. This decrease and later increase is likely driven by the increase in oil prices after the second oil crisis in 1979 – caused by supply fears after the Iranian Revolution – followed by a sharp price decrease in 1986. An advantage of using aggregated emissions data and a comparative case study approach with weights is that we are able to capture the likely confounding effect of this oil price increase since it affects France and the synthetic counterfactual similarly.

For the validity of the identification assumption, it is crucial that there is a good fit on the outcome variable between 1974-1979 – immediately after the Messmer Plan was

Table 1: Country Weights in Synthetic France

Country	Weight	Country	Weight	Country	Weight
Australia	0	Greece	0.002	Norway	0
Austria	0.262	Iceland	0	Portugal	0.143
Belgium	0.351	Ireland	0	Spain	0
Canada	0	Italy	0	Sweden	0
Denmark	0	Japan	0	Switzerland	0.198
Finland	0	Netherlands	0	United Kingdom	0
Germany	0.043	New Zealand	0.001	United States	0

Note: All weights are between $0 \leq w_j \leq 1$ and $\sum w_j = 1$.

enacted, but before its expected impact on emissions. The similarity in emission levels during this intermediate period indicates that we have successfully matched on observed and unobserved predictors of emissions and that the inability to separate autoproducers' emissions in the pretreatment period did not compromise our identification strategy.

The country weights W used to construct synthetic France are reported in Table 1. CO_2 emissions from electricity and heat production during the pretreatment period in France are most accurately replicated by a weighted combination of Belgium, Austria, Switzerland, Portugal, and Germany, with descending weights in that order. The remaining countries in the donor pool receive weights that are smaller than 1%.

The country weights are chosen using predictors of CO_2 emissions from electricity and heat production. To safeguard against specification searches and p-hacking (Abadie, 2021), we only use data from 1960-1973 to determine the country weights and exclude data after the Plan was announced. Table 2 compares the pretreatment values for these predictors in France with those in synthetic France and the arithmetic mean for the 21 OECD countries in the donor pool. On all predictors, France and its counterfactual have almost identical values and a better fit compared to France and the average of the OECD sample. For the first four key predictors, the difference between France and synthetic France is less than 1%, except for domestic oil and coal production where the value for France is 5% lower.

As predictors we also include three years of pre-intervention values of the outcome variable, emissions in 1973, 1969, and 1964 – one, five and ten years prior to the implementation of the Messmer Plan. We include lagged values for two reasons. First, we are interested in matching not only the growth rate of CO_2 emissions but also the overall level of those emissions. Second, adding these lags improves matching on unobservable variables that may have time-varying effects (Abadie, Diamond, and Hainmueller, 2010; Abadie, 2021). Table 2 shows that there is a good match also on these lagged predictors.

Lastly, to quantify the scale of the Messmer Plan, we evaluate the difference in the

Table 2: Predictor Means for CO_2 Emissions from Electricity and Heat

Variables	France	Synth France	OECD Sample
GDP per capita	13705.0	13703.5	13116.7
Urban population	69.8	69.8	69.4
Electricity from combustible fuels per capita	1555.4	1546.1	1810.2
Oil and coal production per capita 1972	423.1	443.8	872.7
CO_2 emissions from electricity and heat per capita 1973	1.9	1.9	2.1
CO_2 emissions from electricity and heat per capita 1969	1.4	1.4	1.7
CO_2 emissions from electricity and heat per capita 1964	1.5	1.4	1.3

Notes: All key predictors, except oil and coal production, are averaged for the ten year period before treatment, 1964-73. GDP per capita is Purchasing Power Parity (PPP) adjusted and measured in 2005 U.S. dollars. Urban population is measured as the percentage of total population. Electricity production from combustible fuels is measured in kWh per capita. Oil and coal production in 1972 is measured in kilograms of oil equivalent per capita. CO_2 emissions are measured in metric tons. The last column reports the averages of the 21 OECD countries in the donor pool.

number of nuclear reactors under construction and in operation in France and its counterfactual, before and after the Plan's announcement. Using this metric, the Messmer Plan significantly bolstered the nuclear energy program in France, leading to a more than six-fold expansion in reactors constructed post-1974 compared to the counterfactual scenario. This expansion suggests that, absent the Plan, France would have built only about 8 reactors in the decade after 1974 – rather than the 51 it actually constructed.[9]

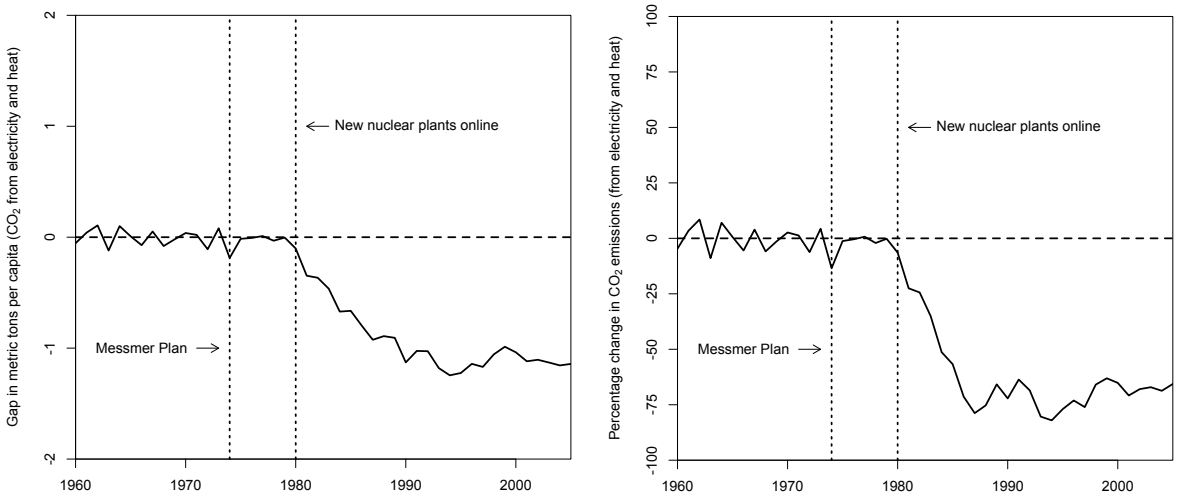
5.2 Emission Reductions from Electricity and Heat Production

The marked increase in reactor construction had a significant impact on CO_2 emissions. The gap plots in Figure 4 show the difference in emissions from electricity and heat production between the two "countries" from 1960-2005, highlighting the Messmer Plan's causal effect on posttreatment emission reductions. Panels (a) and (b) are computed as the difference in emissions in each year and measured in metric tons per capita and percentage change, respectively.

There is a smooth and steady increase in the size of emission reductions in the 1980s as more and more reactors come online. Emission reductions level off thereafter. In an average year from 1980-2005, the point estimate for CO_2 emissions reductions from electricity and heat production as a result of the Messmer Plan is 62% with a range of 60%-67%.[10] This equates to 0.92 metric tons per capita (range 0.82 to 1.19). The largest emission reduction is achieved in 1994 at 82% (range 80%-85%), a reduction of 1.25 metric tons per capita (range 1.10 to 1.55). Absolute emissions are also substantially reduced from an annual average of 75.8 Mt of CO_2 between 1974-1979 to an average of

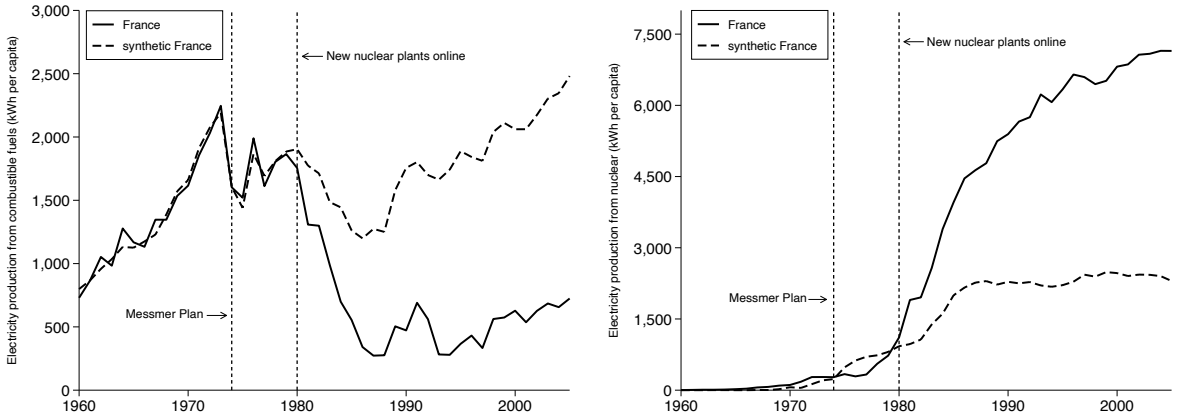
[9] Additional details on how we quantified the Messmer Plan's scale can be found in Online Appendix B.

[10] Ranges are calculated using leave-one-out tests. See Online Appendix C for details.



(a) Metric tons per capita (b) Percentage change

Figure 4: Gap in per capita CO_2 Emissions from Electricity and Heat between France and Synthetic France.



(a) Combustible fuels (b) Nuclear energy

Figure 5: Electricity Production between 1960-2005: France versus Synthetic France.

Note: Electricity production is measured in kWh per capita and only includes electricity from main activity producers between 1974 and 2005.

33.0 Mt between 1980-2005.

The causal effect of the Messmer Plan on France's energy mix is illustrated in Figure 5. Panel 5a reveals a strong similarity between France and its synthetic counterpart regarding the volume of electricity generated from combustible fuels between 1960 and 1979. However, from 1980 onwards, the trajectories diverge significantly, with synthetic France producing over three times more electricity from combustible fuels than France by 2005. The trend for nuclear energy production, displayed in Panel 5b, mirrors the decoupling observed for combustible fuels, but in the opposite direction. Starting from similar low levels in the two decades from 1960 to 1979, nuclear energy production in France begins to surge relative to the counterfactual from 1980 onwards. By 2005, France's nuclear

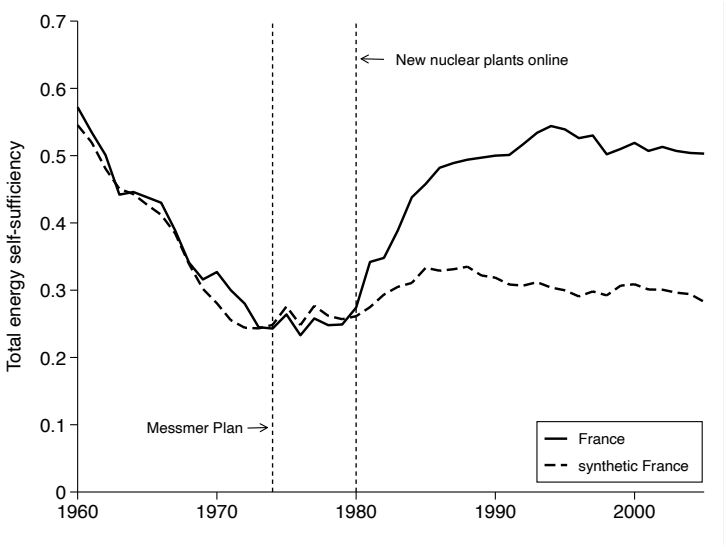


Figure 6: Energy Self-Sufficiency between 1960-2005.

Note: Energy self-sufficiency is the ratio between national production and consumption of primary energy in a year. As such, the measure shows how dependent the country is on imports for its energy needs.

energy production was roughly triple that of synthetic France.

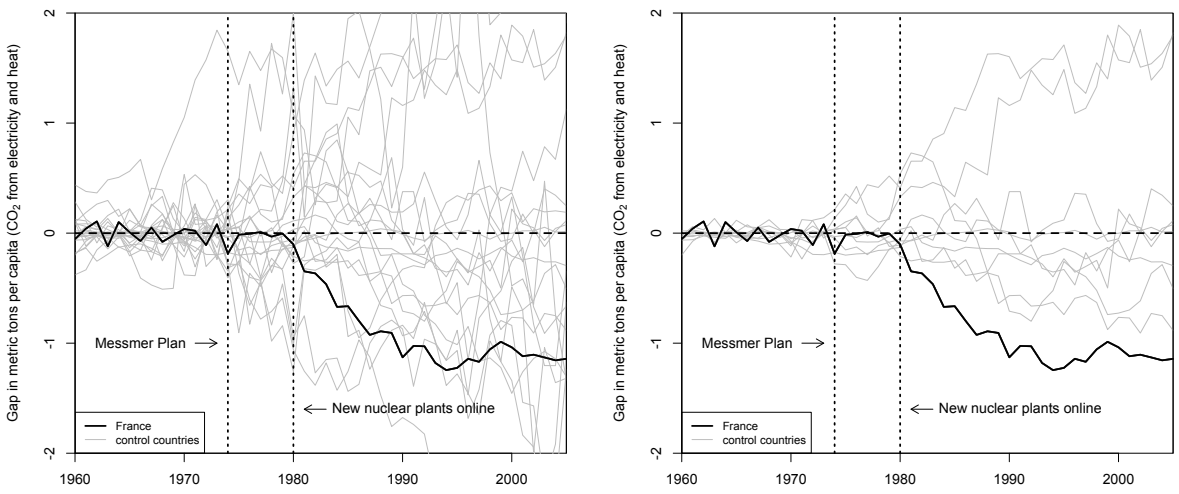
Lastly, the Messmer Plan was also successful in acheiving its stated aim of increasing energy security by reducing France's dependence on imported oil. Figure 6 shows that France and its counterfactual experience a similar decline in energy self-sufficiency in the pretreatment period but as new nuclear reactors come online, the two series diverge. From 1990 onward, France is again above 50% in self-sufficiency, returning to the level observed at the start of our sample period.

5.3 Significance Testing of Main Results

To assess the statistical significance of the estimated emission reductions from electricity and heat production, we use the t-test for synthetic controls proposed by Chernozhukov, Wuthrich, and Zhu (2025) (CWZ) and complement it with in-space placebo inference following Abadie, Diamond, and Hainmueller (2010).[11] The CWZ procedure indicates that the average posttreatment effect is statistically significant at conventional levels, while the placebo-based evidence is qualitatively similar but weaker.

The "t-test for synthetic controls" (Chernozhukov, Wuthrich, and Zhu, 2025) is designed for inference on the average treatment effect over a specified posttreatment period in canonical synthetic-control settings, which corresponds closely to our object of interest. Intuitively, the synthetic control estimator may be biased because the weights are estimated and because the synthetic control may not perfectly approximate the untreated outcome path. To address this, CWZ use a K-fold cross-fitting procedure over the pre-

[11]The results from additional robustness tests – including in-time placebo, leave-one-out, specification-searching, and placebo-sector exercises – are presented in Online Appendix C.



(a) France and 21 control countries

(b) France and 9 control countries

Figure 7: Permutation Test: Per capita CO_2 Emissions Gap in France and Placebo Gaps for the Control Countries.

Note:The left figure shows the gap in CO_2 emissions in France and placebo gaps in all 21 control countries. The right figure shows the gap in France and placebo gaps in 9 control countries, excluding those with a pretreatment MSPE double that of France.

treatment period: they divide the pretreatment period into K blocks and, for each block, estimate the synthetic-control weights on the remaining $K-1$ blocks and evaluate the prediction error on the held-out block. These out-of-sample prediction errors are then used to estimate and remove the bias in the average posttreatment effect. Inference then proceeds using a self-normalized t-statistic constructed from the dispersion of the resulting block-specific bias-corrected estimates, yielding conventional confidence intervals without relying on permutations or long-run variance estimation.

Setting the posttreatment period to start in 1980, when new reactors came online, we find an average emission reduction of 1.005 metric tons of CO_2 per capita, which is significant at both the 10% level (confidence interval of 0.732 to 1.279) and the 5% level (confidence interval of 0.602 to 1.408).[12]

As a complementary exercise, we also perform the standard in-space placebo analysis (Abadie, 2021). Here, each country in the donor pool is iteratively treated as if it had experienced the intervention, with synthetic counterparts derived using the predictors from Table 2. This approach allows us to assess whether the estimated emission reductions

[12]The results remain significant at the 5% level if the posttreatment period starts in 1974. Following the authors' recommendation we set $K = 3$. If we instead set $K = 2$, we find an average emission reduction of 0.956, which is significant at both the 10% level (0.824, 1.088) and the 5% level (0.690, 1.221). Since the t-test methodology utilizes only lagged values of the outcome variable as predictors, this specification does not include our full set of predictors from Table 2. Reassuringly, the resulting estimate is very similar to our main results.

for France are unusually large by comparing them to the placebo outcome for all other countries in the donor pool. This kind of permutation test draws inferences and calculates p-values by finding the percentage of countries with estimated emission reductions at least as large as that found for France.

The results of the in-space placebo test are shown in Figure 7. As frequently observed, the synthetic control method can fail to find convex combinations of other countries that accurately reflect pretreatment period outcomes (Abadie, Diamond, and Hainmueller, 2011; Andersson, 2019). This is especially true for outliers; in our case, countries with, for instance, consistently the highest emission level before treatment (like the US). When we exclude countries with a poor pretreatment fit, defined here as having a mean squared prediction error (MSPE) more than twice as large as France's, we are left with the ten countries illustrated in Panel (b).[13] France here displays the largest emission reduction in the posttreatment period, especially from 1980 and onwards, and the p-value of estimating an emission reduction of this size is thus $1/10 = 0.10$.

5.4 Potential Spillover Effects

Our estimated emission reductions attributed to the Messmer plan could be biased if the Plan affected either nuclear energy policy in the countries that constitute synthetic France or electricity trading between them and France. In this section, we analyze the possibility of spillover effects and find little evidence that they are a significant concern.

5.4.1 Nuclear energy policy spillovers

If neighboring countries reduced their nuclear energy deployment in response to the Messmer Plan, opting instead to rely on electricity imports from France, this would bias our estimated reductions by increasing observed emissions in the countries that make up the synthetic control. However, for such a strategy to have been viable in the early 1970s, policymakers would have had to anticipate a series of developments that were far from certain at the time. For example, they would have had to foresee that: European electricity markets would become increasingly liberalized, allowing for large-scale cross-border electricity flows; France would successfully implement the Messmer Plan, overcoming political, economic and social hurdles that had stalled or derailed similar large-scale nuclear programs in other countries; France would increase electricity exports significantly, well beyond the modest levels seen in the 1960s and 1970s; and French nuclear electricity would

[13] Further details on the retained countries are presented in Online Appendix C.1, together with details on a two-sided post/pretreatment MSPE ratio test following Abadie, Diamond, and Hainmueller (2010). In this test, France's ratio ranks third among the 22 units in the sample, corresponding to a p-value of 0.136. The pretreatment MSPE is defined as $MSPE = \frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}\right)^2$.

become cost-competitive with domestic fossil-based generation, making imports economically attractive. Each of these assumptions involved substantial uncertainty when viewed from the vantage point of the early 1970s.

From 1960 to 1990, the European electricity market was dominated by vertically integrated national monopolies. Cross-border electricity trading existed but was a small share of electricity production and often limited to bilateral contracts, primarily implemented for grid-stability and not driven by market forces (Batalla-Bejerano, Paniagua, and Trujillo-Baute, 2019). Figure 8a shows that France did not export much electricity in the 1960s and 1970s, especially compared to the OECD average. For instance, electricity exports were less than 50% of the level in an average OECD country in the 1970s.

Electricity trading within Europe did increase in the 1980s. However, it was not until the late 1990s – with the adoption of the First Energy Package in 1996 and the beginning of EU-wide electricity market liberalization in 1999 – that internal EU market integration began (Batalla-Bejerano et al., 2019). This was 25 years after the adoption of the Messmer Plan and, even then, France's participation in the liberalization process was limited, since it only complied with the minimum requirement of a 25% market opening (Le Quesne, 2000). Furthermore, many countries were cautious about relying on electricity imports for energy security reasons. Germany, for example, maintained legislation in the 1980s requiring its industry to purchase electricity generated from domestic coal rather than French imports (Jasper, 1990).

Regarding the price competitiveness of nuclear energy compared to fossil fuels, this only became apparent in hindsight, following external shocks such as the 1979 oil crisis and the tightening of air pollution regulation in Europe in the 1980s, which increased coal prices (Smith et al., 2011; IEA, 2015).[14] These developments could not have been foreseen in the early 1970s.

On the other hand, if the countries in synthetic France increased their nuclear energy ambitions as a result of the Messmer Plan, this would again bias the estimated emission reductions – as observed emissions in synthetic France will now be lower than they would have been in the absence of the Messmer Plan. However, data on nuclear energy deployment in counterfactual countries do not support this scenario.

Austria had a nuclear power program in place in the early 1970s with a plan for three nuclear power plants. The first, the Zwentendorf nuclear power plant, began construction in 1972 and was finished in 1978. However, the plant never went into commercial operation following a referendum on nuclear energy in November 1978. After this, no new nuclear reactors were initiated.

Belgium has two nuclear power plants, Doel and Tihange, which began construction

[14]The convention on Long-Range Transboundary Air Pollution (LRTAP) went into effect in 1983, and the protocol on the Reduction of Sulphur Emissions was implemented in 1985, both with the aim of reducing sulphur dioxide emissions in Europe.

in 1969 and 1970, respectively. Doel is comprised of four reactors and Tihange has three. The decision to build each of these seven reactors was taken before the announcement of the Messmer Plan (IAEA, 2020). No more reactors or nuclear power plants were ordered after this.

Germany has built 36 nuclear reactors in total. Of these, 13 began construction between 1974 and 1982 – after the Messmer Plan was announced – but only one of these 13 was ordered after 1976 (Campbell, 1988). Nevertheless, Germany's weight in the synthetic counterfactual is just 4%, so any potential spillover effect should be small.

Portugal has built no nuclear reactors. At the peak of its programme, Switzerland had five nuclear reactors, with four still in operation today. All reactors began construction before the Messmer Plan was announced. The last reactor to begin construction was Leibstadt on January 1st, 1974.

Taken together, there is no evidence that the countries in synthetic France increased their nuclear energy ambitions in response to the Messmer Plan.[15] [16]

5.4.2 Electricity trading spillovers

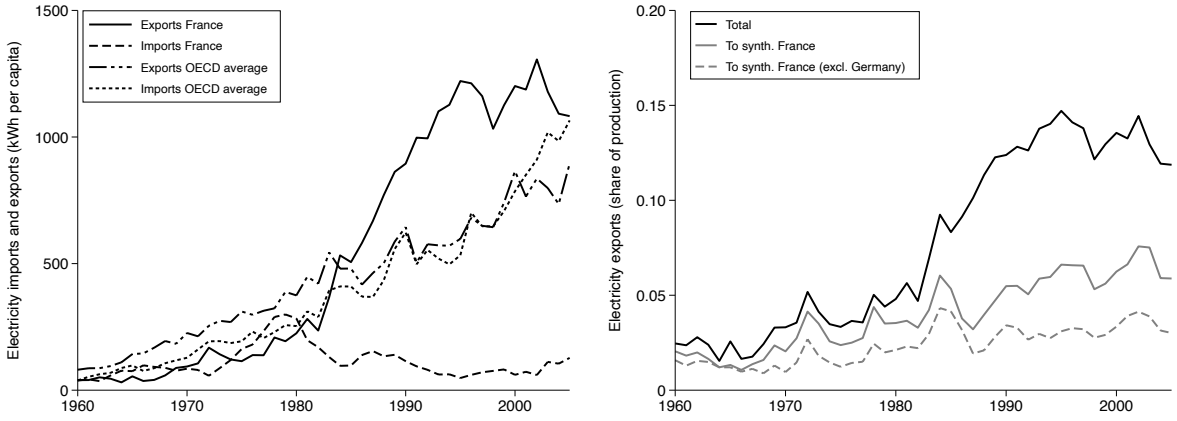
Even if the Messmer Plan did not affect nuclear energy policy in the countries of synthetic France in the decade immediately following its implementation, it is conceivable that by the mid-1980s – when new reactors from the Plan came online and France's electricity exports began to increase – these countries scaled back or postponed their own energy investments in favor of importing French electricity. However, this hypothesis also receives limited support from the data.

Figure 8a illustrates that electricity trading increased across all OECD countries over time, with France showing a similar upward trend for exports. Yet, electricity production also significantly increased in all OECD countries during this time. In France, total electricity production grew more than seven-fold from 1960 to 2005. To account for this, Figure 8b plots French electricity exports relative to electricity production.

This relative measure shows an increased export share in the posttreatment period, averaging about 11 % of total electricity production. However, the share of exports going to countries making up synthetic France remains relatively stable, and increasing only slightly in the posttreatment period.

[15] The countries in the synthetic counterfactual were not unique with regards to their slowdown in the deployment of nuclear reactors. For instance, the US did not order any new reactors between the late 1970s and the end of our sample period, and the vast majority of US reactors in operation today were ordered before 1974 (Davis, 2012).

[16] Apart from nuclear energy, governments tended to promote sources of electricity upon which they historically relied. For Austria, Portugal, and Switzerland this meant hydropower (Nunes 2018; Wagner et al 2015), while for Belgium and Germany it meant coal (Sill 1986; Storchmann 2005). Several policy tools were used, including subsidies and public financing. To our knowledge, no donor country pursued a large-scale industrial policy for either hydropower or coal.



(a) OECD and France

(b) Electricity exports from France

Figure 8: Electricity Imports and Exports: 1960-2005.

On average, between 1980-2005, 5.4% of France's annual electricity production is exported to countries in synthetic France, while imports from these countries represent 1.3% of France's electricity consumption. Therefore, the spillover effects from electricity trading between France and its synthetic counterpart are relatively modest. Excluding Germany – which has a small weight in synthetic France – further reduces this spillover, with exports to synthetic France then accounting for just 3.1% of annual electricity production during the posttreatment period.[17]

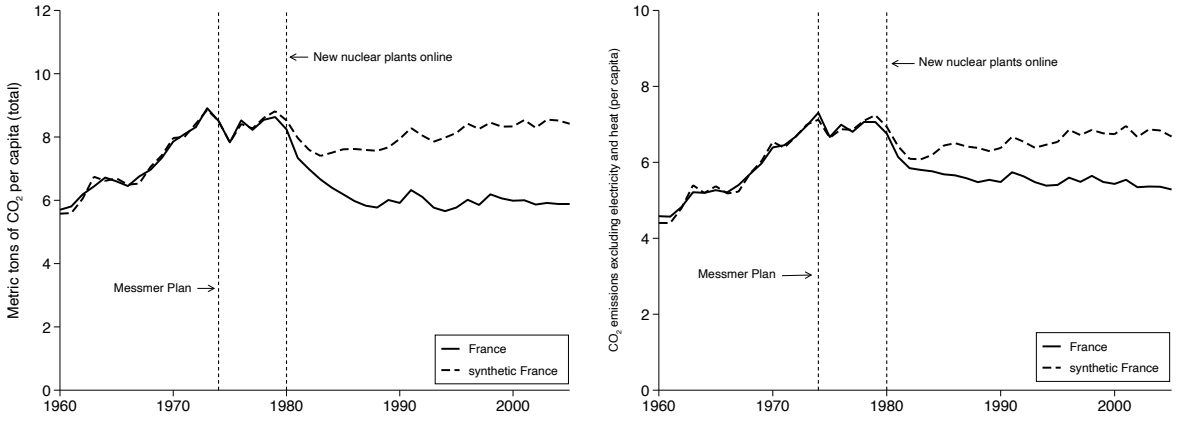
In conclusion, we expect few spillover effects of the Messmer Plan on nuclear energy policy and electricity trading in synthetic France countries. Any that do exist are likely small and unlikely to significantly bias our emission reduction estimate.[18]

5.5 Total Emission Reductions

While the Messmer Plan primarily affected electricity and heat production, it may also have indirectly influenced CO_2 emissions in other sectors. Using the country weights specified in Table 1, we evaluate the consequences of the Messmer Plan on France's total CO_2 emissions. Figure 9a indicates that from 1980 onward, the average per capita reduction in emissions amounts to 1.88 metric tons, which is a 23% reduction in total CO_2 emissions. This number is almost exactly double the emissions reduction we observed solely in the electricity and heat sector, which was 0.92 metric tons per capita. As

[17]Beyond synthetic countries, France also exported electricity to Italy, Luxembourg, Spain and the UK – just over half of all electricity exports are going to these four countries in the posttreatment period. The noticeable increase in exports in the mid-1980s coincides with the completion of an undersea electric cable between France and the UK in 1986. Before this, there was almost no electricity exports to the UK from France.

[18]Online Appendix D provides further spillover analysis by estimating emission reductions from a consumption-based approach, adjusted for electricity trading. This approach shows slightly larger emission reductions from the Messmer Plan in the posttreatment period compared to our main results, although the difference is small.



(a) Total CO_2 emissions (b) Excluding electricity and heat emissions

Figure 9: Path Plot of CO_2 Emissions 1960-2005: France versus Synthetic France.

Note: Panel (a) depicts total CO_2 emissions per capita, while panel (b) excludes emissions from electricity and heat production.

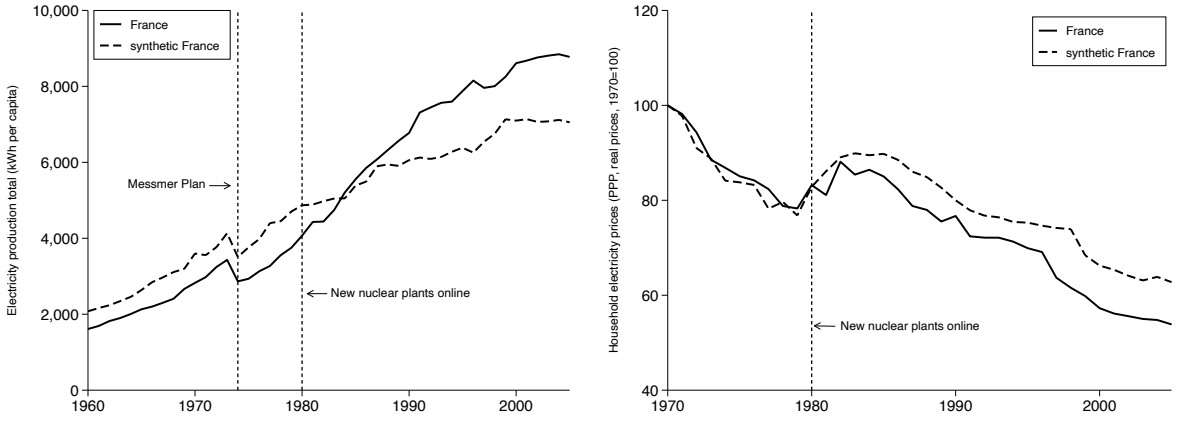
shown in Figure 9b, the remaining 0.96 metric ton reduction in emissions between 1980 and 2005 comes from sectors other than electricity and heat production.[19] Specifically, industry accounts for a relative reduction of 0.51 metric tons, while the residential and services sectors together contribute another 0.45 metric tons.[20] Interestingly, the emission reductions from these sectors also coincide with the roll-out of new nuclear reactors from 1980 onward.

To account for this additional emissions cut of almost 1 ton per capita, we explore two separate hypotheses, which are not necessarily mutually exclusive. The first posits that fuel-switching occurred. For instance, if the Messmer Plan led to an increase in electricity production, beyond merely replacing fossil fuels with nuclear energy, it would likely result in a decrease in electricity prices. This price reduction could prompt a shift away from fossil fuels in other sectors, encouraging greater electricity consumption instead, particularly in the industrial, residential and services sectors.[21] This would result

[19] As a simple engineering benchmark for emissions outside electricity and heat production, we divide these rest-of-economy emissions by total final energy consumption (IEA, 2022c), excluding non-energy use, to obtain the emissions factor of final energy consumption. Holding this emissions factor fixed at its 1974–1979 average and applying it to observed final energy consumption over 1980–2005 yields a naïve counterfactual for emissions outside of electricity and heat production. The difference between this counterfactual and observed rest-of-economy emissions implies an average reduction of 1.35 tons of CO_2 per capita in an average year.

[20] We merged the residential and services sector data, as the IEA was unable to differentiate oil consumption between these sectors before 1985 (IEA, 2022c, p. 129). Furthermore, we allocated emissions from autoproducers to the industry sector, as recommended by the IPCC guidelines. Lastly, no relative emission reductions were observed in the transport, agriculture, and forestry sectors between 1980-2005.

[21] These three sectors combined account for nearly 90% of France's total electricity consumption during our study period. Since electric vehicles were not a meaningful part of the vehicle fleet during our study period, the transport sector could not benefit from an increased supply of electricity as an energy source. In 2005, electricity provided less than 3% of the energy consumed in the transport sector in France, and the average during the period 1980-2005 was around 1.5%.



(a) Total electricity production

(b) Household electricity prices

Figure 10: Total Electricity Production and Prices: France versus Synthetic France.

Note: Electricity production is measured in kWh per capita, and only includes electricity from main activity producers between 1974-2005. Electricity prices include taxes and are measured in real terms and adjusted for differences in purchasing power. To ease comparisons over time, the prices are given as an index, with 1970=100. Note that panel (b) starts in 1970, due to missing data for years prior.

in a comparative emissions reduction relative to a counterfactual scenario. The second hypothesis suggests that a relative economic downturn in France during the posttreatment period suppressed CO_2 emissions.

Figure 10 charts the trajectories of electricity production and household electricity prices between France and its synthetic counterpart. Until 1980, electricity production followed parallel trends. Subsequently, France witnessed a faster growth rate for a decade, coinciding with the extensive rollout of new nuclear reactors. Although the growth rates re-aligned in the 1990s, France's total electricity production consistently outpaced that of its synthetic counterpart. This elevated level of production contributed to lower household electricity prices in France from 1980 onward, as illustrated in Panel 10b.[22]

For an increase in electricity production and a concurrent drop in household electricity prices to occur, the supply curve must shift outward. This typically occurs when the marginal cost of production falls – due to technological progress or reduced input costs. In France, this outward shift was also driven by EDF's anticipation of growing future demand, encouraged by the Messmer Plan's emphasis on electrification and long-term demand projections (Brouard and Guinaudeau, 2015). Consequently, nuclear capacity expanded significantly, both through new plant construction and additional reactors at existing sites. This increased supply helped reduce electricity prices. Furthermore, the shift from fossil fuels to nuclear power likely lowered marginal costs, reinforcing the price

[22]Since at least the early 1970s, EDF operated under multi-year state agreements that included pricing frameworks, which remained unchanged until EU market liberalization in the late 1990s (Hancké, 2002). As Figure 10b shows, electricity prices in France and its counterfactual tracked closely in the 1970s but diverged after 1980, with French prices falling more sharply. This indicates that the Messmer Plan contributed to lower electricity prices – even under continued price regulation.

decline. In the 1980s, nuclear energy became more cost-competitive, aided by rising oil prices after the 1979 oil crisis, that increased prices of all fossil fuels in France (IEA, 2025a), and the phase-out of cheaper high-sulphur coal (Smith et al., 2011; IEA, 2015).

To investigate the validity of the fuel-switching hypothesis, we examine energy consumption across the economy, focusing on both electricity and combustible fuels. In Figure 11, we observe a notable increase in the proportion of energy consumption derived from electricity within the residential, services and industry sectors. Concurrently, there is a corresponding decline in the proportion of energy obtained from combustible fuels. In Online Appendix E, we further decompose energy use by individual fuels: electricity, oil, natural gas, and coal. Overall, following the roll-out of new nuclear reactors in 1980, there is a substitution away from oil and towards electricity and natural gas. This trend supports the notion of fuel-switching, which offers an explanation for the observed reductions in CO_2 emissions from sectors other than electricity and heat production.

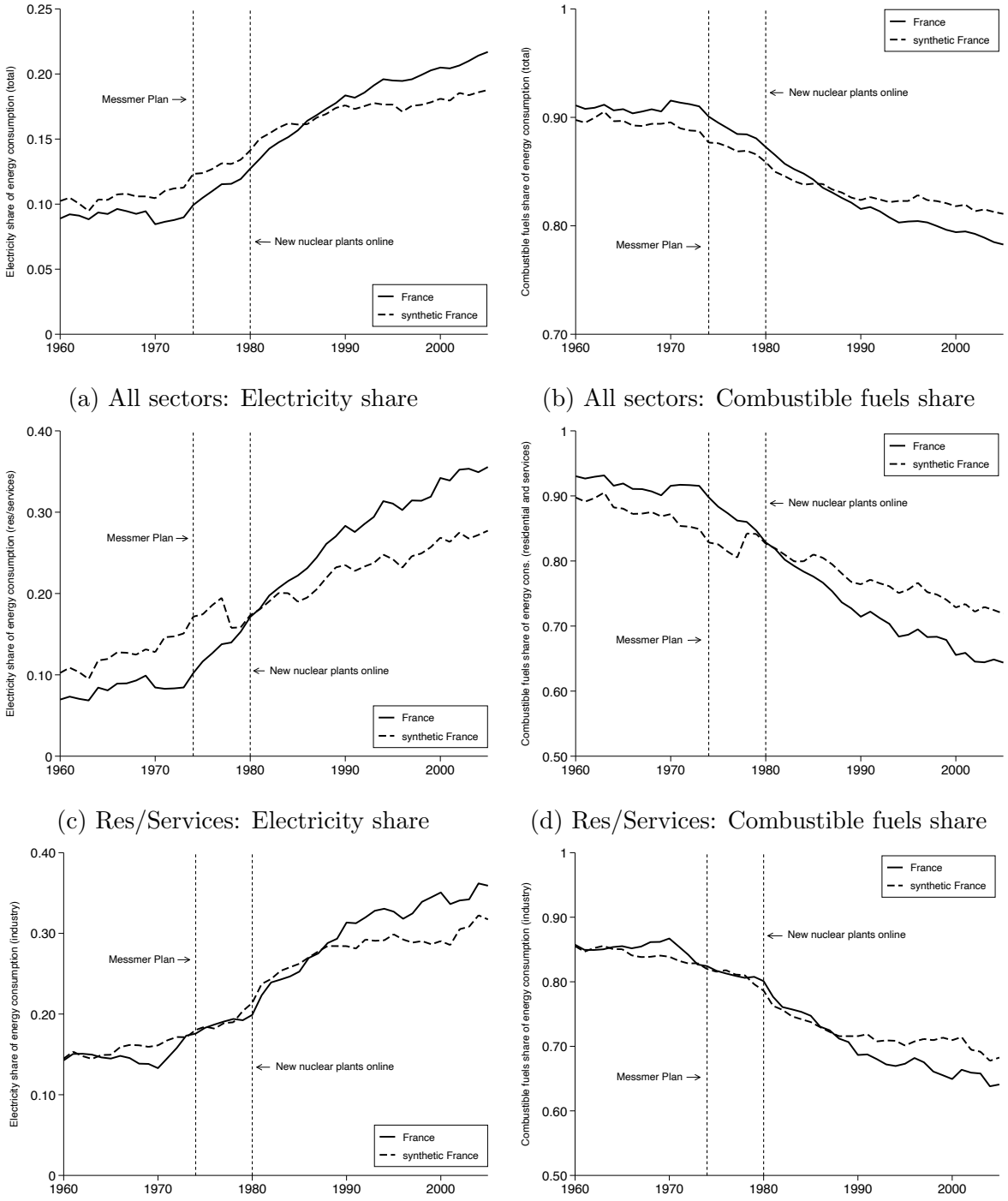
To explore the alternative hypothesis regarding potential emissions reductions driven by an economic downturn, we analyze the two macro variables of gross domestic product (GDP) and unemployment. In Figure 12, the evolution of real GDP per capita during the pretreatment period aligns closely, followed by a slightly higher GDP level in France after the initial oil crisis and until the mid-1980s. However, from 1990 onwards, France's GDP level shows a relative decline. This trend is reflected in the unemployment rate, with France consistently experiencing a notably higher unemployment rate – on average, 2.8 percentage points higher – compared to synthetic France between 1980 and 2005. These macroeconomic indicators lend credence to the alternative hypothesis, suggesting the presence of a relative economic downturn, which, in turn, may have contributed to reduced CO_2 emissions, given the well-established correlation between economic growth and CO_2 emissions (Holtz-Eakin and Selden, 1995; Sheldon, 2019; Mardani et al., 2019).

We have evidence in support of both hypotheses, and they do not need to be mutually exclusive. To establish which hypothesis has the largest effect on relative emission reductions, we conducted a regression analysis aimed at determining the magnitude of the confounding effect originating from the macro variables of GDP and unemployment. This analysis was compared against the effect resulting from the increased share of nuclear energy in electricity production, with all variables calculated as the gap between France and synthetic France.

The following OLS regression model was tested:

$$\Delta CO2_t = \alpha + \Delta X_t \beta + \epsilon_t \tag{1}$$

where $\Delta CO2_t$ is the annual gap between France and its synthetic counterpart in total per capita CO_2 emissions; ΔX_t is a vector of the key explanatory variables: the annual gaps in the share of nuclear in electricity production, GDP per capita and unemployment; and



(a) All sectors: Electricity share

(b) All sectors: Combustible fuels share

(c) Res/Services: Electricity share

(d) Res/Services: Combustible fuels share

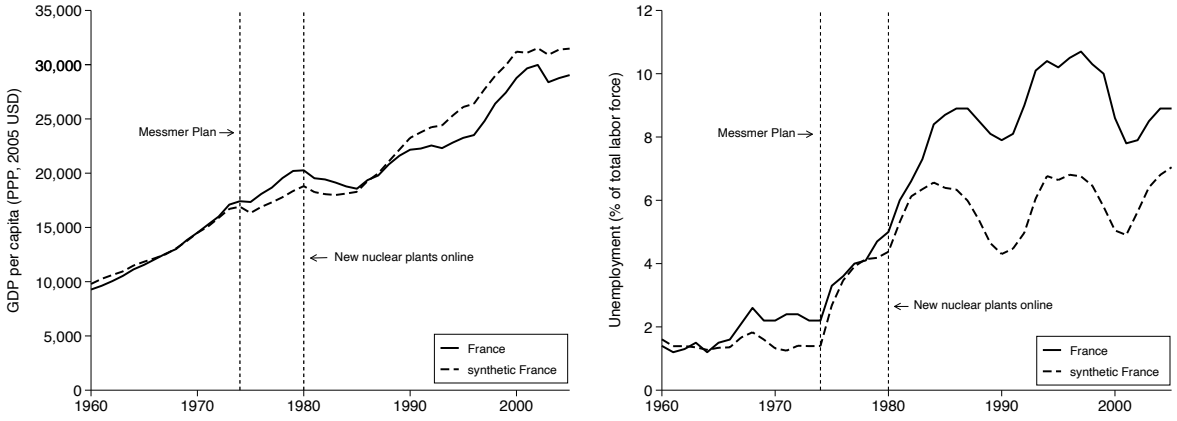
(e) Industry: Electricity share

(f) Industry: Combustible fuels share

Figure 11: Electricity and Combustible Fuels share of Energy Consumption.

Note: The left panels show the electricity share and the right panels the combustible fuels share of energy consumption, with all energy sources converted into oil equivalents. Panels (a)–(b) cover total energy consumption (industry, residential, services, transport, agriculture/forestry, fishing, and other combined), (c)–(d) the residential and services sectors, and (e)–(f) the industrial sector. Source: International Energy Agency (2022c) – World Energy Balances.

ϵ_t is idiosyncratic shocks. The time period runs from 1960-2005, with 46 observations in total.



(a) GDP per capita

(b) Unemployment

Figure 12: GDP per capita and Unemployment between 1960-2005: France versus Synthetic France.

Note: GDP per capita is Purchasing Power Parity (PPP)-adjusted and measured in 2005 U.S. dollars. Unemployment is measured as percentage of total labor force.

Table 3 provides the results. When running each explanatory variable separately, all the coefficients are statistically significant and have the expected signs, with the gap in the share of nuclear showing the largest predictive power with an R^2 of 0.95. However, when running the full model (column 7) the coefficient for GDP is reduced by almost 80% in size and the coefficient on unemployment is now close to zero and no longer statistically significant. The coefficient for the nuclear gap is, however, significant and similar in size in all regression models where it is included.

Using the average gap in the share of nuclear between 1980-2005 of 39.2 percentage points we compute an average emission reduction in the posttreatment period of 1.74 metric tons of CO_2 per capita. The average gap in GDP is -$1169 in the same time period, which gives an average emission reduction of 0.15 metric tons per capita. Lastly, the average gap in unemployment of 2.8 percentage points gives an average emission reduction of <0.01 metric tons per capita.

Adding up the effects of the three key explanatory variables we calculate a total average emission reduction of 1.89 metric tons in the posttreatment period, which matches the 1.88 metric tons that we compute from Figure 9a. Of this total, the gap in nuclear explains 92%, and the macro variables of GDP and unemployment explains the remaining 8%. The conclusion we draw from the regression result is that fuel-switching likely accounts for the largest share of the emission reductions found in the non-electricity and heat sectors in the posttreatment period, and that the relative economic downturn, while significant, is less impactful.

The synthetic control estimate implies a 23% reduction in total CO_2 emissions in the posttreatment period. Attributing the portion associated with the relative decline in GDP per capita and rise in unemployment to factors outside the Messmer Plan reduces

Table 3: Regression Results for Gap in Total CO_2 Emissions Estimations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nuclear share	-5.089***			-4.455***		-4.782***	-4.443***
	(0.286)			(0.307)		(1.018)	(0.690)
GDP per capita		0.594***		0.125***	0.226		0.125***
		(0.093)		(0.042)	(0.148)		(0.040)
Unemployment			-0.640***		-0.482***	-0.047	-0.002
			(0.054)		(0.124)	(0.112)	(0.081)
Observations	46	46	46	46	46	46	46
R^2	0.953	0.624	0.794	0.966	0.836	0.953	0.966

Notes: All variables are computed as the gap between France and Synthetic France. The dependent variable is the gap in total per capita CO_2 emissions (metric tons). The gap in the share of nuclear is measured in percentage points (divided by 100). Real GDP per capita is Purchasing Power Parity (PPP)-adjusted and measured in 2005 U.S. dollars (thousands). Unemployment is measured as percentage of total labor force. Newey-West standard errors in parentheses; heteroscedasticity and autocorrelation robust. The constant is omitted from the output.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the implied effect to just over 21%. France also shifted relatively more toward natural gas in the residential, services and manufacturing sectors. The effect on emission from this substitution is considerably smaller than the shift from oil to electricity, since the latter removes the full carbon content of the displaced fuel from these sectors (see Online Appendix E). Allowing conservatively for this channel, and assuming it's not an indirect effect of the Messmer Plan, we report total emission reductions attributable to the Messmer Plan at around 20%.

5.6 Timeframe for Emission Reductions

As shown in Figures 3 and 4, our results indicate a delay of six years between the policy announcement and the onset of emission reductions – what we term the "transitional period". Yet, despite this initial lag, the emission reductions were substantial and swift once the reactors became operational. By 1984, ten years after the Messmer Plan's announcement, France's CO_2 emissions from electricity and heat production had halved, compared to the counterfactual scenario, and by 1987 they had dropped almost 80%.

The length of the transitional period matches well the average build time of the new reactors. From construction start to commercial operation, the reactors ordered between 1974-1976, just following the announcement of the Messmer Plan, had an average build time of 75.4 months (just over six years), with a standard deviation of 9.7 months and a range of 59 months to 100 months (IAEA, 2023a). This average is similar to the average build time of seven years for all nuclear reactors that have ever been completed in France.

While this time frame does not include planning and permit acquisition, it remains notably shorter than the most recent European examples. For instance, Finland's Olkiluoto 3 reactor, which began construction in 2005, only became commercially operational in 2023. Similarly, construction of Flamanville 3 in France began in 2007 and was connected to the grid toward the end of 2024.

The average build time in France was also shorter than reactor construction times in other countries during this time period, such as Sweden, the US, and Germany. A likely explanation for the relatively shorter construction times in France were the standardized reactor type used throughout the implementation of the Messmer Plan and streamlined planning procedures (Campbell, 1988; Lucas, 1979; Thomas, 1988).

5.7 Abatement Cost

In the final part of our empirical analysis, we estimate the average abatement cost (AAC) of the Messmer Plan as the discounted incremental cost of electricity generation in France relative to the synthetic counterfactual, divided by the total CO_2 reductions attributable to the policy. The estimate is constructed from technology-specific costs of electricity, generation shares, and total electricity production from main activity producers, while including both direct emissions reductions in electricity and heat production and indirect reductions induced by fuel switching in other sectors.

To compare electricity production costs across different sources, we use the concept of Levelized Cost of Electricity (LCOE). It is typically used to compare the cost of adding new capacity across technologies. LCOE accounts for all costs related to the entire lifespan of a power plant, including capital construction, operation, maintenance, fuel, decommissioning and waste management. These costs are adjusted for inflation and discounted back to their present value, summed up and then divided by the expected amount of electricity produced. LCOE estimates are sensitive to the specific circumstances of each country, considering factors such as labor and fuel costs. This means that the LCOE for a particular technology will vary from one country to another in the same year. Under standard assumptions, the LCOE gives an estimate of the average lifetime cost of electricity from a new plant of a given technology, evaluated under the cost conditions prevailing in a specific year and country, and is often expressed in US dollars per megawatt-hour (MWh). While LCOE has important limitations (see, for instance, Joskow, 2011; IEA, 2015), it remains a widely used metric for comparing electricity generation costs across technologies, countries, and over time.

Using the levelized cost concept, we compute the average abatement cost of the Mess-

mer Plan as follows:

$$AAC = \frac{\sum_{t=1980}^{2005} \left(C_t^{FRA} - C_t^{synFRA} \right) (1+r)^{-(t-1980)}}{\sum_{t=1980}^{2005} \left(CO2_t^{synFRA} - CO2_t^{FRA} \right)}, \tag{2}$$

where

$$C_t^j = q_t^j \sum_k s_{k,t}^j LCOE_{k,t}^{FRA}, \qquad j \in \{FRA,\ synFRA\}. \tag{3}$$

Here, q_t denotes electricity production from main activity producers in year t; $s_{k,t}$ is technology k's share in the generation mix in each year; and $LCOE_{k,t}$ is the levelized cost of each technology. Thus, C_t denotes annual generation cost, based on total generation, the technology mix, and technology-specific LCOEs. The cost differential in the numerator is discounted to 1980 using the discount rate r. Lastly, $CO2_t$ is the total amount of carbon dioxide emissions from the economy in year t.

Our abatement cost estimate is reported in present-value terms, using a 5% discount rate consistent with the discount rate underlying the LCOE inputs. In our main specification, we discount cost changes but not physical emissions reductions. Online Appendix F reports both undiscounted estimates and alternative present-value calculations as sensitivity checks.

When computing the AAC, we make three simplifying assumptions. First, to compute C_t^{synFRA} we use the generation mix in synthetic France in each year, but we price each technology using the LCOE estimates for France. This reflects the interpretation of the counterfactual as "France without the Messmer Plan": the relevant comparison is a different generation mix operated under French cost conditions (e.g., fuel, labor, and financing costs), rather than importing donor-country cost levels that need not apply to France and are only sparsely observed in the historical LCOE data.[23] At the same time, this approach abstracts from general-equilibrium effects of the Messmer Plan on technology costs (e.g., learning, standardization, or redirected innovation); we therefore report sensitivity checks using alternative cost assumptions in Online Appendix F.

Second, we treat hydropower generation as exogenous to the Messmer Plan. Hydropower capacity is largely site-constrained and hydro output in France is broadly stable over 1960–2005, averaging about 1,000 kWh per capita. Because consistent historical LCOE data for hydropower are unavailable, and because the main policy margin is between nuclear and combustible fuels, we compute generation costs using electricity production net of hydropower. In the baseline calculation, we therefore hold hydropower fixed at France's observed level in both the realized and counterfactual scenarios, so that hydro costs cancel in incremental cost calculations.[24]

[23] We do not have consistent LCOE data for nuclear and combustible fuels for all of the countries that constitute synthetic France in the posttreatment period IEA (2015).

[24] Online Appendix F reports a robustness check in which hydropower in synthetic France is allowed

Table 4: Inputs for the Average Abatement Cost Calculation

	1981	1984	1989	1992	1998	2005
Nuclear LCOE	60.66	40.44	56.20	58.50	47.93	32.13
Coal LCOE	47.63	72.72	81.22	90.25	68.95	41.17
Nuclear share France	59.0	82.7	91.1	91.0	91.9	90.5
Nuclear share synthetic France	35.4	52.7	58.5	57.3	53.9	47.1
Electricity production France	3.22	4.10	5.76	6.32	7.02	7.89
Electricity production synth Fra	3.68	3.95	5.11	4.97	5.76	6.17
Total reduction in CO_2	0.63	1.10	1.66	1.94	2.27	2.54

Notes: The levelized cost of nuclear and coal is computed using a 5% discount rate and measured in 2013 USD/MWh. Nuclear share refers to the proportion of nuclear energy in total electricity production from main activity producers, excluding hydropower. Electricity production represents output from main activity producers (excluding hydropower) and measured in MWh per capita. Finally, CO_2 emission reductions are measured in metric tons per capita.

Third, we use the levelized cost of coal to represent all combustible fuels. This choice is primarily influenced by data availability, as the IEA provides consistent LCOE estimates for coal and nuclear in France between 1980-2005, but only sparsely for natural gas and no estimates are given for oil. However, coal constitutes more than three fourths of the combustible fuels used for electricity production in France between 1980-2005, and the levelized cost of natural gas consistently exceeds that of coal for those years that an estimate for both are given. This assumption is conservative in the sense that it lowers the estimated cost of the counterfactual scenario, which biases the abatement cost upward.

We sourced our LCOE data from the IEA (2015). The data originates from reports prepared in collaboration by the IEA, the OECD and the Nuclear Energy Agency, with figures provided for the years 1981, 1984, 1989, 1992, 1998, and 2005. While these estimates are not annual, they do span most of the posttreatment period we are interested in. We do not interpolate LCOE values for the intervening years. This means our estimate from equation (2) captures the cost and emissions picture at six points across the posttreatment period, which we treat as representative of the overall trajectory.[25] The LCOE calculations in IEA (2015) were done using a 5% discount rate and presented in units of 2013 USD per MWh. Table 4 presents the LCOE data, along with information on fuel shares, electricity production numbers and the yearly reductions in total CO_2

to vary with the donor-weighted counterfactual. Since this case does not price the incremental cost of additional hydropower in the counterfactual, it should be interpreted as a conservative benchmark.

[25]An alternative approach would be to reconstruct annual investment costs by tracking yearly capacity additions, applying year-specific construction costs, and adding operation, maintenance, and fuel costs separately based on contemporaneous generation. However, this approach is not feasible with the available historical data.

emissions.

Using equation (2) and the data in Table 4, we estimate an average abatement cost of -\$0.9 per metric ton of CO_2. This near-zero estimate reflects the fact that the Messmer Plan produced slightly lower generation costs than the counterfactual, while generating sizable emissions reductions. On the cost side, the Plan increased electricity production, which raised cumulative generation costs, but this effect was more than offset by lower nuclear generation costs in France and by the rising relative cost of fossil-fuel generation during the posttreatment period. On the emissions side, the Plan reduced CO_2 both directly in electricity and heat production and indirectly, through the fuel-switching and broader emissions effects estimated in our empirical analysis. Taken together, slightly negative incremental costs and broad emissions reductions imply an average abatement cost close to zero.

The relative cost advantage of nuclear compared to coal plays an important role for our estimate. While the LCOE of nuclear in France was relatively flat during the 1980s and declined notably between 1992 to 2005, similar trends were observed across other OECD countries (IEA, 2015).[26] What is more relevant for our analysis is that nuclear became increasingly cost-competitive relative to fossil fuels during the 1980s. The LCOE of coal in France rose during this period. This increase was likely due in part to efforts in the 1980s to reduce sulphur dioxide (SO_2) emissions that contributed to acid rain. These efforts led to the phase-out of cheaper, high-sulphur coal – raising fuel costs – and to the adoption of more expensive technologies at coal-fired power plants, such as scrubbers, which increased operational costs (Smith et al., 2011). In addition, the cost of coal (and natural gas) partly rose in response to the second oil crisis that began in 1979, as higher oil prices prompted substitution toward alternative fossil fuels (IEA, 2025a).

One potential objection to our estimated near-zero abatement cost is that the LCOE of coal is overstated since the numbers include construction cost. If the fossil fuel plants were already built, we should exclude the construction cost from our LCOE estimates. However, it is essential to consider three key factors. First, the substantial increase in electricity production during our sample period (see Figure 1b) suggests that France would have needed to build numerous new combustible fuel plants even if it had not adopted nuclear power. Second, fuel, operation and maintenance costs constitute the largest portion – around two thirds – of the levelized cost for coal-fired power plants in France (IEA, 2005). Lastly, the social costs of local air pollution from coal plants are not accounted for (IEA, 2020b), which, if included, would increase the LCOE estimates for coal substantially.[27]

[26] While France followed a similar time *trend* in nuclear LCOE as other OECD countries, the Messmer Plan likely helped keep costs at a lower *level* by reducing capital costs and standardizing reactor types, siting and authorization procedures. Throughout the posttreatment period, France's nuclear LCOE remains consistently about 20% below the average OECD level.

[27] According to one estimate from the European Commission (2003), accounting for the major external

Lastly, our AAC estimate should be interpreted as a measure of incremental electricity-system costs per ton of CO_2 reduced, rather than as a full welfare evaluation of the Messmer Plan. First, due to data availability, our LCOE-based calculation does not track annual capacity additions or annual construction and operation costs for the realized and counterfactual electricity systems. Instead, it uses technology-specific LCOE estimates to price the realized and counterfactual generation mixes at a set of benchmark years. The resulting AAC should therefore be interpreted as an approximate resource-cost measure, rather than as a full plant-level investment accounting of the Messmer Plan. Second, we price both the realized and counterfactual fuel mixes using French technology-specific LCOE series. This choice isolates the cost implications of shifting the generation mix within France, but it abstracts from the possibility that an alternative policy path would have altered innovation, learning, and procurement practices, potentially affecting both nuclear and fossil generation costs. Reassuringly, however, the LCOE trajectories for coal and nuclear are very similar in France and in the OECD and European averages over our sample period (IEA, 2015). Third, to the extent that part of the reduction in nuclear generation costs reflects public financing and loan guarantees, the LCOE estimates may understate social costs if raising public funds is distortionary. While the LCOE data incorporate capital costs borne by the sector, they do not separately identify the incidence of financing or the marginal excess burden of taxation. As such, our AAC may understate the full social cost per ton if such fiscal distortions were quantitatively important. At the same time, our measure does not capture some broader economic benefits of expanded electricity supply, such as higher economic output and consumer surplus, beyond the indirect emissions reductions already included.

6 The Political Economy of the Messmer Plan

The sections above establish large and significant emissions reductions associated with the Messmer Plan, as well as its costs. Here we explain the political economy of adopting and implementing the reform. We focus considerable attention on politics and policymaking because, though seemingly obvious, it is important to stress that the political success of the Plan was essential for it to lead to emissions reductions. And it was not obvious ex-ante that the Messmer Plan would be politically successful. It entailed a large-scale and capital-intensive intervention in the economy to restructure a pre-existing electricity sector of a major industrialized country. Such dramatic reforms to the status quo are difficult for any government to achieve. To be sure, similar large-scale nuclear plans in other industrialized democracies, such as Project Independence in the US or those in the UK, failed to achieve their goals (Campbell, 1988; Helm, 2003; Jasper, 1990; Williams,

costs, like local air pollution, of coal-fired electricity would roughly double its levelized cost in France during our posttreatment period.

1980).

Several conditions set the scene for a large-scale expansion of nuclear power in France.[28] First, given the country's high dependence on imported oil (see Section 3 above), the 1973 oil price spike constituted a significant exogenous shock, which presented the government with a clear and present energy crisis that required a response. Second, thanks to policy support since the Second World War, the infrastructure for a large-scale nuclear program was in place in France when the oil shock hit. Last, political and policymaking institutions in France provided the basis for a centralized and technocratic policymaking process that could be controlled from the executive branch. While all industrialized democracies were affected by the oil price shock and many had pre-existing nuclear programs similar to that of France, none expanded nuclear power at a similar pace and scale. As we show below, the key variable that set France apart from otherwise similar countries was the government's capacity to insulate policymaking and prevent the Plan's opponents from obstructing its adoption and implementation.

6.1 Explaining Political Success

Recent work in political science points to two political pathways that governments can use to overcome opposition to far-reaching energy reforms (Finnegan et al., 2025; Meckling et al., 2022). The first is *insulation*, which entails shielding, or insulating, the policymaking process from opponents so as to reduce their ability to influence the outcome. It can be enabled in several ways, for example, the delegation of policymaking to autonomous bureaucracies or technocratic bodies, centralized policymaking with few veto points and low levels of electoral competition and electoral accountability. With insulation, policy change occurs despite continuing opposition from opponents. The second mechanism is *compensation*, which aims to reduce the costs that opponents face as they transition to the new status quo, so as to incentivize them to cooperate and support reform. Here policy change occurs with the approval or indifference of opponents. Compensation can also take several forms, including direct financial payments, subsidies, tax cuts, phased implementation, transitional assistance and worker retraining. In the case of the Messmer Plan, French governments relied primarily on the insulation pathway.

6.1.1 Opposition to the Messmer Plan

Opposition to the Plan came from virtually all corners of French society (Brouard and Guinaudeau, 2015; Lucas, 1979; Papon, 1979; Jasper, 1990, Ch 9). Organized groups of nuclear scientists and engineers criticized the government's secrecy on nuclear matters and opposed the Plan on the grounds that it was too large and that there were unsolved challenges related to nuclear energy. At the same time, economists at the Institute of

[28]For full details see Online Appendix G.

Energy Economics and Law (Institut Économique et Juridique de l'Énergie (IEJE)) in Grenoble challenged the Plan's assumptions around future energy demand, costs and possible risks. Fossil fuel industries opposed a large expansion of nuclear power, as well as the substitution of electricity for fossil fuels in industrial and residential sectors, notably heating. The country's second largest trade union, the French Democratic Confederation of Labour (CFDT), opposed the Plan and proposed a three-year moratorium on nuclear construction on the basis that France had little experience building the new PWR reactors and such a massive build out was costly and risked worker safety.

Environmental groups vociferously opposed the expansion of nuclear energy (Chafer, 1985; Kitschelt, 1986; Jasper, 1990, Ch 9). Groups had called for a moratorium on nuclear energy before 1973 and intensified their calls in response to the Messmer Plan. They mobilized opposition at the national level in Paris and at the local level, especially in areas where reactors were to be built. Indeed, almost every site chosen for reactor construction was met with local opposition. Opposition turned violent in the late 1970s when protesters bombed EDF buildings and a newly built, but unloaded, reactor. In addition to direct action, groups used the courts to try to block policy change.

Opposition political parties did not take an expressly antinuclear position (Brouard and Guinaudeau, 2015; Nelkin and Pollak, 1980; Jasper, 1990, Ch 5 and 9). However, they attacked the size and suddenness of the Plan, the way that EDF could 'buy off' local governments to get their reactors approved, the lack of public discussion and that the Plan would only profit large industry. By 1977, the Socialists, one of the largest opposition parties, was calling for a two-year moratorium on nuclear construction.

Last, public opinion oscillated during the period (Brouard and Guinaudeau, 2015, 146; Fagnani and Moatti, 1984, 272; Nelkin and Pollak, 1980, 135). While initially positive, the public mood turned antinuclear by 1977. By the early 1980s it was slightly positive again before turning negative after the Chernobyl disaster in 1986.

While antinuclear opposition was pronounced in France, it was not altogether more pronounced than in other industrialized democracies. Indeed, governments across countries faced opposition to nuclear expansion from experts, opposition political parties, legal challenges and civil society (Campbell, 1988; Jasper, 1990; Kitschelt, 1986), though none were as effective as overcoming it as those in France.

6.1.2 Overcoming Opposition via Insulation

The key variable in the French case was the capacity of governments to overcome the Plan's opponents via insulation. Once the executive had decided to pursue the Messmer Plan, it put the full weight of the *dirigiste* state into action behind it.[29] First, the

[29] *Dirigisme* is a type of policymaking whereby governments play a strong directive role in the economy in pursuit of national goals (Hall, 1986, Ch 6; Hall, Hayward, and Machin, 1994, Ch 9; Schmidt, 1996, Ch 2). See Online Appendix G for a detailed discussion of it in France.

country's autonomous state bureaucracy was the primary locus of policymaking and it was impermeable to outside pressure. External actors simply had no formal way to intervene. For example, while there were some consultative processes, such as those associated with the siting of reactors (e.g., the Ornano Plan), they tended to be mere formalities and offered no opportunity to affect the rollout of the policy or block it (Campbell, 1988, Ch 8; Fagnani and Moatti, 1984, 265; Jasper, 1990, 165; Lucas, 1979, Ch 7). Furthermore, nuclear licensing decisions had the status of government decrees and were practically immune from legal challenge (Campbell, 1988, Ch 8). And unlike in other countries where referenda could be called by parliament or citizens, only presidents can call them under the French constitution, which prevented a national vote on nuclear power.

Second, a strong executive vis-à-vis parliament meant that the President and the autonomous bureaucracy it controlled could adopt the Messmer Plan as part of its routine economic planning process rather than through parliamentary wrangling. Indeed, there was neither a debate nor vote on the Messmer Plan in the National Assembly (Fagnani and Moatti, 1984, 265; Papon, 1979, 94). Such a centralized institutional setting protected the Plan from a wide variety of oppositional forces. It prevented opposition parties, as well as government parliamentarians, from obstructing it in the legislature. Furthermore, it prevented business, trade unions, outside experts and the anti-nuclear movement from obstructing the Plan via parliamentary channels, for example by lobbying opposition lawmakers to oppose it. The case was much different in places like the US or UK, where legislatures and bureaucracies were less insulated and opponents were able to lobby politicians, legislative committees and civil servants on nuclear policy (Campbell, 1988, Ch 5; Helm, 2003, Ch 5).

Third, the state's ownership stake in the most important nuclear energy-related firms made it difficult for business to mount an effective opposition. Even though EDF operated as a private sector firm, because the state wholly owned it, it could be compelled to act in a way that was consistent with the goals of the Messmer Plan. The same was true for the reactor manufacturer Framatome and fuel company COGEMA. In contrast, private firms dominated the nuclear sector in most other industrialized democracies. Additionally, opposition from fossil fuel interests was stymied by their lack of power in the planning process, especially compared to EDF (Lucas, 1979, Ch. 5).

Fourth, the state's capacity to influence the allocation of capital enabled it to channel finance to the nuclear industry (Jasper, 1990, 174-75; Lucas, 1985, 37). As described in Section 3 above, this constituted the primary industrial policy instrument associated with the Messmer Plan and happened in two ways. Capital was directly lent to EDF to build nuclear plants via the nationalized banking sector and the Ministry of Finance. Additionally, the state used loan guarantees to underwrite the debt that EDF took on in foreign credit markets, especially the US. The result was that the state could channel large

amounts of capital to the sector and insulate key firms from the pressures of investors and capital markets. This was not the case in places like Germany, Sweden and the US where governments had fewer tools to directly allocate capital (Campbell, 1988, Ch 8). Moreover, given its ownership structure, EDF was not as tightly constrained by financial considerations. It had little need to return short-term profits, which meant it could stick to its long-term plan of nuclear expansion, even in the face of rising near-term costs (Fagnani and Moatti, 1984, 266). The situation was very different in the US, for example, where the sector was crippled as private companies, unsupported by government, were unable to bear the rapidly increasing short-term costs of nuclear expansion in the late 1970s (Campbell, 1988, Ch 6; Fagnani and Moatti, 1984, 266; Thomas, 1988, Ch 4 and 5).

The insulated policy process in France contrasts markedly with other industrialized democracies, where institutions enabled outside groups to influence, and in many cases block, nuclear expansion. In places like Sweden and Italy, antinuclear referenda were initiated by opposition parties and civil society, and in both cases succeeded (Brouard and Guinaudeau, 2015; Jasper, 1990). In Germany, antinuclear advocates leveraged the courts and lobbied opposition political parties to slow down nuclear expansion (Campbell, 1988, Ch 8). Federalism and separation of powers meant that nuclear policymaking in the US was especially decentralized and fragmented, and therefore porous to outside influence, particularly in the implementation phase. Federal policymaking was stymied by civil society and state and local governments, who used legal challenges, laws and referenda to block nuclear expansion (Campbell, 1988, Ch 5). Because of the inability of many governments to overcome opposition to nuclear power, by the early 1980s nuclear expansion had slowed considerably in many countries and altogether collapsed in the US (Campbell, 1988; Jasper, 1990).

6.1.3 Policy Stability

Simply because a policy is adopted and implemented does not mean that it will stay in place over the long term. This is especially true in the context of deeply fractious issues such as nuclear energy. A critical ingredient for achieving the deep emissions reductions that we estimate above was that France's nuclear policy was not reversed. It survived decades of changing governments, shifting political winds, and oscillating public approval. Without this policy stability, it is unlikely that it would have resulted in such large reductions. Indeed, as described above, the stability of French nuclear policy makes it an outlier compared to many of its peers, where nuclear energy faltered significantly in the 1980s as a result of political opposition, court challenges, referenda and policy reversal.

In France, the Plan was sustained because the state's powerful autonomous bureau-

cracy continued to support it and no political coalition emerged that was strong enough to overturn it. As described above, the opposition Socialist Party was hostile to the policy early on, and their reticence continued throughout the 1970s. In the lead up to the 1981 election, the party ran on a platform of nuclear policy reform, including a moratorium on nuclear orders pending a national debate and referendum, and the expansion of coal and renewables (Thomas, 1988, 213). However, after winning power, the new Socialist President François Mitterand did not dramatically change course or call a referendum. The most significant of his reforms was to reduce new reactor orders from an average of five per year after 1973 to three in 1982 and two in 1983, 1984, and 1985 (Fagnani and Moatti, 1984; Thomas, 1988, 213-15). Though, this was likely due as much to sharply reduced electricity demand forecasts as to partisanship. Additionally, planning procedures were amended to allow greater local participation in site selection.

By the mid-1980s, French political parties had depoliticized nuclear power and a cross-party consensus had emerged in support of it (Brouard and Guinaudeau, 2015; Fagnani and Moatti, 1984; Nelkin and Pollak, 1980). This is unsurprising given that, as we describe above, most nuclear plants were under construction or completed by this time, meaning that any phaseout would be costly and leave many stranded assets. Furthermore, the rapid growth of the sector meant that nuclear industrial interests, including companies and labor unions up and down the supply chain, had become consolidated as a powerful political force that resisted major changes to policy (Thomas, 1988, Ch 8; Jasper, 1990, Ch 13).

Beyond political parties, there is little evidence that significant calls for reversal emerged either within the state bureaucracy or from the business community. Moreover, the antinuclear movement within civil society had all but disappeared by the early 1980s (Jasper, 1990, 237) and public opinion turned more positive (Brouard and Guinaudeau, 2015). Though, even if these events had not transpired, a reversal of nuclear policy would be unlikely given the prevailing cross-party consensus and the lack of possibilities for a national referendum.

7 What Can We Learn from the Messmer Plan?

The Messmer Plan offers a historical case study of rapid nuclear energy expansion leading to large and cost-effective emissions reductions. However, the context in which nuclear power operates today is different. To assess the relevance of our findings for contemporary green industrial policy debates across today's OECD countries[30], we evaluate

[30]We focus on today's OECD countries because they are high-income democracies most comparable to France. A discussion of energy policy in China and the Global South is important, as the conditions there are different in many ways, especially related to build times, costs, and policymaking processes. However, those regions are not our focus here.

the extent to which key conditions that enabled the success of the Messmer Plan are still valid today, including: (1) nuclear power being a viable carbon-free technology that can be deployed at scale; (2) relatively short reactor construction times; (3) nuclear being cost-competitive, especially with the help of policy that reduces capital costs; (4) a carbon-intensive electricity grid; and (5) the government being able to overcome political opposition.

Turning first to the viability of nuclear power. At the time of the first oil price shock in 1973, nuclear and hydropower represented the only large-scale technologies for electricity generation apart from fossil fuels (and because hydro is dependent on natural factors, it was not available to all countries). Today, nuclear power is still a viable, large-scale and carbon-free energy technology.[31] Currently, around 13 large-scale conventional reactors are under construction in OECD countries, 24 are planned and around 100 have been proposed (WNA, 2026). In France, the government plans to build six EPR2 (European Pressurized Reactor 2) reactors and has asked EDF to submit plans for an additional eight (Nuclear Engineering International, 2026). The US aims to add 300GW of nuclear capacity by 2050 and have ten new reactors under construction by 2030 (World Nuclear News, 2025). Additionally, the scale of some new nuclear programs is on par with the Messmer Plan. For example, Sweden's program of 10 new reactors, when adjusted for population size, matches the scale of the French experience (Government Offices of Sweden, 2023). More broadly, nuclear plays an important role in limiting warming to below 2°C in the majority of global emissions scenarios (IAEA, 2023b). That said, it is not the only carbon-free electricity source available to governments today. Unlike in the 1970s, renewable technologies like wind and solar are mature, offering governments today a longer menu of carbon-free options.

Regarding the conditions of construction times and costs, there are important differences between the French experience and today. The cost of nuclear has risen over time in all countries, though precise magnitudes are subject to debate (Koomey and Hultman, 2007; Koomey, Hultman, and Grubler, 2017; Grubler, 2010; Bocard, 2014; Gilbert et al., 2017). While cost rises in France have been relatively modest for reactors built before 2000 (i.e., all reactors apart from Flamanville 3), they have been substantial in places like the US and UK (Bocard, 2014; Koomey and Hultman, 2007; Lovering, Yip, and Nordhaus, 2016). Cost escalation has tended to be a consequence of longer construction times, rather than increasing input costs, as longer builds increase interest costs on nuclear's large capital investments (Koomey and Hultman, 2007; Rangel and Lévêque, 2015; Lovering, Yip, and Nordhaus, 2016; Thomas, 2005). Crucially for today, long construction times also increase environmental costs by delaying emissions reductions and

[31] We recognize that nuclear's role in climate mitigation policy is divisive (Schneider and Froggatt, 2021; Haywood, Leroutier, and Pietzcker, 2023). We do not seek to weigh in on this important debate here, but rather present the full range of existing carbon-free technologies.

increasing the stock of GHGs in the atmosphere.

The Messmer Plan's reactors had a notably, and historically, short average construction time of around six years. More recent examples of reactor construction across OECD countries present a varied picture. Since 2000, 24 reactors have come into commercial operation (IAEA, 2025).[32] Average build times for these were around five years in Japan, nine in South Korea and 10 in the US.[33] Build times have been longer in Europe, with Czechia's two reactors taking around 15 years on average, Finland's Olkiluoto 3 taking 18 years, and France's Flamanville 3 taking 17 years. Several factors have increased construction times. Regulatory changes during the construction phase, especially more stringent safety rules, have generated redesigns and work stoppages (Koomey and Hultman, 2007; Thomas, 2005). Reactors have also tended to be larger over time, which increases technological complexity and construction difficulty (Rangel and Lévêque, 2015; Bocard, 2014). Relatedly, in many cases, the absence of design standardization undermined learning-by-doing and economies of scale (Rangel and Lévêque, 2015; Lovering, Yip, and Nordhaus, 2016; Thomas, 2005).

In the French case in particular, the high cost of its most recent reactor, Flamanville 3, reflects a breakdown in the model that contained costs under the Messmer Plan. Unlike the standardized and continuously built reactors under the Plan, Flamanville is a large, 'first-of-a-kind' complex reactor design built after a nuclear hiatus, which had eroded industrial capabilities, supply chains, and the nuclear workforce (Gaster, 2025; Grubler, 2010; Bocard, 2014). Additionally, construction failures and over 7,000 design changes added construction delays and costs (Gaster, 2025; Cour des Comptes, 2020). Institutionally, the French state was not able to exercise effective oversight to keep the project on track and contain costs (Cour des Comptes, 2020). Overall, the experience points to the importance of large orders, continuous construction, standardized reactor designs, and institutional capacity in generating economies of scale, developing a skilled workforce, and minimizing construction delays – all which contain costs. Indeed, governments seem to be learning this lesson, as recently announced nuclear plans in France, Sweden and the US rely on large orders of standardized reactor designs. The experience may also highlight the difficulties of moving from a program of standardized adoption and scaling up of an existing technology under the Messmer Plan (i.e., PWR reactors) to one of innovating at the technological frontier (i.e., the EPR programs) (Acemoglu, Aghion, and Zilibotti, 2006). In response to the challenges of Flamanville 3, the French government and EDF are actively reforming nuclear governance (Gaster, 2025). EPR2 reactors have been simplified and EDF now has operational authority over all aspects of reactor design

[32]Two in Czechia connected to the grid in 2000 and 2002; one in Finland in 2022; one in France in 2024; five in Japan between 2001-2009; 12 in South Korea between 2001-2023; and three in the US connected in 2016, 2023, and 2024.

[33]US build time excludes the Watts Bar-2 reactor, which began construction in 1973 and suffered unprecedented delays. It did not come into commercial operation until 2016.

and construction. Within the state, a newly created interministerial committee acts as the government's project management and coordination office. Time will tell whether these changes can deliver France's EPR2 program on time and on budget.

In contrast to nuclear, recent experience with renewables paints a different picture. Build times have been much shorter. In the OECD, according to one study, they are around two years for solar PV, three years for onshore wind and five years for offshore wind, on average (Gumber, Zana, and Steffen, 2024). At the same time, costs for wind and solar have decreased. In France in 2020, utility-scale solar PV and onshore wind had a lower LCOE compared to new nuclear,[34] while commercial solar PV, residential solar PV and offshore wind were more expensive (IEA, 2020a). According to LCOE estimates from the IEA, the basic cost pattern observed in France applies more generally for OECD countries (IEA, 2020b).[35] In Europe in 2020, onshore wind and utility-scale solar PV were cheaper than nuclear, and offshore wind was more expensive.[36] In the US, utility-scale solar PV and onshore and offshore wind were cheaper than nuclear – a pattern found more recently by Bilicic and Scroggins (2025) as well. Japan is different. There nuclear had a lower LCOE than utility-scale solar PV and onshore and offshore wind. Given their favorable costs and build times in most contexts today, it is no surprise that solar PV and onshore wind account for the vast majority of newly-installed electricity capacity in the OECD and worldwide (OECD, 2023; IEA, 2025b).

Carbon-free electricity sources are capital intensive, and therefore their LCOEs depend heavily on the cost of capital. This was true for nuclear in the 1970s and is still true for nuclear and renewables today (IEA, 2020b; Worland, 2023). Crucially, the Messmer Plan used state finance, loans and loan guarantees to reduce capital costs for nuclear expansion. By the mid-1980s France enjoyed the lowest LCOE for nuclear among the OECD (IEA, 2015). Today, policy instruments for reducing capital costs are just as relevant for green industrial policy. For example, the French government plans to use subsidized state loans to cover 60% of the cost of its EPR2 program (Nuclear Engineering International, 2026). Similarly in Sweden, the government intends to rely on loans and loan guarantees to support its large-scale nuclear expansion (Government Offices of Sweden, 2023).

The fourth condition is the carbon-intensity of the grid. France's electricity grid was very carbon-intensive before the adoption of the Messmer Plan, with fossil fuels accounting for 50%-60% of electricity production (Figure 1a above). While today several OECD countries have relatively clean grids (e.g., Sweden and the UK), many still have

[34]Extending the operational life of existing nuclear reactors (i.e., nuclear LTO) had a lower LCOE than new nuclear.

[35]Looking beyond the OECD, we see a similar pattern in China and India (IEA, 2020b). In China in 2020, onshore wind and utility-scale solar were less expensive than nuclear, while offshore was more expensive. In India, onshore wind and utility-scale solar were also less expensive than nuclear (there is no estimate for offshore wind as India does not have any offshore wind projects).

[36]Costs for nuclear in the IEA data should be interpreted with some caution as they are based on a very limited set of projects (one in Europe, one in the US and one in Japan) (IEA, 2020b).

grids that are similarly, or even more, carbon-intensive than France's in the 1970s, such as Australia, Japan, Poland and the US. This suggests that emissions reductions of similar magnitude to the Messmer Plan remain possible today.

The last condition is politics. The Messmer Plan generated significant political opposition. To overcome it, successive French governments were able to insulate the policymaking process through use of the state's autonomous and technocratic bureaucracy and centralized decisionmaking. Thinking counterfactually about the contemporaneous experiences of comparable countries like the US, Germany, and Sweden, the Plan would likely not have been adopted and implemented at scale without this policymaking process, and therefore not have achieved large emissions reductions. Today, opposition to transformative green industrial policy is just as apparent as it was in the 1970s. Just consider the US Inflation Reduction Act, which the second Trump administration has weakened. Furthermore, insulation remains just as much of a viable political pathway to overcoming opposition. Similar to France, jurisdictions today, such as California, rely on autonomous bureaucracies to shield policymaking from opponents (Meckling et al., 2022). In other contexts, electoral rules and low electoral competition have provided the basis for insulation and enabled governments to increase climate policy stringency (Finnegan, 2022a,b; Finnegan et al., 2025). What is more, in contexts where insulation has not been feasible, governments have alternatively used compensation as a political pathway to overcome resistance from opponents (Finnegan, 2022b; Finnegan et al., 2025). For example, Germany's coal phaseout relies on large payments to coal-related businesses, workers and regions as a way to secure their support.

In sum, we find that nuclear is still a viable carbon-free electricity option, however governments today have more choice than in the 1970s. Most notably, wind and solar are mature carbon-free technologies with often shorter build times and costs compared to nuclear. Consequently, a modern equivalent of the Messmer Plan could invest in a variety of carbon-free electricity technologies, rather than only one. Just as in the 1970s, governments today can rely on the same types of policy tools (state finance, loans and loan guarantees) to lower the cost of capital for carbon-free energy projects. Furthermore, governments today can leverage complementarities between green industrial policy and carbon pricing to further drive down emissions (Andersson and Finnegan, 2025).[37] Indeed, many electricity grids across the OECD today are equally, and in some cases more, carbon-intensive than France's in the 1970s, suggesting that large-scale emissions reductions from green industrial policy are still possible. Regarding political economy,

[37]Rapid decarbonization requires lowering the cost of capital for zero-carbon energy, especially in a high interest rate environment. In contrast, fossil fuel generation predominantly relies on variable fuel costs, which carbon pricing will raise. An effective climate policy would thus be to reduce the relative price of zero-carbon energy sources through a dual approach of green industrial policy and carbon pricing. This approach could be revenue-neutral if the proceeds from the carbon price are used to fund green industrial policy. For a full discussion see Andersson and Finnegan (2025).

overcoming opposition to reform is still as critical an ingredient today as it was in the 1970s. Furthermore, governments today can still rely on the same political pathway for doing so – insulation – as French policymakers did. So while the exact technological choice may be different today, given the longer menu of carbon-free options and the costs, construction times and political economy associated with each, the core insight of our study remains relevant: ambitious, state-driven green industrial policy can be a politically-feasible strategy to achieve rapid and substantial reductions in carbon emissions on a scale necessary to meet global climate targets.

8 Conclusion

Governments around the world are turning to green industrial policy and increased electrification to decarbonize their economies and drive economic competitiveness. We assess the ability of these policies to reduce emissions by analyzing the case of France. In response to the 1973 oil price shock, France launched the Messmer Plan, an ambitious industrial policy to both enhance energy security by replacing fossil fuels with nuclear in electricity production and grow an internationally competitive French nuclear industry. Using state financing, loan guarantees, contracts with suppliers and streamlined planning procedures, the government incentivized and supported the rapid roll out of nuclear energy. Politically, the Plan faced intense opposition. To overcome it, the government relied on the dirigiste policymaking style of the French state to insulate decision making and implement nuclear expansion over the objections of the antinuclear movement, the fossil fuel industry, academic experts, trade unions and opposition political parties. The French experience contrasts markedly with that of other industrialized democracies, such as the US, the UK, and Germany, where political forces prevented a radical transition toward nuclear.

As a result of the Messmer Plan, we find that carbon dioxide emissions from electricity and heat production fell by more than 60% in the years that followed. For the economy as a whole, total CO_2 emissions were around 20% lower in an average year, due, in large part, to increased electrification. It took around six years from the announcement of the policy until emission reductions commenced and the average abatement cost was close to zero per metric ton of CO_2. These findings show that ambitious industrial policy can be an environmentally and economically efficient, as well as politically feasible, tool for mitigating carbon emissions in the energy sector. Indeed, our results provide strong evidence that active state intervention in the form of industrial policy can quickly and dramatically decrease emissions. We are not aware of any other single policy that has been shown to decrease emissions on the same scale, and as rapidly, as the Messmer Plan in France.

While our study is ambitious in scope, there is opportunity for more research on the

local effects of green industrial policy. Our analysis primarily addresses the global environmental impact of the Messmer Plan, focusing on the reduction of carbon dioxide emissions. However, the Plan likely also resulted in decreased local air pollutants, particularly in areas where fossil fuel plants were decommissioned due to the rise in nuclear energy production. This reduction in local pollutants could have significant benefits for nearby populations, as decreases in air pollution are linked to improved outcomes in areas like infant mortality and academic performance (Chay and Greenstone, 2003; Ebenstein, Lavy, and Roth, 2016). Moreover, our analysis has focused on the green aspects of green industrial policy, without assessing local economic impacts, such as changes in employment and economic growth in the areas affected by the Messmer Plan. A comprehensive estimation of local costs and benefits of the Plan, considering local air pollution, employment and economic growth, represents a promising area for further study.

References

Abadie, Alberto. 2021. "Using synthetic controls: Feasibility, data requirements, and methodological aspects." *Journal of Economic Literature* 59 (2):391–425.

Abadie, Alberto, Alexis Diamond, and Jens Hainmueller. 2010. "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program." *Journal of the American Statistical Association* 105:493–505.

———. 2011. "Synth: An R Package for Synthetic Control Methods in Comparative Case Studies." *Journal of Statistical Software* 42:1–17.

———. 2015. "Comparative Politics and the Synthetic Control Method." *American Journal of Political Science* 59 (2):495–510.

Acemoglu, Daron. 1998. "Why do new technologies complement skills? Directed technical change and wage inequality." *The quarterly journal of economics* 113 (4):1055–1089.

———. 2002. "Directed technical change." *The review of economic studies* 69 (4):781–809.

———. 2023. "Distorted Innovation: Does the Market Get the Direction of Technology Right?" In *AEA Papers and Proceedings*, vol. 113. American Economic Association, 1–28.

Acemoglu, Daron, Philippe Aghion, Leonardo Bursztyn, and David Hemous. 2012. "The environment and directed technical change." *American economic review* 102 (1):131–166.

Acemoglu, Daron, Philippe Aghion, and Fabrizio Zilibotti. 2006. "Distance to Frontier, Selection, and Economic Growth." *Journal of the European Economic Association* 4 (1):37–74.

Akerlof, George, A Greenspan, E Maskin, W Sharpe, R Aumann, LP Hansen, D McFadden et al. 2019. "Economists' Statement on Carbon Dividends." *The Wall Street Journal* January 17.

Alderman, Liz. 2022. "France Announces Major Nuclear Power Buildup." *The New York Times* February 10, 2022.

Allan, Bentley, Joanna I Lewis, and Thomas Oatley. 2021. "Green industrial policy and the global transformation of climate politics." *Global environmental politics* 21 (4):1–19.

Allan, Bentley B. and Jonas Nahm. 2025. "Strategies of Green Industrial Policy: How States Position Firms in Global Supply Chains." *American Political Science Review* 119 (1):420–434. URL https://www.cambridge.org/core/journals/american-political-science-review/article/strategies-of-green-industrial-policy-how-states-position-firms-in-global-supply-cl BB673EA2C45CA650F164B678393F9913.

Altenburg, Tilman and Claudia Assmann. 2017. "Green Industrial Policy: Concept, Policies, Country Experiences." *UN Environment, Geneva, Bonn* .

AMECO. 2018. "Macro-economic database AMECO." Annual macro-economic database of the European Commission's Directorate General for Economic and Financial Affairs. Data retrieved from AMECO, https://economy-finance.ec.europa.eu/economic-research-and-databases/economic-databases/ameco-database_en.

Andersson, Julius and Jared Finnegan. 2025. "Complementary but Different: The Politics of Green Industrial Policy and Carbon Pricing." https://freepolicybriefs.org/wp-content/uploads/2025/04/20250414.pdf.

Andersson, Julius J. 2019. "Carbon taxes and CO_2 emissions: Sweden as a case study." *American Economic Journal: Economic Policy* 11 (4):1–30.

Apergis, Nicholas, James E Payne, Kojo Menyah, and Yemane Wolde-Rufael. 2010. "On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth." *Ecological Economics* 69 (11):2255–2260.

Batalla-Bejerano, Joan, Jordi Paniagua, and Elisa Trujillo-Baute. 2019. "Energy market integration and electricity trade." *Economics of Energy & Environmental Policy* 8 (2):53–68.

Baumgartner, Frank R and Bryan D Jones. 1993. *Agendas and instability in American politics*. University of Chicago Press.

Bilicic, George and Samuel Scroggins. 2025. "2025 Levelized Cost of Energy+." *Lazard* .

Bistline, John, Neil Mehrotra, and Catherine Wolfram. 2023. "Economic Implications of the Climate Provisions of the Inflation Reduction Act." Tech. rep., National Bureau of Economic Research.

Bocard, Nicolas. 2014. "The cost of nuclear electricity: France after Fukushima." *Energy Policy* 66:450–461.

Brouard, Sylvain and Isabelle Guinaudeau. 2015. "Policy beyond politics? Public opinion, party politics and the French pro-nuclear energy policy." *Journal of Public Policy* 35 (1):137–170.

Campbell, John L. 1986. "The State, Capital Formation, and Industrial Planning: Financing Nuclear Energy in the United States and France." *Social Science Quarterly* 67 (4):707–721.

———. 1988. *Collapse of an industry: Nuclear power and the contradictions of U. S. policy*. Ithaca: Cornell University Press.

Chafer, Tony. 1985. "Politics and the perception of risk: A study of the anti-nuclear movements in Britain and France." *West European Politics* 8 (1):5–23.

Chay, Kenneth Y and Michael Greenstone. 2003. "The impact of air pollution on infant mortality: evidence from geographic variation in pollution shocks induced by a recession." *The quarterly journal of economics* 118 (3):1121–1167.

Chernozhukov, Victor, Kaspar Wuthrich, and Yinchu Zhu. 2025. "Debiasing and t-tests for synthetic control inference on average causal effects." *Forthcoming in the Journal of Political Economy* .

Collier, Ruth Berins, David Collier et al. 1991. *Shaping the political arena*, vol. 11. Princeton: Princeton university press.

Colmer, Jonathan, Ralf Martin, Mirabelle Muûls, and Ulrich J. Wagner. 2025. "Does Pricing Carbon Mitigate Climate Change? Firm-Level Evidence from the European Union Emissions Trading System." *The Review of Economic Studies* 92 (3):1625–1660.

Cour des Comptes. 2012. "The cost of the nuclear power sector: Thematic public report." *Cour des Comptes* Paris.

———. 2020. "La filière EPR." URL `https://www.vie-publique.fr/rapport/275117-la-filiere-epr-cour-des-comptes`.

Cullenward, Danny and David G. Victor. 2020. *Making Climate Policy Work*. Cambridge, UK: Polity Press.

Davenport, Juliet and Nick Wayth. 2023. "Statistical Review of World Energy 2023." *Energy Institute* .

Davis, Lucas W. 2012. "Prospects for nuclear power." *Journal of Economic perspectives* 26 (1):49–66.

Ebenstein, Avraham, Victor Lavy, and Sefi Roth. 2016. "The long-run economic consequences of high-stakes examinations: Evidence from transitory variation in pollution." *American Economic Journal: Applied Economics* 8 (4):36–65.

European Commission. 2003. "External Costs: Research results on socio-environmental damages due to electricity and transport." *European Commission, Directorate-General for Research* Brussels.

Fagnani, Jeanne and Jean-Paul Moatti. 1984. "The politics of french nuclear development." *Journal of Policy Analysis and Management* 3 (2):264–275.

Feenstra, Robert C., Robert Inklaar, and Marcel P. Timmer. 2015. "The Next Generation of the Penn World Table." *American Economic Review* 105 (10):3150–3182.

Ferman, Bruno, Cristine Pinto, and Vitor Possebom. 2020. "Cherry picking with synthetic controls." *Journal of Policy Analysis and Management* 39 (2):510–532.

Finnegan, Jared. 2022a. "Changing Prices in a Changing Climate: Electoral Competition and Fossil Fuel Taxation." *Comparative Political Studies* 56 (8).

———. 2022b. "Institutions, Climate Change, and the Foundations of Long-Term Policymaking." *Comparative Political Studies* 55 (7).

———. 2023. "Rishi Sunak is introducing the polarised climate policies of the US, Canada and Australia to the UK." *The Conversation* October 04, 2023.

Finnegan, Jared, Phillip Lipscy, Jonas Meckling, and Florence Metz. 2025. "The Institutional Sources of Economic Transformation: Explaining Variation in Energy Transitions." *The Journal of Politics* .

Finon, Dominique and Carine Staropoli. 2001. "Institutional and technological coevolution in the French electronuclear industry." *Industry and Innovation* 8 (2):179–199.

Gaster, Robin. 2025. "Lessons From France's Nuclear Program." Policy report, Information Technology and Innovation Foundation (ITIF). URL `https://itif.org/publications/2025/09/02/lessons-from-frances-nuclear-program/`.

Gilbert, Alexander, Benjamin K. Sovacool, Phil Johnstone, and Andy Stirling. 2017. "Cost Overruns and Financial Risk in the Construction of Nuclear Power Reactors: A Critical Appraisal." *Energy Policy* 102:644–649.

Gourevitch, Peter Alexis. 1986. *Politics in hard times: Comparative responses to international economic crises*. Cornell University Press.

Government Offices of Sweden. 2023. "Färdplan för ny kärnkraft i Sverige." Tech. rep., Government Offices of Sweden.

Gröndahl, Marie-Pierre. 2022. "Thierry Breton: 'Il faudra investir 500 milliards d'euros dans les centrales nucléaires de nouvelle génération'." *Le Journal du Dimanche* January 09, 2022.

Gross, Daniel P. and Bhaven N. Sampat. 2023. "America, Jump-Started: World War II R&D and the Takeoff of the US Innovation System." *American Economic Review* 113 (12):3323–3356.

Grubler, Arnulf. 2010. "The costs of the French nuclear scale-up: A case of negative learning by doing." *Energy Policy* 38 (9):5174–5188.

Gumber, Anurag, Riccardo Zana, and Bjarne Steffen. 2024. "A global analysis of renewable energy project commissioning timelines." *Applied Energy* 358:122563.

Hall, Peter A. 1986. *Governing the economy: The politics of state intervention in Britain and France*. New York: Oxford University Press.

Hall, Peter A, Jack Hayward, and Howard Machin. 1994. *Developments in French politics*. Macmillan.

Hancké, Bob. 2002. *Large firms and institutional change: Industrial renewal and economic restructuring in France*. Oxford University Press, USA.

Harrison, Ann, Leslie A Martin, and Shanthi Nataraj. 2017. "Green industrial policy in emerging markets." *Annual Review of Resource Economics* 9:253–274.

Haywood, Luke, Marion Leroutier, and Robert Pietzcker. 2023. "Why investing in new nuclear plants is bad for the climate." *Joule* 7 (8):1675–1678.

Helm, Dieter. 2003. *Energy, the State, and the Market: British Energy Policy Since 1979*. Oxford University Press.

Holtz-Eakin, Douglas and Thomas M Selden. 1995. "Stoking the fires? CO2 emissions and economic growth." *Journal of public economics* 57 (1):85–101.

Hufbauer, Gary Clyde and Euijin Jung. 2021. *Scoring 50 years of US industrial policy, 1970–2020*. Peterson Institute for International Economics.

IAEA. 2020. "International Atomic Energy Agency, Country Nuclear Power Profiles: Belgium (2020 Edition)." `https://www-pub.iaea.org/MTCD/publications/PDF/cnpp2020/countryprofiles/Belgium/Belgium.htm`.

———. 2023a. "International Atomic Energy Agency, Country Statistics: France." `https://pris.iaea.org/pris/CountryStatistics/CountryDetails.aspx?current=FR`.

———. 2023b. "Nuclear Energy in Mitigation Pathways to Net Zero." https://www-pub.iaea.org/MTCD/Publications/PDF/PAT-004_web.pdf.

———. 2025. "Power Reactor Information System (PRIS) Database." https://pris.iaea.org/pris/home.aspx.

IEA. 2005. "Projected Costs of Generation Electricity: 2005 Edition." *International Energy Agency* Paris.

———. 2015. "Projected Costs of Generation Electricity: 2015 Edition." *International Energy Agency* Paris.

———. 2020a. "Levelised Cost of Electricity Calculator." https://www.iea.org/data-and-statistics/data-tools/levelised-cost-of-electricity-calculator.

———. 2020b. "Projected Costs of Generation Electricity: 2020 Edition." *International Energy Agency* Paris.

———. 2021. "International Energy Agency: Electricity Information (2022 Edition), Database Documentation."

———. 2022a. "International Energy Agency: Electricity information (2022 Edition)." https://doi.org/10.5257/iea/elec/2022.

———. 2022b. "International Energy Agency: Greenhouse Gas Emissions from Energy (2022 Edition)." https://doi.org/10.5257/iea/co2/2022.

———. 2022c. "International Energy Agency: World Energy Balances (2022 Edition)." https://dx.doi.org/10.5257/iea/web/2022.

———. 2024. "Emission Factors 2024: Database Documentation." *International Energy Agency* Paris.

———. 2025a. "Energy Prices (April 2025 Edition): Database Documentation." *International Energy Agency* Paris.

———. 2025b. "Global Energy Review 2025." Tech. rep., Paris: International Energy Agency.

Ikenberry, G John. 1986. "The irony of state strength: comparative responses to the oil shocks in the 1970s." *International Organization* 40 (1):105–137.

———. 1988. "Conclusion: an institutional approach to American foreign economic policy." *International organization* 42 (1):219–243.

IPCC. 2006. "2006 IPCC Guidelines for National Greenhouse Gas Inventories." Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T., and Tanabe K. (eds). Published: IGES, Japan.

Iwata, Hiroki, Keisuke Okada, and Sovannroeun Samreth. 2010. "Empirical study on the environmental Kuznets curve for CO2 in France: the role of nuclear energy." *Energy policy* 38 (8):4057–4063.

Jarvis, Stephen, Olivier Deschenes, and Akshaya Jha. 2022. "The private and external costs of Germany's nuclear phase-out." *Journal of the European Economic Association* 20 (3):1311–1346.

Jasper, James M. 1990. *Nuclear politics: Energy and the state in the United States, Sweden, and France*, vol. 1126. Princeton University Press.

Joskow, Paul L. 2011. "Comparing the costs of intermittent and dispatchable electricity generating technologies." *American Economic Review* 101 (3):238–241.

Juhász, Réka, Nathan J Lane, and Dani Rodrik. 2023. "The New Economics of Industrial Policy." Working Paper 31538, National Bureau of Economic Research.

Kantor, Shawn and Alexander T Whalley. 2023. "Moonshot: Public r&d and growth." Tech. rep., National Bureau of Economic Research.

Keeler, John TS. 1993. "Executive power and policy-making patterns in France: Gauging the impact of fifth republic institutions." *West European Politics* 16 (4):518–544.

Kitschelt, Herbert P. 1986. "Political opportunity structures and political protest: Anti-nuclear movements in four democracies." *British journal of political science* 16 (1):57–85.

Kline, Patrick and Enrico Moretti. 2014. "Local economic development, agglomeration economies, and the big push: 100 years of evidence from the Tennessee Valley Authority." *The Quarterly journal of economics* 129 (1):275–331.

Knopf, Brigitte, Michael Pahle, Hendrik Kondziella, Fabian Joas, Ottmar Edenhofer, and Thomas Bruckner. 2014. "Germany's nuclear phase-out: sensitivities and impacts on electricity prices and CO2 emissions." *Economics of Energy & Environmental Policy* 3 (1):89–106.

Koomey, Jonathan and Nathan E. Hultman. 2007. "A Reactor-Level Analysis of Busbar Costs for US Nuclear Plants, 1970–2005." *Energy Policy* 35 (11):5630–5642.

Koomey, Jonathan, Nathan E. Hultman, and Arnulf Grubler. 2017. "A Reply to "Historical Construction Costs of Global Nuclear Power Reactors."." *Energy Policy* 102:640–643.

Krugman, Paul R and Maurice Obstfeld. 2009. *International economics: Theory and policy*. Pearson Education.

Kupzok, Nils and Jonas Nahm. 2024. "The Decarbonization Bargain: How the Decarbonizable Sector Shapes Climate Politics." *Perspectives on Politics* 22 (4):1–21. URL `https://www.cambridge.org/core/journals/perspectives-on-politics/article/decarbonization-bargain-how-the-decarbonizable-sector-shapes-climate-politics/A96CF0A6C399240BC4414EED53E3EF54`.

Le Quesne, Nicholas. 2000. "The Circuit Breaker." *Time Magazine* March 6, 2000.

Leroutier, Marion. 2022. "Carbon pricing and power sector decarbonization: Evidence from the UK." *Journal of Environmental Economics and Management* 111:102580.

Lovering, Jessica R., Arthur Yip, and Ted Nordhaus. 2016. "Historical Construction Costs of Global Nuclear Power Reactors." *Energy Policy* 91:371–382.

Lucas, Nigel. 1979. *Energy in France: Planning, Politics and Policy*. Europa Publications Limited.

———. 1985. *Western European energy policies: a comparative study of the influence of institutional structure on technical change*. Clarendon Press.

Mardani, Abbas, Dalia Streimikiene, Fausto Cavallaro, Nanthakumar Loganathan, and Masoumeh Khoshnoudi. 2019. "Carbon dioxide (CO2) emissions and economic growth: A systematic review of two decades of research from 1995 to 2017." *Science of the total environment* 649:31–49.

Masson-Delmotte, Valérie, Panmao Zhai, Hans-Otto Pörtner, Debra Roberts, Jim Skea, Priyadarshi R Shukla et al. 2018. *Global Warming of 1.5 C: IPCC special report on impacts of global warming of 1.5 C above pre-industrial levels in context of strengthening response to climate change, sustainable development, and efforts to eradicate poverty*. Cambridge University Press.

Mckenzie, David. 2023. "Is there any impact evaluation evidence on government policies for green technology adoption and innovation for firms in developing countries?" *World Bank Blogs* March 27, 2023.

Meckling, Jonas. 2021. "Making industrial policy work for decarbonization." *Global Environmental Politics* 21 (4):134–147.

Meckling, Jonas and Bentley B. Allan. 2020. "The evolution of ideas in global climate policy." *Nature Climate Change* 10 (5):434–438.

Meckling, Jonas, Phillip Y Lipscy, Jared J Finnegan, and Florence Metz. 2022. "Why nations lead or lag in energy transitions." *Science* 378 (6615):31–33.

Menyah, Kojo and Yemane Wolde-Rufael. 2010. "CO2 emissions, nuclear energy, renewable energy and economic growth in the US." *Energy policy* 38 (6):2911–2915.

Nahm, Jonas. 2021. *Collaborative Advantage: Forging Green Industries in the New Global Economy*. Oxford University Press.

Naudet, G. 1993. "French nuclear organization." Tech. rep., CEA.

Nelkin, Dorothy and Michael Pollak. 1980. "Political parties and the nuclear energy debate in France and Germany." *Comparative Politics* 12 (2):127–141.

Nordhaus, William D. 2008. *A Question of Balance: Weighing the Options on Global Warming Policies*. Yale University Press.

North, Douglass C. 1991. "Institutions." *Journal of Economic Perspectives* 5 (1):97–112.

Nuclear Engineering International. 2026. "France confirms nuclear expansion plan." URL `https://www.neimagazine.com/news/france-confirms-nuclear-expansion-plan/?cf-view`. Accessed: 2026-03-20.

OECD. 2023. "Renewable Energy Market Update: Outlook for 2023 and 2024." *OECD Publishing* .

Pack, Howard and Kamal Saggi. 2006. "Is there a case for industrial policy? A critical survey." *The World Bank Research Observer* 21 (2):267–297.

Papon, Pierre. 1979. "Why France has had no public nuclear debate." *Nature* 281 (5727):94–95.

Parry, Ian, Chandara Veung, and Dirk Heine. 2015. "How Much Carbon Pricing is in Countries' own Interests? The Critical Role of Co-Benefits." *Climate Change Economics* 6 (04):1550019.

Popp, David. 2019. "Environmental policy and innovation: a decade of research." *NBER Working Paper Series* .

Rangel, Lina Escobar and François Lévêque. 2015. "Revisiting the Cost Escalation Curse of Nuclear Power: New Lessons from the French Experience." *Economics of Energy & Environmental Policy* 4 (2):103–126. URL https://www.jstor.org/stable/26189383.

Rodrik, Dani. 2008. "Industrial policy: don't ask why, ask how." *Middle East development journal* 1 (1):1–29.

———. 2014. "Green industrial policy." *Oxford review of economic policy* 30 (3):469–491.

Schmidt, Vivien A. 1996. *From state to market?: the transformation of French business and government*. Cambridge University Press.

Schneider, Mycle and Antony Froggatt. 2021. "The world nuclear industry status report 2019." In *World Scientific Encyclopedia of Climate Change: Case Studies of Climate Risk, Action, and Opportunity Volume 2*. World Scientific, 203–209.

Sheldon, Tamara L. 2019. "Carbon emissions and economic growth: A replication and extension." *Energy Economics* 82:85–88.

Smith, Steven J, John van Aardenne, Zbigniew Klimont, Robert Joseph Andres, April Volke, and Sabrina Delgado Arias. 2011. "Anthropogenic sulfur dioxide emissions: 1850–2005." *Atmospheric Chemistry and Physics* 11 (3):1101–1116.

Song, Li and Xiaoliang Zhou. 2021. "Does the green industry policy reduce industrial pollution emissions?—Evidence from China's national eco-industrial park." *Sustainability* 13 (11):6343.

Suleiman, Ezra N. 1974. *Politics, power, and bureaucracy in France: The administrative elite*, vol. 1257. Princeton University Press.

The World Bank. 2015. "World Bank Database." Data retrieved from World Development Indicators, http://data.worldbank.org/indicator.

Thelen, Kathleen and Sven Steinmo. 1992. "Historical institutionalism in comparative politics." In *Structuring politics: Historical institutionalism in comparative analysis*, edited by Sven Steinmo, Kathleen Thelen, and Frank Longstreth. Cambridge, UK: Cambridge University Press, 1–32.

Thomas, Steve. 2005. "The Economics of Nuclear Power: Analysis of Recent Studies." Research report, Public Services International Research Unit (PSIRU), University of Greenwich. URL http://www.psiru.org/reports/2005-09-E-Nuclear.pdf.

Thomas, Steve D. 1988. *The realities of nuclear power: international economic and regulatory experience*. Cambridge University Press.

Thompson, Andrea. 2022. "What Scientists Say about the Historic Climate Bill." *Scientific American* August 12, 2022.

Wade, Nicholas. 1980. "France's All-out Nuclear Program Takes Shape: If the experiment is successful, France may become a showcase for nuclear power." *Science* 209 (4459):884–889.

Williams, Roger. 1980. *The nuclear power decisions: British policies, 1953-78*. Routledge.

WNA. 2026. "Plans For New Reactors Worldwide." `https://world-nuclear.org/information-library/current-and-future-generation/plans-for-new-reactors-worldwide`.

Worland, Justin. 2023. "What High Interest Rates Mean For U.S. Renewable Energy." *Time Magazine* May 18, 2023.

World Nuclear News. 2025. "Trump sets out aim to quadruple US nuclear capacity." URL `https://www.world-nuclear-news.org/articles/trump-sets-out-aim-to-quadruple-us-nuclear-capacity`.

York, Richard. 2012. "Do alternative energy sources displace fossil fuels?" *Nature climate change* 2 (6):441–443.

Zhang, Junjie, Rongwen Jia, Hangjun Yang, and Kangyin Dong. 2022. "Does electric vehicle promotion in the public sector contribute to urban transport carbon emissions reduction?" *Transport Policy* 125:151–163.

Zysman, John. 1983. *Governments, markets, and growth: financial systems and the politics of industrial change*. Cornell University Press.

Online Appendix

This online appendix contains supporting material for "Industrial Policy and Decarbonization: The Case of Nuclear Energy in France". It reports data sources, the scale of the Messmer Plan, robustness tests, a consumption-based perspective, a decomposition of the fuel-switching effect, sensitivity analysis of the average abatement cost, and a discussion of the conditions for reform.

A Data Sources

- Carbon dioxide (CO_2) emissions. Measured in metric tons per capita. Source: IEA (2022b). Available at: https://www.iea.org/data-and-statistics.
- GDP per capita (PPP, 2005 USD). Expenditure-side real GDP at chained PPPs (rgdpe) divided by population (pop). Source: Penn World Table, version 8.0 (Feenstra, Inklaar, and Timmer, 2015). Available at: https://doi.org/10.15141/S5159X.
- Urban population. Measured as a percentage of total population (World Development Indicators series SP.URB.TOTL.IN.ZS). Source: The World Bank (2015). Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS.
- Electricity production. Measured in kWh per capita. Source: IEA (2022a). Available at: https://doi.org/10.5257/iea/elec/2022.
- Domestic oil and coal production. Measured in kilogram of oil equivalent per capita. Sources: International Energy Agency: Oil Information (2022 Edition) https://doi.org/10.5257/iea/oil/2022; International Energy Agency: Coal Information (2022 Edition) https://doi.org/10.5257/iea/coal/2022.
- Unemployment rate in OECD countries. Percentage of total labor force. Source: AMECO (2018) database. Available at: `https://economy-finance.ec.europa.eu/economic-research-and-databases/economic-databases/ameco-database_en`.
- Household electricity prices. Source: International Energy Agency: World Energy Prices (2020 Edition). Available at: https://www.iea.org/data-and-statistics.
- Energy consumption from electricity and combustible fuels. Measured in oil equivalents. Source: World Energy Balances (IEA 2022c).
  Available at: https://dx.doi.org/10.5257/iea/web/2022.
- Emission Factors. Source: IEA (2024). Available at:
  https://www.iea.org/data-and-statistics/data-product/emissions-factors-2024.
- Energy Prices. End-use energy prices. Source: IEA (2025a). Available at:
  https://www.iea.org/data-and-statistics/data-product/energy-prices

B The Scale of the Messmer Plan

Measuring the magnitude of an industrial policy can be challenging (Juhász, Lane, and Rodrik, 2023). Especially compared to quantifying policy instruments like carbon taxes, which can be expressed in tangible terms such as cents per litre of gasoline or the percentage increase in coal prices. Accurately assessing the scope of an industrial policy is nonetheless important. It allows us to grasp the policy's scale and expected impact in easily comprehensible units.

To quantify the scale of the Messmer Plan, we computed the difference in the number of nuclear reactors either under construction or in operation in France and its counterfactual, before and after the plan's announcement. This calculation was adjusted to account for variations in population sizes across countries in 1974.

By the time the Messmer Plan was announced in 1974, France already had nuclear power plants in commercial operation or under construction. Of the five countries in the donor pool that receive a positive weight, Portugal never deploys nuclear power plants during our sample period. Austria, Belgium, Switzerland, and Germany, on the other hand, all have nuclear power plants in operation – or where construction had started – both before and after the Messmer Plan was enacted.[38]

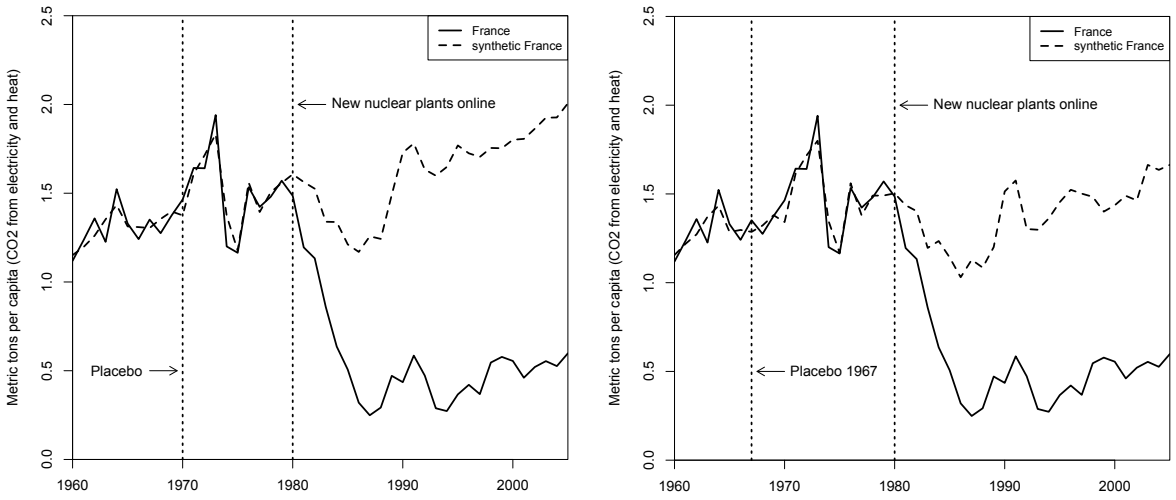
Prior to 1974, both France and synthetic France had a similar number of reactors under construction or in operation, with about 3 reactors per ten million people. However, following the announcement of the Messmer Plan, France began construction on an additional 9.5 reactors per ten million people, whereas synthetic France only added 1.5 reactors.[39] Thus, according to this measure, the Messmer Plan resulted in a more than six-fold increase in the number of nuclear reactors constructed after 1974, compared to the counterfactual scenario.

The six-fold increase in reactor construction suggests that, absent the plan, France would have built only about 8 reactors in the decade after 1974 – rather than the 51 it actually constructed. While France was already on a nuclear expansion path (as reflected in the synthetic control, which also shows post-1974 additions), the Messmer Plan delivered a substantial acceleration.

The increase in nuclear reactors due to the Messmer Plan is further reflected in the net electricity capacity from nuclear energy. While France and synthetic France had similar nuclear capacity in the transitional period, an average of 0.85 gigawatt-electric (GWe) per ten million people between 1974-1979 in France and 0.89 GWe in synthetic France, this grew to just over 10 GWe in France by 2005 but only 2.9 GWe in synthetic France.

[38] Austria built and finished the Zwentendorf nuclear power plant between 1972-1978, but the plant was never put into commercial operation following a referendum on nuclear energy in November of 1978.

[39] For synthetic France, there were four reactors in Belgium and 13 in Germany that began construction after 1974. Note, however, that the reactors in Belgium were ordered before 1974 (IAEA, 2020), as were most of the reactors in Germany (Campbell, 1988).



(a) 1970 (b) 1967

Figure 13: Placebo In-Time Tests: 1970 and 1967

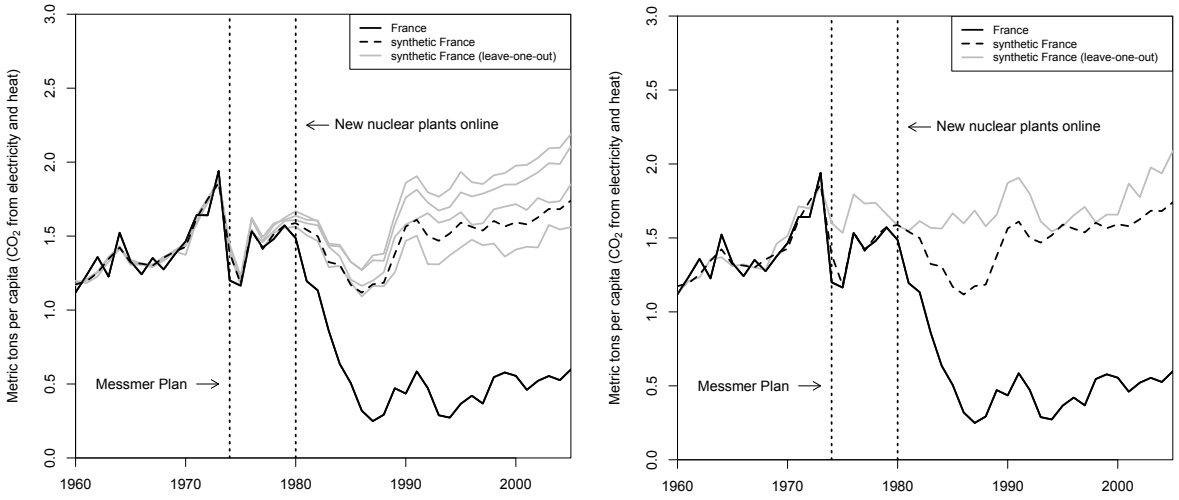
C Robustness Tests

To test the robustness of the main results, we perform a range of tests: in-time placebo, leave-one-out, specification searching, and placebo sector.

With the in-time placebo test, we adjust the treatment year to 1970 and 1967, periods before the Messmer Plan's implementation, constructing counterfactuals with data only from years before these dates. Our objective is to verify the absence of a divergence in the emissions trajectories between France and synthetic France before 1980 – prior to the operationalization of the first new nuclear reactors. An observed placebo effect would raise questions about our claimed causal effect from the Messmer Plan. Figure 13 shows that no placebo effect is found as the two series remain aligned until 1980. This is consistent with the results from the main specification and the existence of the transitional period between 1974-1979 in this study reduces the need for the in-time placebo test.

In the leave-one-out test, we aim to investigate whether the posttreatment results primarily depend on one or more control countries, and whether the accuracy of the pretreatment fit relies on the inclusion of a specific control country. Furthermore, we use this test to estimate a range for our causal effects. To do so, we iteratively eliminate one of the five countries that received a weight larger than 1%. The results, presented in Figure 14, indicate emission reductions ranging from 59.8% (when Portugal is excluded) to 67.1% (when Germany is excluded). All but one of these alternative estimates is above our point estimate of 62%, suggesting our main estimate is conservative and sits at the lower end of the range observed in our robustness checks.

It is important to note that the inclusion of Belgium seems necessary to capture the effects on emissions from the two oil crises. In panel (b) of Figure 14, where Belgium is excluded, we obtain a poorer fit in the transitional period compared to the main



(a) Excluding AT, DE, PT, and CH (b) Excluding Belgium

Figure 14: Leave-One-Out Tests.

Note: In panel (a) we have iteratively excluded Austria, Germany, Portugal, and Switzerland from the donor pool. In panel (b) we have excluded Belgium.

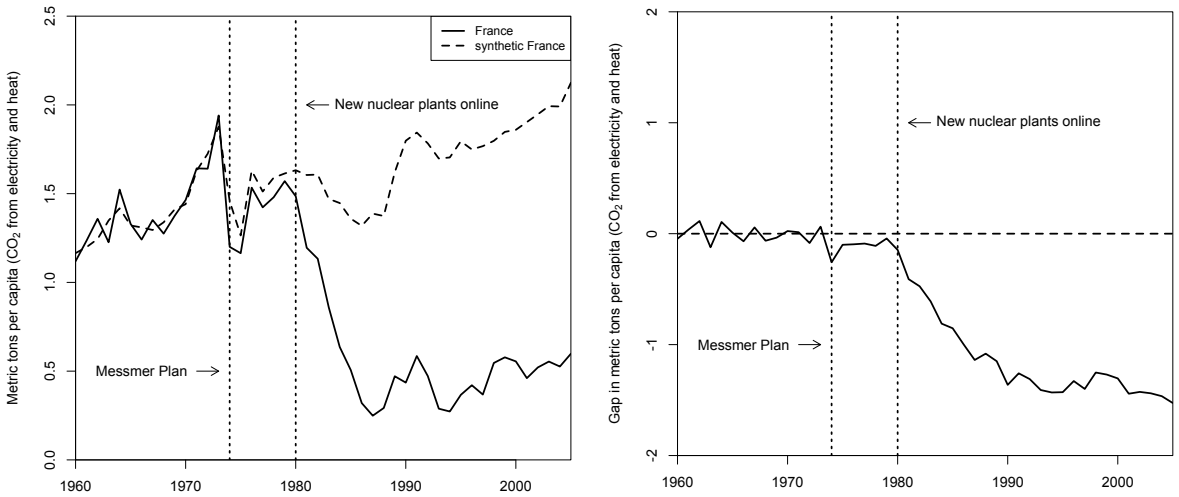


Figure 15: Benchmark Specification

specification, and we also don't obtain the slump in emissions in synthetic France in the 1980s. Similar to France, Belgium used oil as the primary energy source for electricity production in the early 1970s and was still heavily dependent on oil at the time of the second oil crisis. Furthermore, Belgium also had existing nuclear power plants at the time of the first oil crisis.[40] Taken together, Belgium is likely the country most similar to France when it comes to the fuel mix in the pretreatment period – and thus an important inclusion in the donor pool to be able to create a credible "twin" – which may explain

[40]Belgium has two nuclear power plants, Doel and Tihange, that began construction in 1969 and 1970, respectively, and with seven reactors in commercial operation – four in Doel and three in Tihange. The decision to build the first three reactors, Doel 1 and 2, and Tihange 1, was taken in 1966 and the decision to expand with four more reactors, Dole 3 and 4, and Tihange 2 and 3, was taken in 1973 (IAEA, 2020).

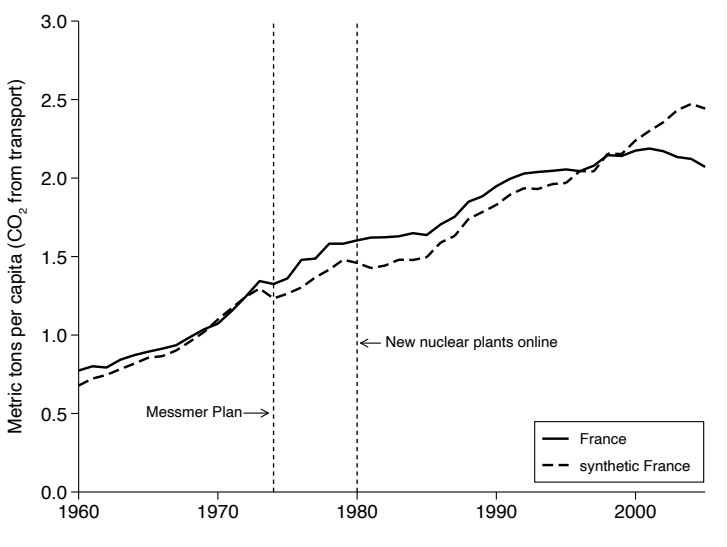


Figure 16: Placebo Sector: Transport

why it is given the largest weight in synthetic France, of around one third.

A potential concern with the synthetic control method is that the choice of predictors and lags of the outcome variable has a large impact on the estimated results and thus creates opportunities for specification searching. Following the recommendation of Ferman, Pinto, and Possebom (2020) we construct a counterfactual using only pretreatment lags of the outcome variable. This specification produces similar results. The largest weights are still given to Belgium and Austria, and Germany and Portugal still receive meaningful weights. In the path and gap plots in Figure 15, we see a good fit in the pretreatment period, and, compared to the main specification, slightly poorer fit in the interim period and larger relative emission reductions from 1980 and onwards.

For the last robustness check, we do a placebo sector test: comparing the trajectories of emissions in a sector that arguably should not be affected by the Messmer Plan. For this purpose we picked the transport sector, where the level of emissions is similar in size to emissions from electricity and heat production, and where, during the sample period, oil was always the main source of energy – electric vehicles is not a meaningful portion of the vehicle fleet at this time.

Figure 16 shows that transport emissions in France and synthetic France closely match in the years before the Messmer Plan was implemented. Then, from 1974 until the mid-1990s, emissions were relatively higher in France, around 8% on average, before decreasing in the final years of our observation period. The significant relative reduction in emissions within the electricity, heat, industry, residential, and services sectors from 1980 and onwards was not mirrored in the transport sector.

The transport sector also speaks to a broader concern: that France-specific shocks unrelated to the Messmer Plan – such as the relative decline in GDP per capita and rise in unemployment documented in Section 5.5 – may be driving the estimated emission

reductions. Transport fuel demand responds positively to income. A relative economic downturn in France should therefore depress transport emissions relative to synthetic France. Instead, we find the opposite: transport emissions in France run above those in synthetic France for most of the posttreatment period. This pattern is difficult to reconcile with a macroeconomic explanation for the reductions observed in the electricity, heat, industry, residential, and services sectors, and it is consistent with the regression evidence in Table 3, which attributes the large majority of the total emissions gap to the expansion of nuclear generation rather than to the macroeconomic variables.

C.1 Permutation test

Table 5: Placebo Countries Retained in the Permutation Test

Placebo country	Synthetic control composition
Austria	France (0.410), Portugal (0.310), Norway (0.224), United States (0.045)
Greece	Spain (0.282), Portugal (0.256), Japan (0.145), Finland (0.142), New Zealand (0.121), Iceland (0.054)
Iceland	Switzerland (0.797), Norway (0.110), New Zealand (0.091)
Italy	Portugal (0.296), Japan (0.255), Iceland (0.215), Greece (0.097), Finland (0.087), Denmark (0.039)
Netherlands	Ireland (0.420), Switzerland (0.245), Australia (0.139), United Kingdom (0.111), United States (0.054)
Norway	Switzerland (0.773), Iceland (0.227)
Portugal	Switzerland (0.679), Norway (0.254), Greece (0.049), France (0.017)
Spain	Greece (0.334), Iceland (0.288), Portugal (0.202), Ireland (0.086), Sweden (0.064), Canada (0.026)
Switzerland	Portugal (0.427), Norway (0.378), Iceland (0.146), Sweden (0.048)

Notes: The table reports the nine placebo countries retained after applying the pretreatment fit filter used in the in-space placebo exercise in Section 5.3. For each placebo country, the second column lists the donor countries and their control weights. Near-zero weights are omitted.

Our primary hypothesis in Section 5.3 is directional: the nuclear buildout reduces emissions from electricity and heat production by displacing fossil fuel based generation. For this reason, our main placebo inference reports a one-sided p-value for unusually large negative gaps.[41] Following standard practice, we also apply a pretreatment fit filter to exclude placebo runs with poor pretreatment fit (Abadie, Diamond, and Hainmueller, 2010). Table C.1 reports the nine placebo countries retained after applying this filter, together with the composition of their synthetic controls.

As a complementary robustness check, we also consider a two-sided null of "any effect" (positive or negative). For this purpose, we use the post/pre MSPE ratio as the test

[41] Abadie (2021, Section 3.5) discusses the advantages of one-sided inference in comparative case-study settings, where sample sizes are often small.

statistic (Abadie, Diamond, and Hainmueller, 2010; Abadie, 2021). Because it is based on squared errors, this statistic treats unusually large positive and negative deviations symmetrically. Using the posttreatment period 1980-2005, when reactors ordered under the Messmer Plan begin operating, France's MSPE ratio ranks third out of the 22 units in our sample, yielding $p = 3/22 = 0.136$.

D Consumption-Based Perspective

In this section, we estimate the Messmer Plan's impact on emissions from a consumption perspective, adjusting for electricity imports and exports. Two methods are employed:

Simple Trade-Adjustment.— In this method, we adjust electricity production by adding imports and subtracting exports, providing an estimate of actual domestic electricity consumption. We then multiply this consumption figure by the national emission factors – for France and synthetic France respectively – to estimate consumption-based emissions.

This approach is intuitive and transparent. It directly reflects how much electricity is used domestically and applies country-specific average emissions intensities. Our simpler measure is available for all years in our sample period (1960-2005) for France and synthetic France.

Trade-Adjusted (Refined).— This method uses trade-corrected emissions factors from the IEA. They are computed using detailed bilateral trade data for electricity (imports and exports) and country-specific emission factors for each trading partner (IEA, 2024, Ch 4). The goal is to calculate a more precise consumption-side emission factor for each country, reflecting the actual carbon intensity of traded electricity flows. This refined measure is available from 1990–2005 for synthetic France and 1960–2005 for France.

The consumption-based methods, shown in Figure 17 as "simple trade-adjustment" and "trade-adjusted", consistently point to larger emission reductions than our main production-based estimate. The simpler approach yields average reductions of 65.4% (1980–2005) and 74.9% for the later part of the posttreatment period (1990–2005) – when almost all the Messmer Plan reactors were in commercial operation. The more detailed method using IEA correction factors produces a slightly higher estimate for the later part: 76.6% (1990–2005). However, the overall difference across approaches is modest. For the period 1990–2005, the range of estimated reductions lies between 70.5% (production-based) and 76.6% (trade-adjusted).

While the refined (IEA-corrected) method is more data-intensive and methodologically sophisticated, it may not necessarily be more accurate. There are several reasons to treat the simpler method as at least equally valid. First, much of the trade for synthetic France occurs between its constituent countries (e.g., in-between Germany, Switzerland, Austria), resembling regional balancing within synthetic France more than traditional

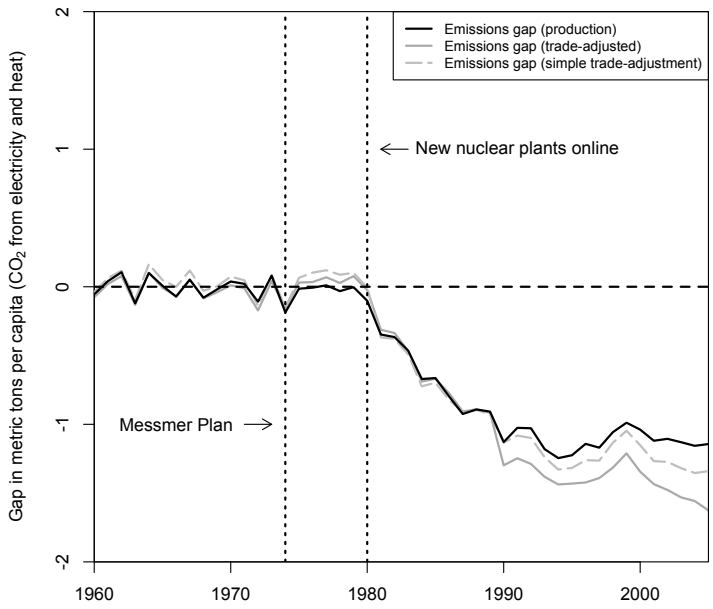


Figure 17: Consumption-based vs. Production-based emissions estimates

international trade. This is reflected in synthetic France's trade balance being close to zero – imports and exports largely offset each other.

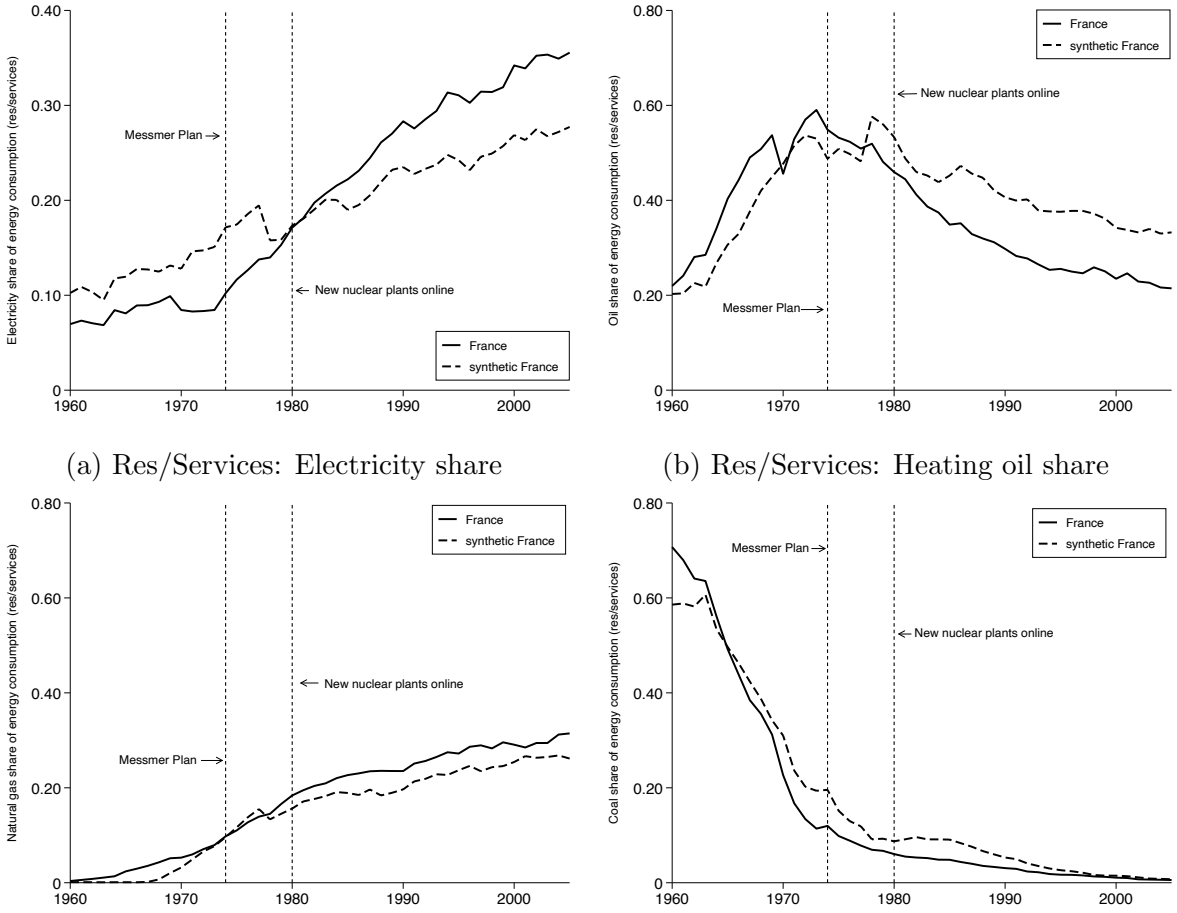
Second, countries like Austria and Switzerland serve as transit hubs for electricity (e.g., French exports to Italy via Switzerland), meaning electricity attributed as "imported" to these countries may not actually be consumed there. This can distort emissions accounting in the IEA-based method.

As such, the refined method may introduce bias to the emissions estimate from electricity consumption due to transit effects ("wheeling") and the within-synthetic France trade.

E Decomposition of Fuel-Switching Effect

In this section, we further decompose energy use in the residential, services, and manufacturing sectors to examine the fuel-switching effect attributed to the Messmer Plan, focusing on the individual fuels: electricity, oil, natural gas, and coal. Overall, following the roll-out of new nuclear reactors in 1980, there is a substitution away from oil and towards electricity and natural gas.

Figure 18 show the shares of electricity and fossil fuel consumption in the combined residential and services sectors in France and synthetic France. Two main conclusions emerge. First, France exhibits a shift away from heating oil and toward electricity, relative to its synthetic counterfactual. This timing aligns with the rollout of new nuclear reactors and a relative decline in electricity prices in France. This increase in electricity use is likely driven by electric heating, rather than greater appliance use, since appliance adop-



(a) Res/Services: Electricity share

(b) Res/Services: Heating oil share

(c) Res/Services: Natural gas share

(d) Res/Services: Coal share

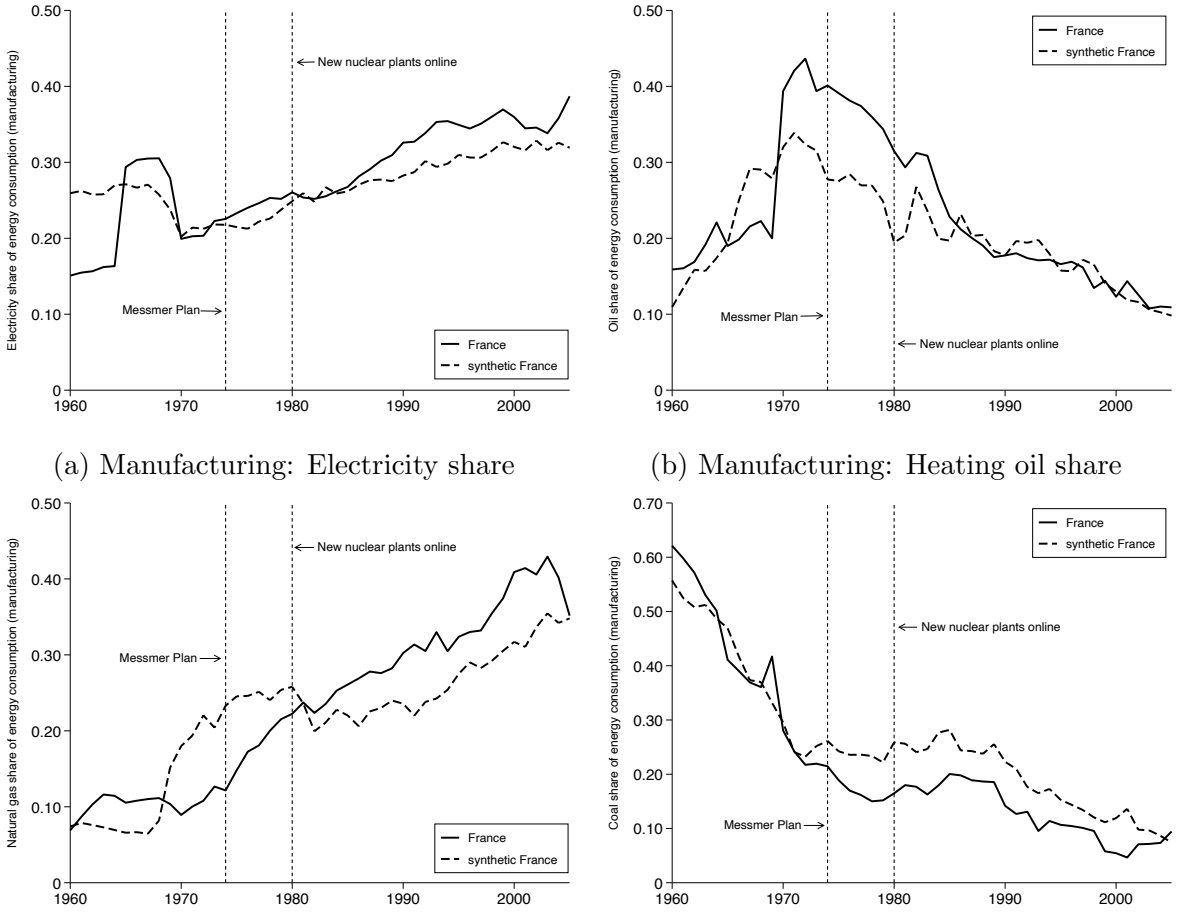
Figure 18: Decomposition of Energy Consumption in Residential and Services Sectors.

Note: The figure shows the share of energy consumption coming from electricity and combustible fuels. To make aggregation and comparisons possible, all energy sources were first converted into oil equivalents. Source: IEA (2022c) – World Energy Balances.

tion should be the same in synthetic France (driven, for instance, by economic growth). Second, coal trends downward in both France and its synthetic counterfactual during the entire sample period, whereas there is an increase in natural gas in France compared to its counterfactual in the posttreatment period; a bit less than four percentage points higher relative share of natural gas usage in the posttreatment period.

Taken together, the evidence points to a relatively stronger fuel-switching pattern in France, specifically from heating oil to electricity and natural gas.

We interpret this as a causal outcome of the Messmer Plan. The rollout of nuclear reactors drove down electricity prices, creating stronger incentives to substitute away from heating oil. Fossil fuel prices – especially for oil – should have evolved similar across France and its counterfactual, so the observed differential likely reflects the relative price advantage for electricity in France. While reduced heating oil usage may have occurred along both intensive and extensive margins (e.g., reduced indoor temperature



(a) Manufacturing: Electricity share

(b) Manufacturing: Heating oil share

(c) Manufacturing: Natural gas share

(d) Manufacturing: Coal share

Figure 19: Decomposition of Energy Consumption in the Manufacturing Sector.

Note: The figure shows the share of energy consumption coming from electricity and combustible fuels. To make aggregation and comparisons possible, all energy sources were first converted into oil equivalents. Source: IEA (2022c) – World Energy Balances.

vs. switching fuels), the synthetic control should capture changes on the intensive margin.

Within the industrial sector, manufacturing is by far the largest energy consumer – with over 90% of the total energy consumed in the three sectors of mining, construction, and manufacturing. Figure 19 decomposes energy usage in the manufacturing sector. In panel (a), we see a relative shift to electricity consumption in France, compared to the counterfactual, from 1980 and onwards.[42] Focusing on the period of 1970-2005, there is a shift also within the group of fossil fuels. Coal usage continues to trend downward in both France and its synthetic counterfactual, whereas there is a relative substitution away from oil to natural gas in France compared to its counterfactual; a five percentage points higher relative share of natural gas on average.

The timing of the increase in natural gas use – coinciding with the post-1980 rollout of new nuclear reactors – is consistent with the interpretation that this was part of the

[42]Note that the data at this disaggregated level is more variable for the 1960s, with a break in 1965 for France "when more detailed data on electricity consumption became available" (IEA, 2021, p.62).

broader indirect energy-system response to the Messmer Plan. However, we cannot rule out that some of the shift toward natural gas reflect other France-specific developments in response to the oil crises in the 1970s.

The magnitude of the natural gas channel is, however, mechanically much smaller than substitution from oil to electricity in our direct sectoral accounting of emissions. Using emission factors (IPCC, 2006), natural gas emits 56.1 tCO_2 per terajoule (TJ), compared with about 74 tCO_2/TJ for oil. Thus, switching from oil to natural gas reduces direct emissions by roughly 18 tCO_2/TJ, whereas switching from oil to electricity reduces direct emissions in the consuming sector by the full oil emissions factor, since emissions from electricity generation are accounted for separately in the electricity and heat sector. The oil-to-electricity channel is therefore approximately four times larger per unit of final energy than the oil-to-gas channel in direct sectoral emissions accounting. For this reason, while the relative shift toward natural gas may contribute to the estimated rest-of-economy emissions reduction, it doesn't account for reductions of the same order as the shift from direct oil use toward electricity.

F Sensitivity analysis of the average abatement cost

Table 6: Sensitivity of the Average Abatement Cost Estimate

Specification	AAC ($/tCO$_2$)
Baseline discount rate: $r = 5\%$	**-0.9**
Panel A. Discount-rate sensitivity	
No discounting: $r = 0\%$	3.1
Lower discount rate: $r = 3\%$	0.2
Higher discount rate: $r = 7\%$	-1.5
Panel B. Alternative treatment of emissions	
Costs and emissions both discounted at 5%	-1.6
Panel C. Alternative counterfactual assumptions	
Hydropower in synthetic France included	21.6
European LCOE used as proxy for synthetic France	-27.8

Notes: The table reports sensitivity checks for the average abatement cost (AAC) of the Messmer Plan. Panel A varies the discount rate applied to cost changes in the numerator of the AAC calculation. Panel B reports an alternative specification in which emissions reductions in the denominator are also discounted. Panel C reports alternative counterfactual assumptions regarding hydropower production and the cost of electricity in synthetic France. The baseline specification corresponds to the AAC estimate reported in Section 5.7.

Table 6 shows that the average abatement cost remains close to zero under alternative discount rates and when emissions reductions are also discounted. The estimate becomes more positive when hydropower in synthetic France is allowed to evolve freely in the counterfactual since this specification does not account for the incremental cost of additional hydropower and therefore likely understates the cost of the counterfactual electricity mix.[43] By contrast, using European average LCOEs (excluding France) as a proxy for synthetic France LCOEs makes the AAC more negative. We do not construct donor-weighted synthetic France LCOEs because IEA (2015) does not report LCOE data for all countries in synthetic France. For coal, data are available only for Belgium, Portugal, and Germany; for nuclear, only for Belgium, Germany, and Switzerland; and in both cases the coverage is sparse over the posttreatment period.

[43] In this alternative specification, non-hydropower electricity production in the counterfactual is defined by subtracting hydropower generation in synthetic France from total counterfactual electricity production, rather than subtracting France's observed hydropower generation as in the baseline AAC.

G The Conditions for Reform

Here we describe in detail the conditions that set the scene for the Messmer Plan in France.

G.1 Exogenous shock

Scholars of political economy have long pointed out how exogenous shocks and crises can facilitate far-reaching reforms (e.g., Baumgartner and Jones, 1993; Collier, Collier et al., 1991; Gourevitch, 1986; Ikenberry, 1988). During these 'critical junctures' the limitations of existing policy arrangements are laid bare, and actors search for new ideas, instruments, and institutions that can respond to the challenge of the times. Politics and policymaking are rendered more fluid and ideas previously considered radical become practical. The 1973 oil price shock constituted such a critical juncture and presented governments with a clear and present crisis that needed a response. Indeed, in its aftermath all industrialized democracies sought to reform their energy sectors to reduce dependence on imported oil (Finnegan et al., 2025).

G.2 Technological capacity

In many ways, the infrastructure for a large-scale nuclear program was in place in France when the oil shock hit (Grubler, 2010; Jasper, 1990, Ch 5; Lucas, 1979; Naudet, 1993; Thomas, 1988, Ch 8). On the eve of the price shock, the country had eight reactors in commercial operation and five under construction. It had developed significant expertise in nuclear engineering through long-standing investments in research and development to the public nuclear research body Commissariat à l'Énergie Atomique (CEA). The firms Framatome and COGEMA, as well as a broader national supply chain of electro-mechanical producers, had expertise and experience related to reactor design, manufacturing, fuel production and commission and maintenance services. Finally, EDF, the national utility, could construct and operate nuclear power stations.

Technologically, EDF and CEA had resolved their conflicts over reactor choice, settling on US-licensed Westinghouse pressurized water reactors (PWRs) and abandoning the domestic graphite-gas design. This enabled an initially fragmented French nuclear supply chain to standardize exclusively on the Westinghouse PWR design (Campbell, 1988, Ch 8; Thomas, 1988, 218). This was not the case in the UK, for example, where political debates about reactor choice endured throughout the 1970s and stymied its nuclear rollout (Helm, 2003; Williams, 1980).

Lastly, an off-the-shelf plan for rapid expansion was available when the price shock hit. The PEON (Production d'Électricité d'Origine Nucleaire) Commission, which advised the government on nuclear energy development, had coincidentally laid out a roadmap for a

significant nuclear build out of 13,000 MWe in its April 1973 report, six months before the price shock.

Consequently, by the time the oil price spiked in October 1973, the French government did not need to develop a nuclear industry from scratch nor design a policy for rapid expansion, but rather only put its weight behind existing plans and actors.

It is crucial to point out, however, that while exogenous shocks and technological capacity are important for understanding the French case, these factors alone do not explain the political success of the Messmer Plan. All industrialized countries were affected by the oil price shock and many had pre-existing nuclear programs similar to those of France, yet not all expanded nuclear power at a similar pace and scale. The key variable that set France apart from otherwise similar countries was its political and policymaking institutions.

G.3 Political and policymaking institutions

Institutions are formal and informal rules that structure political, economic, and social interaction (North, 1991; Thelen and Steinmo, 1992). They vary across countries and shape politics and policymaking by affecting the degree of power actors have over policy outcomes.

In the postwar period, French political institutions were characterized by *dirigisme* – a type of policymaking whereby governments play a strong directive role in the economy in pursuit of national goals (Hall, 1986, Ch 6; Hall, Hayward, and Machin, 1994, Ch 9; Schmidt, 1996, Ch 2). Dirigisme describes institutional arrangements as well as policies, and contrasts with neoliberal policymaking styles that minimize state intervention. Under dirigisme, governments tend to focus on steering production and investment and can unilaterally intervene in the economy. While this route was not always taken by French governments, it was typically used to pursue 'heroic' policies that were central to the government's agenda and/or national security, such as nuclear energy (Schmidt, 1996).

Several key institutions undergirded French dirigisme during this period. First, an autonomous state bureaucracy comprised of highly trained civil servants recruited from the elite grandes écoles with deep technical expertise and long-term employment security was the primary locus of policymaking and could be impermeable to outside interests (Suleiman, 1974; Schmidt, 1996, Ch 7). Second, and relatedly, civil servants in the Planning Commission used indicative economic plans to outline the allocation of resources among the major sectors of French industry (Hall, 1986, Ch 7; Hall, Hayward, and Machin, 1994, Ch 9). Third, the financial system was based primarily on bank lending, which empowered the French state to use the nationalized banking sector to selectively provide capital to firms and industries in alignment with its broader economic goals (Hall, Hayward, and Machin, 1994, Ch 9; Zysman, 1983, Ch 3). Last, decision-making

was centralized within a powerful executive headed by the President with a majority in the National Assembly (Keeler, 1993). Opposition parties and, given the unitary nature of the French state, regional authorities had little influence.

Beyond these general factors, characteristics of energy policymaking and the energy sector in particular offered the state additional capacity for intervention. State engineers belonging to the Corps d'État (Corps des Mines and Corps des Ponts) strongly identified with the national goal of energy independence and were responsible for the nuclear program within the ministries, especially the Ministry of Industry, as well as holding top management positions within EDF and the CEA (Finon and Staropoli, 2001, 185). Additionally, authorities responsible for nuclear safety and siting were integrated within the Ministry of Industry and the CEA, which worked to streamline implementation (Finon and Staropoli, 2001, 185). Last, the state was a majority shareholder in the country's most important energy-related firms, including EDF, the nuclear manufacturer Framatome and the nuclear fuel producer COGEMA, and nuclear research and development was coordinated through the CEA, a public body. Taken together, this provided the conditions for an autonomous, centralized, and technocratic policymaking process that could be controlled from the executive branch.

The case was very different in other industrialized democracies. Policymaking in nearly all other similar countries was less autonomous and less centralized under the control of the executive. Countries like the US had strong legislative and judicial branches that could obstruct or veto executive action (Campbell, 1988). Most other countries had bureaucracies that were more permeable to the influence of outside interests groups. Policymaking processes in these countries also offered more access to the public and outside critics, in the form of public hearings and consultations, than in France. At the same time, almost no other industrialized country had a state planning system as powerful as France. Similarly, financial systems in peer countries tended to be private and outside of direct state control, as were key nuclear-related firms.