FRENCH INDUSTRIAL POLICY: DEMONS, GODS, AND CHALLENGES

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RESUME

Cet article met en perspective le cadre politique et institutionnel dans lequel se définit les politiques industrielles en France. Les interventions économiques des gouvernements relevant des politiques industrielles se sont multipliées ces dernières années dans les pays riches. La France s'inscrit dans ce mouvement avec d'autant plus d'aisance qu'elle a toujours conservé une forte propension (relative) à l'intervention. En décrivant le cadre institutionnel et politique de la politique industrielle en France, cette étude met en évidence à quels objectifs prioritaires elle a répondu hier et devra répondre demain. Après avoir défini les moyens d'identification de la politique industrielle en France, j'analyse les trois dimensions qui structurent l'élaboration de cette politique industrielle : ses démons — la désindustrialisation et la planification, ses dieux — les champions et la technologie, et ses défis — l'Europe, la décarbonation et l'intelligence artificielle.

MOTS CLES

Politique industrielle – France – Industrie – Champions – Décarbonation – Intelligence artificielle

JEL

H25 – L52 – O14 – O25 – O31 – R28

ABSTRACT

The paper puts into perspective the political and institutional framework in which French industrial policies are designed. In many rich countries, we observe an increase in States' intervention under industrial policies' objectives. France is fully involved in such a movement given its long tradition of interventionism. To understand the design of the French industrial policy, the paper highlights to which priorities the French industrial policies obeyed in the past, and to which challenges they are going to face in the future. After defining the main tools used by the French authorities, I analyse the three dimensions which frame the design of the policy: the two demons — industry decline and economic planning, the worship of national champions and of technology and the three challenges associated with the European union, the greening of the economy and artificial intelligence.

KEYWORDS

Industrial policy – France – Industry – Champions – Green industry – Artificial Intelligence

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French Industrial Policy: Demons, Gods, and Challenges

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Summary The paper puts into perspective the political and institutional framework in which French industrial policies are designed. In many rich countries, we observe an increase in States' intervention under industrial policies' objectives. France is fully involved in such a movement given its long tradition of interventionism. To understand the design of the French industrial policy, the paper highlights to which priorities the French industrial policies obeyed in the past, and to which challenges it is going to face in the future. After defining the main tools used by the French authorities, I analyse the three dimensions which frame the design of the policy: the two demons — industry decline and economic planning, the worship of national champions and of technology and the three challenges associated with the European union, the greening of the economy and artificial intelligence.

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Sarah Guillou

December 2, 2024

As noted by Criscuolo et al. (2023) and Evenett et al. (2024), government economic interventions related to industrial policies have multiplied in recent years in wealthy countries. These interventions seem to enter a self-sustaining process of cascading reactions to measures taken by one country and then another. This also demonstrates that the sectors attracting the attention of wealthy countries are the same, i.e., those in which they are in competition. France is part of this movement with even greater ease as it has always maintained a relatively strong propensity for intervention, which distinguishes it within the European Union. Thus, from Etienne Davignon to Thierry Breton, French personalities have marked the history of European industrial policy. By describing the institutional and political framework of industrial policy in France, this study highlights the priority objectives it has addressed in the past and will need to address in the future. This is not an evaluation but a description of the political economy of industrial policy in France. After defining the means of identifying industrial policy in France (section 1), I analyze the three dimensions that structure the development of this industrial policy: its demons - deindustrialization and planning (section 2), its gods - champions and technology (section 3), and its challenges - Europe, decarbonization, and artificial intelligence (section 4).

Section 1. The Challenge of Identification and Measurement

By industrial policy (IP), I mean all policies aimed at orienting or even modifying the productive specialization of an economy. Specialization can be defined by the shares of different production activities in total production.[1] The impact of IP on specialization can be qualitative, which is mainly the objective of horizontal policies such as support for R&D or energy savings, or it can affect the structure of specialization by strengthening certain sectors or technologies, developing new sectors, which are more related to vertical policies. My approach is a proactive vision of industrial policy. This excludes a large part of the support whose main objectives are to help and support declining sectors or regions. In Hufbauer & Jung (2021), a comprehensive study on

[1] Activities are traditionally distinguished into three major sectors: agriculture, industry, and services. The industry sector is further subdivided into manufacturing production, energy and water production, and extractive activities. Within each of these groups, it is possible to refine the understanding of specialization.

American industrial policy over the past 50 years, the definition is much broader as industrial policy encompasses all support measures towards businesses or sectors regardless of the objective. It can be a growth objective, support for declining sectors, job or business rescue, externality management, or promoting dominance in a technology. This definition is used by Criscuolo et al. (2019), who focus on subsidies to support jobs. The inclusion or not of safeguard measures is a first criterion for defining the scope of industrial policy. A second criterion concerns the sectors involved. In the France Stratégie report by Aussilloux et al. (2020), industrial policy is studied through the lens of traditional manufacturing industries (from telecommunications to automotive to pharmaceuticals) or what was once called the secondary sector. This is a strict approach in terms of sectoral scope that dates back to the origins of industrial policy practice. But the report also considers that industrial policy can be a means of modifying production processes, particularly towards less polluting forms. This sectoral scope restriction is increasingly absent in academic and institutional articles (IMF 2024b) but remains very present in the communication of public decision-makers who discuss deindustrialization. Finally, a third criterion concerns the verticality of interventions or, in other words, the sectoral nature of industrial policies. Some associate industrial policy only with measures specifically targeting businesses in a particular sector and exclude from its scope more horizontal policies that would favor a context of growth and competitiveness. According to Aiginger (2007), this is also a dividing line in support for industrial policy. Ultimately, three criteria allow for classifying definitions of industrial policy: scope (secondary sector or more), objectives (specialization, support for declining industries, influence on production processes), and verticality. In the definition I adopt, industrial policy can affect all sectors, even non-secondary ones, and aims at specialization without excluding horizontal policy processes through technological choices and the nature of production. It is close to that of Noland & Pack (2003), who define it as "an effort by a government to change the sectoral structure of production toward sectors it believes offer greater prospects for accelerated growth than would be generated by a typical process of industrial evolution according to static comparative advantage" or Lane (2020), who defines it as "intentional political action meant to shift the industrial structure of an economy" or Juhász et al. (2023) or Cherif & Hasanov (2019). It should be noted that the goal of modifying specialization is itself motivated by a growth or welfare objective. This leads me to assert that industrial policy is eminently political in the sense that it responds to democratic choices and a societal project. The definition of welfare depends on citizens' preferences. Thus, one may want GDP growth coupled with a decarbonization objective, education, technological choices... This is consistent with the position of Mazzucato & Rodrik (2023), who assert that industrial policy must be framed within the objectives of reducing inequalities and sustainable growth. But while they set this framework as a constraint for defining industrial policy, I leave open the choice of ex-ante preferences that will guide industrial policy. Many economic measures claim to be industrial policy, especially in France, where this policy is strongly supported by voters. How to qualify a policy as industrial beyond expressing its intention to affect specialization ? Industrial policy does not encompass a set of specific techniques like monetary policy or trade policy, or a set of tools like tariffs or key interest rates, for example. From regulation to subsidies to taxation, all tools can be mobilized, so industrial policy does not only involve aid to businesses. Conversely, not all aid to businesses can be attributed to industrial policy intentions. Empirical ex-post identification of industrial policy is therefore not easy because the instruments are multiple, intervention with businesses responds to various objectives, and the public actors involved are numerous. Identification requires highlighting the public decision-maker's intention to durably

affect productive specialization to achieve an economic growth objective, in quality or volume.

1.1 State aid to businesses, a favored tool of industrial policy

As this study defines industrial policy, it is incorrect to associate all state aids to businesses with industrial policy. As we will see, many aids are not intended to influence specialization but to modify behaviors, support employment, or regional development.[2]

However, the diversity of public aid to businesses and its proliferation over the past twenty years must be examined, as industrial policy is part of this prolific dynamic. It is within the description of this whole that it is important to distinguish what constitutes an active industrial policy.

1.1.1 Legal and theoretical definition of state aid and diversity of motives

The definition of state aid or public aid to businesses is found in the regulatory acts that limit them. It is primarily European rules that specify what constitutes state aid. While the Treaty on the Functioning of the European Union (TFEU) prohibits aid to businesses (Article 107, paragraph 1), it does not, however, provide a precise definition. The Court of Justice of the European Union (CJEU) clarifies that state aid occurs when government intervention provides an economic advantage to a business that would not have been obtained under market conditions. Four criteria characterize state aid.

First, the aid must target businesses or productions. Consequently, aid that goes directly to consumers to finance the demand for certain products (such as the ecological bonus for purchasing electric vehicles) is also considered state aid to businesses. Second, the aid must come from public administrations, both central and decentralized. In France, the existence of multiple levels of territorial administration increases the number of actors likely to intervene with businesses. Although regions have the main prerogatives for economic development, other motives such as environmental protection, regional planning, or transportation can lead to support for local businesses. According to the French Court of Auditors (Cour des Comptes), "economic development expenditures represent an average of 11% of total regional expenditures, 4% of those of municipalities and intermunicipal cooperation establishments (EPCI), and 2% of departmental expenditures" (Cour des Comptes 2023a, page 214).[3] Third, the aid must be selective, meaning it targets a specific entity. Therefore, a general tax measure, such as a reduction in the tax rate for all businesses, does not fall under the category of state aid. Finally, the aid must affect the competitive situation of the targeted market. The criterion for assessing the distortion effect on competition and a transaction not carried out under normal market conditions is fundamental for qualifying explicit government support to the economy. This leads to comparing the aid policy to the counterfactual of a private investor's situation. Besley & Seabright (1999) emphasize the key role of the market economy investor principle as a reference behavior for judging competition distortion.

[2] Admittedly, preventing a sector from disappearing does influence specialization, but it is more a strategy of conservation and transition towards disappearance rather than an orientation of specialization.

[3] Between 2014 and 2020, the court estimates the average annual amount of local authorities for economic development purposes to be 8.5 billion euros.

The list defined by the European Commission and CJEU rulings overlaps with that proposed by Schwartz & Clements (1999) to define aid. These authors identify seven categories: direct payments to producers or consumers; guaranteed loans, subsidized interest rates, or subsidized loans; tax credits or tax debt reductions; equity investments in businesses; provision of goods and services below market prices (in-kind subsidies); purchase of goods and services above market prices (procurement subsidy); and implicit payments through regulation allowing off-market transactions or privileged market access.

European texts more specifically add the transfer of buildings or land free of charge or under particularly favorable conditions and the coverage of operating losses.

It is evident that the tools of intervention are numerous, but the motive of industrial policy is not characteristic of the definition of state aid. While industrial policy often leads to the implementation of state aid, conversely, the qualification of state aid does not imply the identification of an industrial policy. Many other political, social, and economic motives can justify the use of state aid: regional planning, training, digitalization of the territory, aid to declining industries, guiding consumption and usage patterns... In economic theory, state aid is often described such as the provision of a subsidy. More precisely, state aid will be modeled by an increase in the unit price that remunerates production (if the company is a price taker) or by a reduction, initiated by public policy, in the production cost (including the cost of capital) of the company. The intention of industrial policy is set ex ante and does not take a specific form in theoretical modeling. Empirically, the polymorphism of state aid complicates the identification of its effects. It is however necessary to improve the evaluation of its effects since we observe an important growth in the aid granted to economic actors and a shift in doctrine regarding the role of subsidies.

1.1.2 Public aid to businesses has been steadily increasing since 2000

The 1990s saw a reduction in state intervention in European countries and the United States, while more expansive industrial policies emerged in Asia from the 1970s to the 1990s (Lane 2022). This trend began to reverse in the 2000s, particularly after the 2008 financial crisis in developed countries. The crisis prompted substantial state support, initially targeting the banking sector and subsequently extending to the broader economy, including the automotive industry.[4]

The European Union increasingly adopted exceptional measures to relax aid conditions for businesses. A temporary framework was introduced in 2020 in response to the Covid-19 crisis.

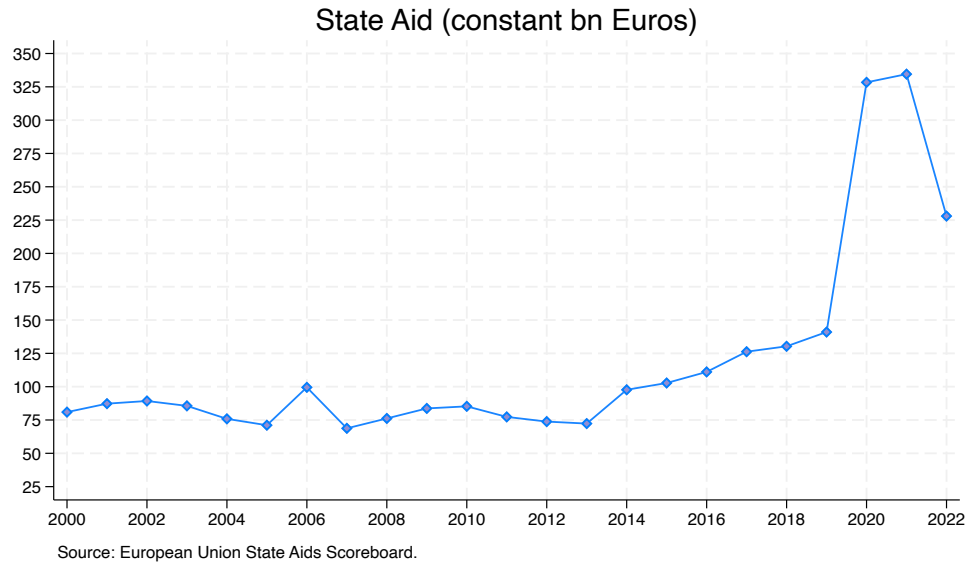
In France, business aid during the Covid-19 crisis in 2021 amounted to nearly 160 billion euros. This included financing for partial unemployment (26 billion euros), the solidarity fund for businesses, and guaranteed loans. For some businesses, this aid more than offset the activity shock they experienced (see Guillou, Mau & Treibich 2023). At the European level, the Next Generation EU (NGEU) plan, effective from 2021, provided an additional 750 billion euros to member states' budgets.[5] For instance, the 100 billion euros *France Relance* plan was to be funded with 39.4 billion euros from NGEU.

Then, on March 23, 2022, the Commission implemented an emergency aid mechanism to

[4] In the United States, GM and Chrysler reportedly received loans amounting to $17.4 billion from the Bush administration at the end of 2008, followed by public aid totaling $22 billion as part of a restructuring plan.

[5] As of February 1, 2024, only a little over a third of the budget had been disbursed to the member states.

Figure 1: European Union total State Aids (constant bn euros)



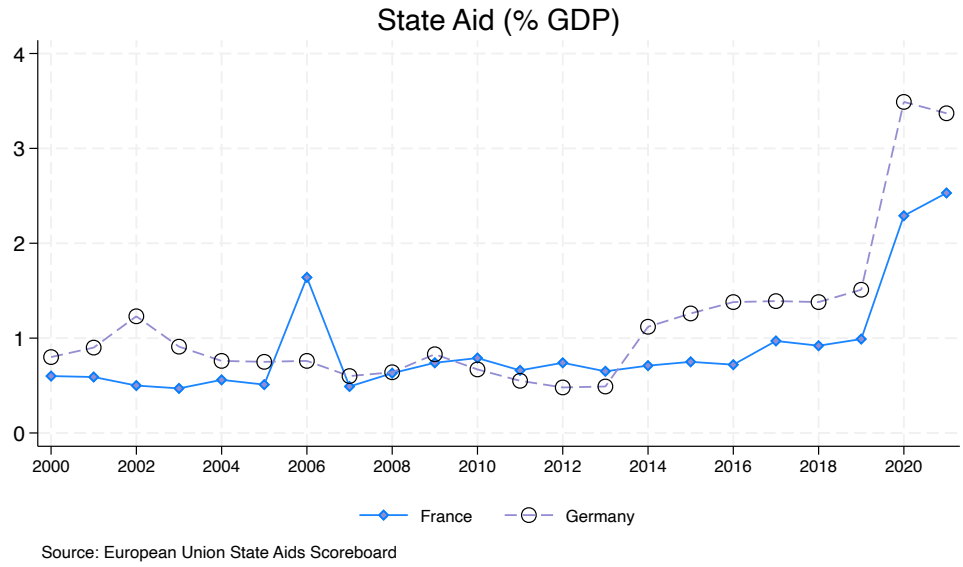
address the increase in gas and electricity prices resulting from the Russo-Ukrainian war. The temporary crisis framework allows for support to energy-intensive businesses that face a dramatic increase in gas and electricity prices (European Commission 2022). It was amended on July 20, 2022.

By the end of 2023, although prices had receded, the Israeli-Palestinian conflict increased the level of uncertainty. The Commission decided to extend the exceptional regime allowing states to aid their businesses beyond the treaty framework until the end of March 2024. According to the new rules, states can provide up to 2 million euros in subsidies or loans to businesses facing difficulties due to rising energy costs. However, aid for adapting to climate constraints, which ended at the end of 2023, is no longer covered by these exceptions.

Figures 1 and 2 show a significant increase in the amount of aid associated with the Covid crisis, as well as a previous break in 2013. The total amount of aid declared to the European Commission by the entire EU in 2021 reached 334 billion euros in current prices. Until 2014, this sum primarily included aid related to environmental protection (10-20%), Research, Development, and Innovation (8-14%), and regional aid (12-23%). Environmental aid increased significantly from 2015 onwards, followed by aid associated with exceptional economic disruptions, which explains the increase from 2020 onwards.[6] German aid increased in 2014 and then followed a parallel trend to French aid.

[6]The different classes of expenditures are: Environmental protection including energy savings; Research and development including innovation; Sectoral development; Training; Promotion of export and internationalisation; Regional development; SMEs including risk capital; Culture; Rescue & Restructuring Compensation of damages caused by natural disaster; Employment; Agriculture, Forestry and Rural areas; Fisheries and aquaculture; Heritage conservation; Closure aid; Remedy for a serious disturbance in the economy; autres.

Figure 2: State aids in percentage of GDP in France and Germany



How can we explain this increase in aid observed in Europe, the United States, and Asia? In my opinion, there are three main reasons for the growing state intervention in the economy. The first is the insurance role of the state, which has increased with the frequency and intensity of risks and crises. The second is the economic and technological competition between states for comparative advantages and strategic trade policy. We are seeing more interventionist policies from countries involved in global trade and the technological race. The third reason is the need to direct capital into assets that align more closely with ecological transition objectives and, more generally, national security goals.

Until 2022, in the United States and the European Union, support for businesses existed but took the form of either safeguard measures or more horizontal measures to co-finance R&D, for example. It was not a proactive industrial policy involving direct subsidies as observed more recently. For instance in France, Pisani-Ferry et al. (2016) show that support for innovation from 2000 to 2015 was mainly concentrated on indirect aid (tax credits) and that the share of subsidies had decreased—halved—over the period.

Despite this significant reduction in the importance of direct aid, Daniela Gabor (2023) shows that the level of interventionism remains confined to guiding capital and managing risk. It does not involve producing or setting quantified production targets to achieve objectives; most industrial policies remain at the stage of capital orientation. According to Gabor (2023), while the European Green Industrial Deal and the Inflation Reduction Act follow the same logic focusing on guiding capital allocation, the CHIPS and Science Act is more directive and disciplines capital to ensure a national security objective. In the first type of intervention, "derisking" tools are used—loans, tax credits, guarantees, equity investments—while the CHIPS and Science Act is more selective about projects, restricts share buybacks, investments with partners in geopolitical tension (Russia and

China), and requires capacity investment commitments. What Daniela Gabor calls the "derisking State" policy involves assigning political objectives to economic actors, such as decarbonization, and incentivizing them by financing the risk associated with the necessary investments to achieve the objective. The pace of achieving these objectives depends on the willingness of the economic actors.

Nevertheless, there is undeniably a resurgence of subsidies as a means of supporting businesses. Throughout the 1980s and 1990s, subsidies were considered a source of inefficiency and rent-seeking. In a competitive market, it is quite easy to show that the introduction of subsidies (for exports or production) leads to a decrease in welfare, measured by the sum of the economic agents' surpluses. The cost to public administrations and the loss of consumer surplus due to the increase in domestic market prices are not offset by the increase in producer surplus. There is a deadweight loss in welfare equivalent to the imposition of a tariff in a competitive market. Economically, subsidies were seen as a waste of resources both in the short and long term and as an instrument serving lobbies and vested interests. In imperfect competition, for example when a small number of actors share the market, it can be shown that subsidies allow capturing part of the demand from competitors and then may increase the economy's surplus. This is demonstrated by Brander & Spencer (1985) in the context of Cournot competition. However, the theoretical demonstration is not robust when changing the type of competition (price competition à la Bertrand rather than quantity) and introducing dynamic effects. There is a large economic literature that theoretically shows the pitfalls of industrial policies.

More recently, warnings have come from international institutions, which is related to their international perspective and the preferred choice of cooperative solutions. It is notable, however, that recent studies recognize a legitimate space for industrial policy, particularly in achieving environmental objectives (Millot & Łukasz Rawdanowicz 2024). However, these studies highlight the risks associated with reduced competition and protectionism (Millot & Łukasz Rawdanowicz 2024, IMF 2024b) and remind us not to exclude cost-benefit trade-offs in a very constrained budgetary context (IMF 2024a). They agree to limit government interventions to situations of significant market imperfections, leading to high societal costs, that the market alone cannot resolve.

Despite this body of warnings, both old and recent, governments have used this support channel more or less openly. This legitimately lead Juhász et al. (2023) to wonder why economic literature has focused on whether to engage in industrial policy rather than how to conduct industrial policy. After World War II, governments began to provide subsidies for the expansion of industries or businesses (excluding those for conservation or safeguarding purposes) as soon as they were no longer directly involved in production. The privatizations of the 1980s and the withdrawal of states from the productive system, except in sovereign or strategic sectors (railways, telecommunications, energy, and water), led states to consider other modes of intervention to promote the expansion of certain industries or businesses.

Even the United States, highly critical of foreign subsidies, did not hesitate to subsidize the semiconductor sector in the late 1980s to protect against Japanese imports. The government allocated hundreds of millions of dollars in 1987 to form an R&D consortium, Sematech. Goldberg et al. (2024) show that the policy of supporting the semiconductor industry primarily used subsidies in both Asia and the United States.

Despite their own behavior, during the 1980s and 1990s, the United States was the first to complain about subsidies provided by its trading partners, notably Japan, South Korea, and even

Europe. It was at their initiative that the GATT negotiations were launched, leading to the subsidies code from the Tokyo Round and then to the Agreement on Subsidies and Countervailing Measures (SCM Agreement) from the Marrakech Agreement of 1994. Faced with the United States, other countries wanted more transparency in the conditions under which the United States could impose countervailing measures.

This agreement had the merit of classifying different types of subsidies and introducing more precise rules on the activation of countervailing measures in international trade law. According to the agreement, export subsidies are classified into three categories: prohibited specific subsidies, actionable subsidies (which can be challenged), and non-actionable subsidies (which cannot be challenged). Specific subsidies are those tied to export objectives and the obligation to use domestic products. Actionable subsidies are those for which complaining states must demonstrate that harm is caused by foreign subsidies. The agreement also included a commitment by signatories to declare the subsidy schemes they implemented. However, this commitment has rarely been upheld. Today, in light of the proliferation of subsidies, some, like Hillman & Manak (2023), call for a new international agreement to restore transparency and fairness in these policies and their new justifications.

Is France more generous in terms of business aid? Figure 2 shows that Germany, which talks less about industrial policy, has been aiding its businesses more, relative to its GDP, than France since 2014. However, France appears as the most lavish OECD country in terms of industrial policy support according to Criscuolo et al. (2023). Focusing on subsidies and tax credits, the comparison of about ten OECD countries covered by the study identifies the United Kingdom and France as the biggest spenders as a percentage of their GDP. The average is 1.4% of GDP compared to 2.3% and 2.2% for the United Kingdom and France, respectively.

Sharing the same level of deindustrialization and a high proportion of vertical (sectoral) support, the UK and France differ in the share of subsidies versus tax credits. Subsidies dominate in France, particularly due to the apprenticeship tax and support for renewable energies, while tax credits dominate in the United Kingdom due to the tax reduction scheme associated with capital investments. France focuses more than a third of its interventions on employment and skills. This suggests that French intervention methods extend beyond the state aid recorded in the European Scoreboard statistics.

1.2 Industrial Policy Channels Beyond Public Aid

There are numerous indirect aids that operate through taxation. For example, support for R&D in France primarily takes the form of a tax credit. Temporary tax exemptions are also another means of attracting businesses to a territory. More generally, taxation is extensively used to influence behaviors. Given the diversity of these mechanisms, we will not dwell on this instrument. However, it is worth noting that tax credits are increasingly used to direct investments. They avoid immediate public expenditure and only create a fiscal expense (foregone revenue) if a company's behavior and/or targeted expenditure are observed, thus potentially increasing the future tax base. Given our definition of industrial policy, protectionist measures must be excluded from the industrial policy's tools. Tariffs or regulations to limit foreign imports can temporarily protect an industry, but this is a defensive industrial policy. While protection can be seen as a strategic trade policy to temporarily eliminate competition until knowledge and efficient size are acquired to be competitive, such a policy

is better exercised by subsidizing local actors rather than excluding competition through tariffs. Among the alternatives to subsidies, we will consider public procurement and equity financing.

1.2.1 Public Procurement

The political debate recurrently raises the question of a "Buy European Act" (BEA) as a means of promoting European actors and as a lever for industrial policy. France is the first to highlight the opportunity of such a mechanism. Many French policymakers, including President Emmanuel Macron, support such a measure as a way to address the difficulties of European companies in industry and to fight the protectionist measures of our partners (see Guillou et al. 2024). A BEA would involve allocating a portion (e.g., 50%) of public contracts to companies headquartered in Europe or those committed to local production thus having a subsidiary and being European in residence if not in headquarters. The value of public procurement suggests a considerable leverage effect on demand, estimated between 1,500 and 2,000 billion euros annually in the European Union and about 300 billion euros in France (DG GROW 2021). Does public procurement really belong to industrial policy tools? Firstly, it should be noted that not all public procurement results in public contracts, and for those that do, not all lead to tenders, which would be the legal modality for exercising discrimination in favor of domestic offers. As Saussier & Tirole (2015) remind, public procurement includes not only public contracts but also public service delegations and partnership contracts. Moreover, only a portion of public contracts are awarded through tenders. Proponents of an affirmative answer to the above question cite the importance of market opportunities for business growth. Thus, if public procurement could favor local supply, it would support businesses against foreign competition. However, this argument is overly simplistic, as we will explain, and it overlooks the reality of a domestic bias (see Guillou et al. 2024). Indeed, public procurement is naturally heavily oriented towards local bidders despite non-discrimination rules imposed by the European public procurement directive or the 2012 WTO Government Procurement Agreement (GPA). This is known as the domestic bias. According to a study by the European Court of Auditors (2023), only 5% of contracts in EU member states are awarded to non-local offers.[7] France discriminates the most in favor of local suppliers in Europe. This domestic bias results from the fact that not all public procurement goes through tenders subject to non-discrimination rules due to scope exclusions (such as defense equipment) and contract value thresholds, and are thus awarded by mutual agreement. The second reason is higher transaction costs for foreigners, giving a real advantage to local companies. The third reason is the importance of established relationships for recurring contracts, which favor local companies whose executives are known. It is also noteworthy that, according to the European Court of Auditors (2023), France has the lowest rate of awarding contracts to the highest bidder in terms of price, meaning it is the member state that most uses the quality of so-called "strategic" contracts, which impact the environment, social aspects, or innovation, allowing deviation from the lowest bid. The European average for awarding contracts to the lowest-price bidder is 60%, while France is below 10%. Based on national accounting data, Desrieux & Ramirez (2021) show that the imported share of French public procurement is similar to other industrialized countries and below the European average. French administrations do not seem

[7] The 5% average is even driven by specific States such as Ireland, Luxembourg and Belgium which allocate more than 10% of tenders to foreigners.

to shy away from using legal tools to exercise national preference. Therefore, public procurement is not excluded from the intervention methods of French administrations to support local supply. France tends to favor this support method more than its partners. However, assessing the impact on industrial specialization is challenging. Moreover, the argument that public procurement would provide development opportunities to companies in the learning phase that have not yet reached critical size is difficult to sustain when considering the nature of the public procurement tool. A more nuanced response is needed to avoid confusing objectives. The two policies — industrial policy and public procurement — have different goals and intervention horizons that are rarely compatible. Indeed, public procurement serves short- to medium-term objectives to meet collective needs. It responds to a well-identified need of the community that must be met while minimizing budgetary costs and ensuring the quality of the service or product obtained. Public procurement cannot be assigned a structural objective of industrial specialization. However, many observers see the need for public procurement to serve industrial policy. It is one thing to observe that public procurement has supported or even enabled the development of certain sectors; it is another to assign industrial objectives to public procurement. The sequence of decisions that can use public procurement must be clarified. First, the government can decide to fulfill an industrial or technological objective: for example, going to the moon, having quantum computers, or nuclear power plants. Then, it will launch tenders and ensure payment for the service provided. In this case, public procurement is subordinated to the industrial policy objective. There is no immediate need for satisfaction. Some public contracts may make this immediacy problematic and conflict with industrial objectives. For example, when the government wants to set up a health data platform (like the Health Data Hub), the primary goal is not to support the French cloud industry but to quickly have a functional and secure platform to develop artificial intelligence on health data. However, awarding a public contract to a foreign provider, here Microsoft's Azure, contradicts the intention to develop an autonomous cloud sector that meets security labels like *SecNumCloud* established by the government itself. An arbitrage and a hierarchy of objectives are therefore necessary. It is a question of whether achieving industrial objectives requires disciplining public procurement and modifying the selection criteria for offers. Thus, public procurement can be integrated into the definition of industrial policy. It is more problematic to systematically make public procurement a tool of national preference whose effectiveness in promoting industry is not demonstrated (Guillou et al. 2024). In summary, public procurement can occasionally serve an industrial policy oriented towards meeting fundamental public service needs: transport, energy, telecommunications, security. Public procurement is then subordinated to the conjunction of industrial efforts and public service needs. Thus, it has always been an important lever for defense industries or energy sectors in France, where the mission of public interest or sovereign goal is strongly present.

1.2.2 Equity Financing and Quasi-Equity

The state intervenes here as a capital provider. This aligns with the post-2009 investor state model, which, despite wanting to maintain austerity policies, has committed to directing the economy's growth trajectory and investments (Lepont 2023). Since the 2020 pandemic, state support has increasingly taken the form of investment funds in addition to debt. This also fits the view of state intervention as an insurer ("derisking") that supports the risk of private actors (Gabor 2023). A company needs equity to start its activity and grow. By providing equity, the state becomes a

shareholder and can influence the company's strategy according to the rights associated with the shares. Targeting certain companies, equity investment reflects industrial policy choices. This is not about acquiring stakes or nationalizing (partially or fully) by buying assets but about financing future activity potential or, in other words, investment. If the choice of targets is not too dispersed, it can indicate the direction of industrial policy. Quasi-equity corresponds to a form of capital financing similar to a loan but not at the same level of claim priority. In case of company default, creditors are repaid before shareholders. Increasing debt is thus a risk for shareholders as they are further down the repayment order. The advantage of quasi-equity is that it removes this debt characteristic, somewhat lightening its burden for future investors. However, it must be repaid at maturity. In France, the state's arm for equity investment since 2013 is the Public Investment Bank (BPI).[8] It replaced OSEO, CDC Entreprises, and the Strategic Investment Fund. The state and the Caisse des Dépôts are its shareholders. Today, it manages 44 billion euros in assets and 90 funds (Cour des Comptes 2023c). The value of assets under management has doubled since 2013. It has acquired a major role in financing the French economy using credit and guarantee tools. But it also provides subsidies and takes stakes in companies targeted by economic policy (innovative startups, strategic defense companies, companies relocating...). To gauge the growth of its activities, note that personnel expenses increased by 60% between 2016 and 2021. Its operating budget rose from 542 million in 2016 to 870 million euros in 2021. The BPI hosts numerous funds that invest in company equity. Criscuolo et al. (2023)[page 17] show that France, among the studied countries, uses equity financing the most, besides guaranteed loans, notably through BPI's actions.

It has become one of the main equity investors with 7 billion euros in direct management assets in 2023, but it also is a partner in financing rounds. Additionally, the bank has developed a fund-of-funds investment activity, investing in venture capital funds. It has indeed taken a significant role in venture capital financing in both seed and development phases. The principle of the investment fund is to exit the capital during market introduction or buyout by investors, ensuring the process's viability.

Since the 2020 crisis, funds specifically oriented towards reindustrialization have emerged. The pandemic highlighted that some medical protection products and equipment were no longer manufactured in France. As we will see later, the deindustrialization demon predates the pandemic but took on a deadly dimension during the Covid-19 pandemic. Funds were created to co-finance production relocation investments: industry recovery fund, reindustrialization and modernization fund, and relocation fund. These funds were endowed with over €1 billion and are managed by the BPI. The concept of strategic autonomy has since imposed itself, and the question of key sectors for growth, well-being, and sovereignty has motivated the creation of additional funds. We will return to this later. However, they are not entirely used for equity investment.

The 2023 Cour des Comptes report on the BPI is quite critical of the bank's diversification strategy while recognizing its full role in financing the economy. Comparing the growth of private sector investment and its debt, the BPI's role has clearly intensified, indicating increased intervention. Should we conclude a strengthening of industrial policy through company financing? Clearly, beyond correcting financial market failures, the BPI has acquired a growing role in financing the French economy. As this financing is sometimes directed towards specific sectors, the BPI is indeed

[8]The merger was decided under François Hollande's Presidency by a 2012 law (July, 31) and was effective on July 12, 2013.

an actor in industrial policy.

Joe Biden's Presidence industrial policy

During Joe Biden's term, which began in 2021, three bipartisan laws were passed: the Infrastructure Investment and Jobs Act, the CHIPS and Science Act, and the Inflation Reduction Act.

On November 15, 2021, a $1.2 trillion plan was passed, the Infrastructure Investment and Jobs Act. The plan aims to boost investments in American infrastructure, including roads, highways, and other transit systems. Already in this law, Subtitle D contains provisions related to climate change, specifically to fund programs for reducing carbon emissions in transportation.

Then, on July 27, 2022, the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act reinforced a law supporting the semiconductor industry passed in 2020. This additional $280 billion plan allocates $54 billion to the semiconductor industry, particularly to develop new production capacities. The law was signed by Joe Biden on August 9, 2022. However, certain conditions are required, such as (i) a 10-year ban on expanding production capacities in China; (ii) a commitment to provide affordable childcare services in new facilities. Consequently, investments by companies in manufacturing projects related to the electronics and computing sector have increased significantly. Since 2022, these investments have multiplied by 20 (voir par exemple Chorzempa 2024).

Finally, on August 16, 2022, the Inflation Reduction Act was adopted, involving €394 billion in spending to combat climate change. In total, the plan involves a budgetary expenditure of $500 billion to develop clean energy, reduce healthcare costs (allowing the government to negotiate drug prices), and increase tax revenues (increasing enforcement resources and adopting a 15% corporate minimum tax). Nearly $400 billion (394) is allocated to pollution reduction programs, including $250.6 billion in the energy sector and $23.4 billion for clean vehicles, including electric ones. The majority of these $394 billion are expenditures through tax credits, with $216 billion directed to businesses. Additionally, consumers are encouraged to shift their consumption towards products that contribute to achieving climate goals. Thus, starting in 2023, certain electric vehicles meeting local production criteria will be eligible for a $7,500 subsidy (new car) and $4,000 (used car) per household. Hydrogen production will be subsidized at $3 per kilogram of clean hydrogen, as will nuclear energy production, eligible for a $15 per MWh tax credit, and decarbonized energy production, for which the tax credit amounts to $30 per MWh until 2034.

In total, since 2021, nearly $2 trillion has been directed by these plans, with at least a quarter related to industrial policy.

Sources: Infrastructure Investment and Jobs Act of 2021, H.R. 3684, 117th Congress (2021-22); Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act of 2022, H.R. 4346; Inflation Reduction Act of 2022, H.R. 5376, 117th Congress (2021-22).

1.3 The Inflation of Industrial Policy Actors and Objectives

The inflation of actors in charge of industrial policy and recommendation bodies has never really abated in France. Numerous reports have examined French innovation policy, directly, like the Beylat-Tambourin report (2013) or the France Stratégie report (2019), or through investment

policies in technologies like the Juppé & Rocard (2009), the Gallois (2012)'s report, the Villani (2018)'s report, or the Potier (2020)'s report. Following the Beffa (2005)'s report "for a new industrial policy," the latest report on industrial policy is the France Stratégie report for the National Assembly released in December 2020 (Aussilloux et al. 2020). The succession of these reports marks the political interest in innovation and the motivation to place the economy on a technological progress trajectory. It also shows the constant concern about the French economy's innovation performance relative to its main partners.

For 15 years, recurring objectives have been 1) integrating SMEs into the innovation process and technology diffusion within them; 2) financing innovation and the lack of venture capital; and 3) articulating public research and private actors.

For 10 years, we have observed a verticalization of policies, meaning increasingly targeted intervention. While intervention in specific sectors was excluded, or even identifying these sectors, such restraint has gradually disappeared. In 2009, investment plans for the future were launched with the identification of strategic priorities. In 2014, Arnaud Montebourg, Minister of Productive Recovery, launched the thirty-four plans of the new industrial France, 34 roadmaps from renewable energies to electric propulsion satellites. Demonstrating undeniable voluntarism, they were manifestly a scattering of public energies: no future innovation - conceivable today - was forgotten. The Potier (2020)'s report listed 20 strategic sectors, including 10 priorities on which public efforts should focus, and France 2030, launched in 2023, lists 10 priority axes closely associated with sectors.

It seems that every new report, every new plan reinvents the wheel, presenting itself as the launch of a new cycle, a new industrial renewal. It is highly likely that the report from the mission entrusted to Olivier Lluansi on deindustrialization in 2023 will not deviate from previously issued recommendations. Plans and lists of sectors where public action decides to invest are recurrent. And with them, new, more or less durable bodies are created to implement the new ideas from these reports.

For example, the Juppé & Rocard (2009)'s report led to the investment plans for the future, which we will discuss later, and the General Investment Commission in charge of managing these plans. The Gallois (2012)'s report proposed creating a Commissariat for Prospective to produce reports on the productive apparatus's situation. The main proposal to relieve companies of part of the social contributions to shift them to taxation led to the *competitiveness and employment tax credit (CICE)* in 2014, which was fully transformed into a reduction in social charges in 2019.

Table 1 shows the plurality and diversity of mechanisms with various tools and bodies whose objectives overlap. Thus, the PIA covers a multiplicity of tools (repayable advances, non-consumable endowments, equity, grants, loans, guarantee funds) just like the BPI. An innovation council was created in July 2018 to identify strategic priorities and guide investments from the Innovation and Industry Fund. Following the economic crisis from the pandemic, additional tools were created: industry recovery fund, reindustrialization and modernization fund, and relocation fund. These funds were placed under the BPI's governance. We will return to these tools later.

Pisani-Ferry et al. (2016) also show the multiplicity of innovation support mechanisms that Table 1 does not fully present. This report counts the increase from 30 national innovation support mechanisms in 2000 to 62 mechanisms in 2015. This institutional voluntarism and proliferation of mechanisms likely reflect the authorities' anxiety about deindustrialization and the obsession with planning.

Table 1: List of institutions and programs for industrial policy

Name	Tools	Period
Agence de l'innovation industrielle	Call	2005-2008
Agence Nationale de la Recherche	Call	2005
Banque Publique Investissement	Diverse	2013
Commissariat Général à l'investissement	Directions	2010
Secréatriat Général pour l'Investissement	Directions	2010
Conseil de l'innovation	Call	2018
Agence de l'innov. de défense	Directions	2018
Instituts Carnot	Subsidies	2012
Sociétés d'Accélération Transfert de Technologie	Advice	2017
Haut commissariat Général Plan	Advice	2019
Fonds de compétitivité des entreprises	Call	2007
Projets structurants R&D des pôles de compétitivité	Call	2004
Crédit Impôt Recherche	Tax credit	1984
Jeunes entreprises innovantes	Tax credit	2014
Plans d'Investissement d'Avenir	Diverse	2010
Fonds de relance de l'industrie	Call	2020
Fonds de réindustrialisation et de modernisation	Call	2022
Fonds de relocalisation	Call	2020

Section 2. The Demons of Deindustrialization and Planning

The discourse on industrial policy is often associated with the observation of deindustrialization. This association is paradoxical because France is one of the most deindustrialized countries in Europe along with the country where industrial policy is most discussed. It is almost as an admission of the failure of industrial policy to curb deindustrialization. Either France loves industrial policy because it is deindustrializing, or it handles industrial policy poorly, or industrial policy has been insufficient to counter deindustrialization, which results from other internal and external logics.

This association is also counterproductive for at least two reasons. First, industrial policy cannot be reduced with targeting only industry or the manufacturing sector. To be coherent, industrial policy must embrace the entirety of the specialization that characterizes a country's productive value, from energy to high-tech services. Second, there is no guarantee that an industrial policy, then focused on industry, will be a means to counter deindustrialization, as suggested above. On the one hand, because it cannot be reduced to protectionism or the safeguarding of declining industries, and on the other hand, because the levers of industrial policy cannot counter productivity gains and international competition, quite the contrary. Deindustrialization is the result of an evolution of productive specialization that is only very partially the effect of a misguided industrial policy.

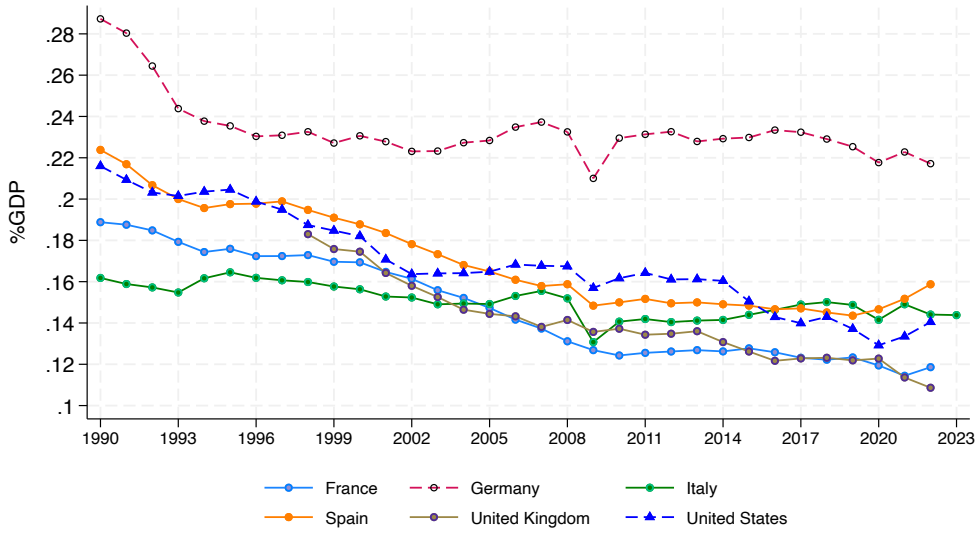
The idea of an industrial policy that promotes more industrial specialization is another proposition. But let us already recognize three unavoidable consequences: i) increasing the share of industry will be at the expense of other sectors, whether it be sectors benefiting from demand dynamics such as health, housing, consumer goods, personal services, or public administration; ii) an unavoidable lever for intensifying industry is defense spending; iii) a larger share of industry will result in higher CO2 emissions as long as production processes are not fully decarbonized, even if it is green industry (hydrogen, wind turbines, solar panels, batteries, heat pumps, electric vehicles...).

If we must characterize French industrial policy over the past 50 years, it has rested on two pillars: defense and nuclear (voir Guillou 2023a). In this sense, the bipartisan consistency in favor of these two pillars—at least until President François Hollande's term—has allowed for successful achievements. No one disputes French competitiveness in this area, the presence of international champions, and being at frontier technologies. Success in defense is less frequently highlighted, but France is the third-largest exporter in the world (by volume), and its companies, from Naval Group to Thales and EADS, have a long history of commercial successes. These two sectors have benefited from public procurement, subsidies, public research centers, and political consistency, which has anchored public support in a credible duration necessary for investments with very distant and uncertain profitability.

We will return to nuclear energy later. This section aims to document the deindustrialization of the French economy and to what extent industrial policy must and can aim to strengthen the industrial specialization of the French economy.

Figure 3 shows that France is one of the economies where manufacturing contributes the least to GDP. But deindustrialization is a dynamic concept. To judge its relative pace in France, one must look at the evolution of this share and not the level of this share. Has it been faster in France than elsewhere? To judge the evolution, we observe the evolution of the share using an index based in 1990 supposing that all countries started from the same level at that date (Figure 4). We observe a decline in this share for all countries without exception since 1990, a stabilization for Germany since 1998, a slight growth for Italy since 2009, and for most countries, a stabilization since 2009,

Figure 3: Industry Share of GDP per country



Source: UNIDO, 2024.

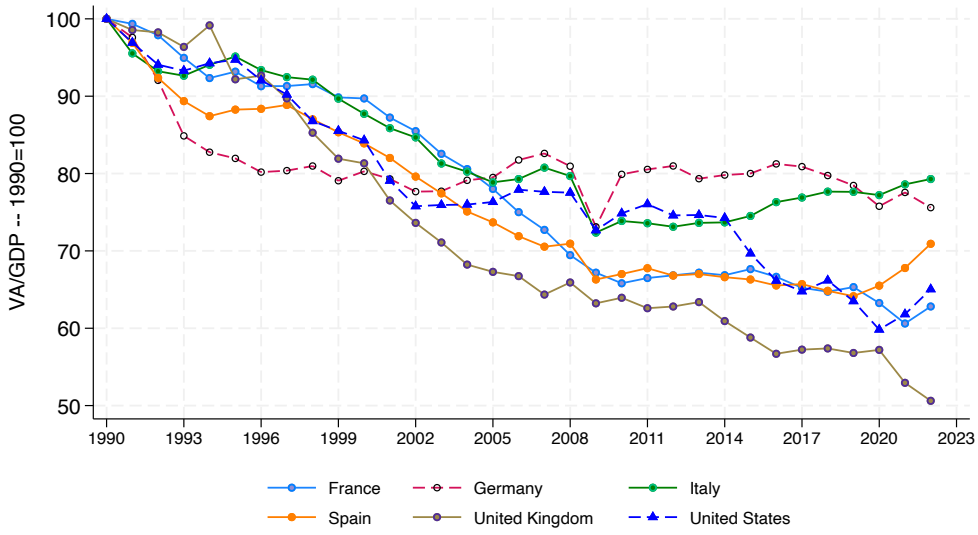
slightly downward. The decline has been continuous for France since 1990 but has slowed since 2009. Two groups of countries stand out in Europe: France and Spain; and Germany and Italy. If we compare France to Anglo-Saxon countries, deindustrialization is less severe in France than in the United Kingdom and similar to that in the United States.

2.1 International Comparisons of Deindustrialization

Today, France has the lowest percentage of value from manufacturing sectors relative to its GDP in Europe. Thus, in 2019, Germany was at 19 %, Italy at 15 %, France at 10 %, the United Kingdom at 9 %, and the United States at 11 %, similar to Spain and the Netherlands. These shares are slightly higher if we include the entire industry (including water, energy, and mining products). The contribution of industrial value added to GDP has decreased for all these countries, as observed in Figure 3 over the past 30 years.

The reading could be more severe in terms of employment, whose evolution may reflect not only a change in specialization but also productivity gains. The decline is also general. In France, between 2000 and 2021, manufacturing activities lost 22% of jobs, or nearly 900,000 jobs. This does not mean that manufacturing production in value has declined (see Figure 5) over the same period. Guillou, Bock, Elewa & Salies (2023) show that the decline in manufacturing value added from 2010 to 2019 is owed to low-tech manufacturing sectors. Like the rest of Europe, France's global market shares have remained in traditional industry sectors: automotive, transportation, chemicals, pharmaceuticals, steel, food processing, textiles, and luxury goods. Germany's weight in European manufacturing production is dominant, as shown in Figure 6. From 2000 to 2012,

Figure 4: Change in the Industry Share from 1990



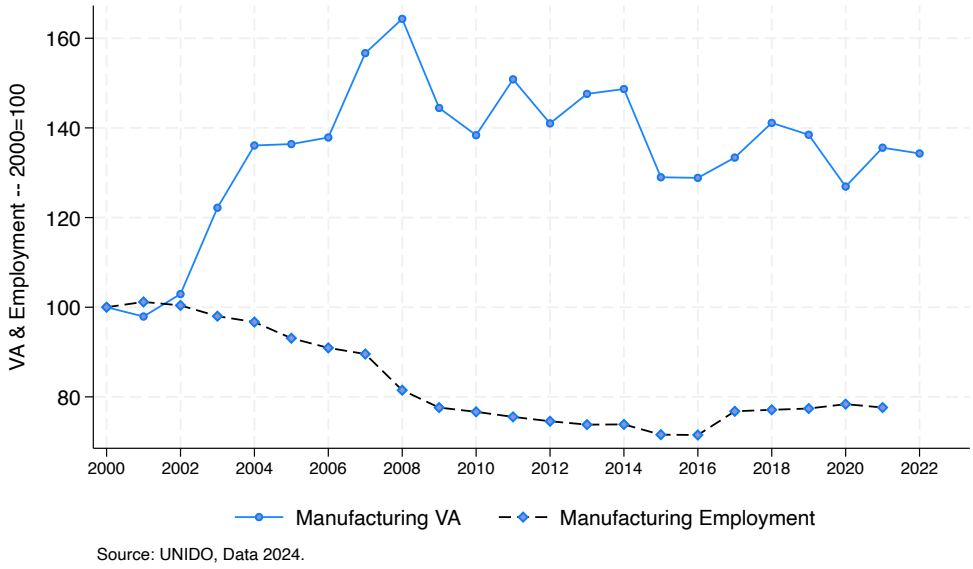
Source: UNIDO, 2024.

the four major industrial powers lost ground to the rest of the EU, then Germany increased its contribution to the point of being equivalent to the sum of France, Italy, and Spain on one side, and the rest of the EU on the other. German manufacturing production has substituted French, Italian, and Spanish production since the crisis until 2016. Then, the rest of the European Union increased its contribution.

The deindustrialization of rich countries has paralleled the shift of manufacturing production to Asian countries, mainly China, as seen in Figure 7. This is one of the manifestations of globalization's impact and the rise of emerging countries in global markets on the manufacturing production of old industrial powers. The subject has been well documented for the United States relative to China. Global competition has increased since China's accession to the WTO in low-tech manufacturing, which has significantly declined in rich countries. Apart from protectionism, this evolution was difficult to counter, especially since it allowed considerable purchasing power gains that accompanied the substitution of imports for local production and freed up resources for other activities. Industrial policy could not be of much help except by renouncing these purchasing power gains.

As we enter a phase of globalization where these new competitors invest in the technological race, the loss of market shares takes on a more critical dimension related to mastering the future. Moreover, the disjunction between political liberalism and economic liberalism creates a market economy under the yoke of dirigiste and authoritarian decisions and an asymmetry in the treatment of companies depending on whether they serve political interests. The market economy can potentially be hindered by authoritarian decisions outside of exceptional situations. The only focus on Ricardo's comparative advantages to optimize the allocation of global resources is no longer possible. Economic liberalism is subordinated to politics in the world's largest market. Economic sovereignty or strategic autonomy have become structuring concepts of industrial policies. But

Figure 5: Manufacturing Value Added and Employment Changes



Source: UNIDO, Data 2024.

while these concepts undeniably legitimize more State intervention, their operational scope is not very precise as integration into global value chains is not immediately reversible, and the structuring of comparative advantages in certain critical resources and materials is well established and difficult to contest.

What about the traditional arguments in favor of industry?

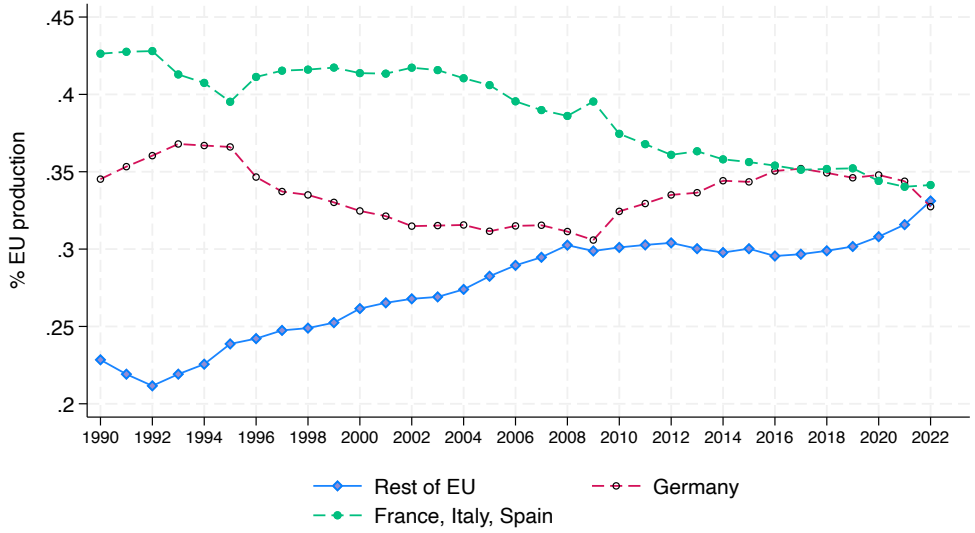
2.2 The Importance of Industry

Three main arguments in favor of industry are advanced: (i) industry is the engine of exports; (ii) industry is the engine of R&D; (iii) industry fuels the demand for high-value-added services and pays high wages.

Regarding exports, as long as trade is mainly in manufactured goods, service economies with lower manufacturing capacities will be de facto less export-oriented. We observe that the French trade balance has deteriorated since the early 2000s without an evident correlation with manufacturing value added or employment decline. Of course, exports are correlated with manufacturing production because we mainly export manufactured goods. However, exports have increased much more in recent years than manufacturing value added, indicating the growing openness of the French economy. Moreover, the correlation is less direct with the trade balance. This is explained by the dynamics of imports, service exports, which are naturally more independent of manufacturing value added, and the difference in cycles between France and its trade partners.

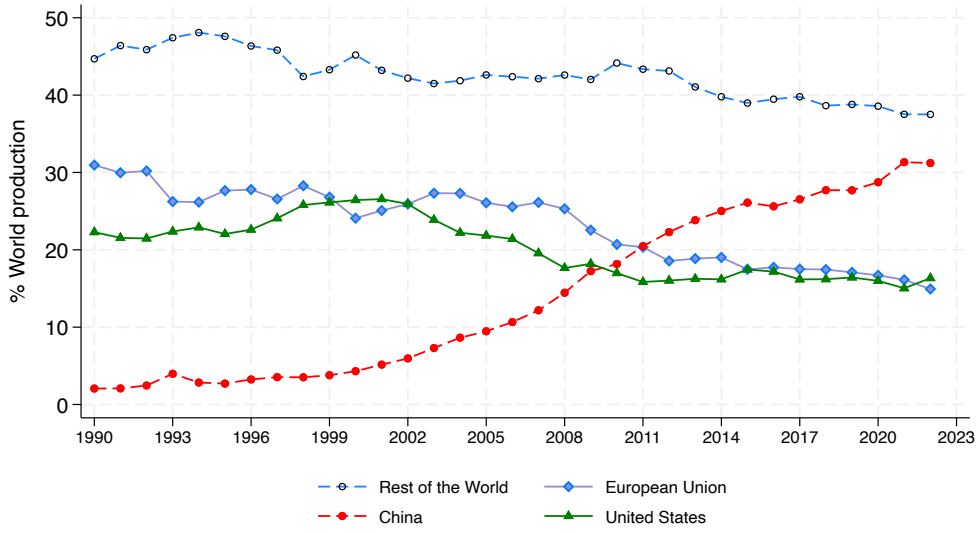
Regarding R&D, there are four manufacturing sectors that invest heavily in R&D: automotive, aerospace, chemicals-pharmaceuticals, and electronics. Indeed, these four sectors account for 45%

Figure 6: Share of European Union Manufacturing Value Added



Source: UNIDO, Data 2024.

Figure 7: Share of World Manufacturing by country



Source: UNIDO, data 2024.

of the expenditure of the top 2500 global exporters. In France, globally, manufacturing sectors represent 71% of R&D expenditure. But if we exclude the four leading sectors, business services invest more in R&D than the manufacturing sectors. Notably, while 30% of manufacturing jobs were lost, the number of researcher jobs increased by 100% in the French economy over 20 years.

Regarding industry and business services, there is a consensus on the driving role of industry in the demand for high-skilled services. However, the growth of high-skilled services also has an autonomous dynamic independent of the share of manufacturing value added in the country. Two driving forces have very different consequences for the understanding of the service-industry relation. The first force lies on manufacturing companies which incorporate more and more services into their content and to outsource this segment of their production, reducing the share of manufacturing value added. The second is rather a pull effect created by the demand of industry for skilled services. The first force explains part of the deindustrialization of developed economies, the second force explains the driving role of industry for growth. Moreover, manufacturing companies are incorporating more and more service content, especially as they are high value-added. Ding et al. (2022) show that the growth of non-manufacturing employment in manufacturing companies is strongly correlated with the growth of their intangible assets. The growth of intangible assets is assessed through R&D subsidiaries.

Regarding wages, the manufacturing industry has long provided a wage premium, that is, a favorable hourly wage gap relative to an equivalent job in other market sectors of the economy, even when controlling for employee characteristics. Empirical evidence on France is not abundant. However, this wage gap has significantly reduced or even disappeared. A recent study by the Federal Reserve, Bayard et al. (2022), shows that jobs in manufacturing sectors no longer have this wage advantage since the 2000s, and this observation is mainly the result of the evolution of production job wages within manufacturing sectors since the 1990s (inversion of the hourly wage gap in 2006). The decline in worker unionization explains 70% of the reduction in this gap for unionized jobs, while technological factors explain the reduction or even inversion of the gap for the hourly wage of non-unionized job wages.

Guillou, Bock, Elewa & Salies (2023) show that it is only in high-tech manufacturing that wage levels are higher than the average for the market sector; this is not the case in low-tech manufacturing. Moreover, other sectors besides high-tech manufacturing also have wages well above the market sector average. These include high-value-added service sectors, such as information and communication technology services. Furthermore, in terms of productivity growth, there is also a strong distinction between high-tech and low-tech manufacturing. Deindustrialization does not explain the slowdown in productivity gains. As shown by Guillou, Bock, Elewa & Salies (2023), and also by David et al. (2020), the slowdown does not come from a change in specialization and is not mainly caused by tertiarization but is due to intrasectoral productivity declines.

This brief synthesis of the advantages of manufacturing specialization tempers the major role that industry plays in economic growth. Moreover, at constant prices, the share of the manufacturing sector in GDP has remained fairly constant since 1990 (from 13% to 11%). In my opinion, there is both an excess of concern and an excess of expectation regarding the manufacturing industry.

2.3 Can We Plan Reindustrialization?

France has a more pronounced administrative planning tradition than other market economies. It dates back to the post-war period and continues to today. Planning, often accompanied by the qualifier "strategic", is close to the sovereign missions of security and also suggests that the government establishes a vision for the future.

In January 1993, nearly a third of a century ago, the Commission chaired by Christian Blanc submitted its report "For a Strategic State, Guarantor of the General Interest." This report was part of the preparation for the XI plan of the General Planning Commission. This institution for planning State economic interventions was the heir to a planning body created by General de Gaulle in 1946 with Jean Monnet at its head. The XI plan would be the last, and the General Planning Commission would disappear a few years later, transformed into a strategic analysis center in 2006, reduced in 2013 to an expertise production agency, *France Stratégie*, General Commissariat for Strategy and Foresight. [9]

Economic planning refers to planned economies where production is decided upstream, in quantity and quality, and the allocation of resources necessary to deploy and redirect to achieve it. From 1946 to 1993, planning five-year plans with quantified, indicative, and incentive objectives will become increasingly difficult to maintain or integrate into budgetary laws. However, economic strategy and planning have always gone hand in hand in French economic governance. Although it disappeared in 2006, a new economic planning tool was established in 2010: the investment plans for the future, under the presidency of Nicolas Sarkozy and following the Attali-Juppé report, which we will discuss later. French governments abhor a vacuum in planning.

Finally, it is one of the most liberal governments of the $V^{ème}$ Republic—that of President Emmanuel Macron—that reinstated it, offering François Bayrou the position of Commissioner of a High Commission for Planning in 2020. This High Commission does not seem set to leave a memorable mark in the history of French planning. Emmanuel Macron's second term also announced the establishment of ecological planning. Given the urgency of the climate change issue, the question of the appropriateness of this term is of a different nature.

It is in this tradition of planning that the reversal of the deindustrialization process is considered within the competence of government policies. Planning can be very rigid and dirigiste if the means of production are public, incentive if budgetary and fiscal means are used, or simply directional if it merely animates the debate through studies attempting to create coherence in public spending. However, can reindustrialization be planned, in the sense of setting quantitative objectives within a time horizon? This seems to be a challenge. Yet, calls for reindustrialization have flourished since the Covid-19 crisis. As mentioned earlier, it created an unprecedented situation or rather accelerated an awareness of a change in the global economic order and the return of States in market operations (voir Guillou 2023a).

[9] In 1946, the focus was on reconstruction as well as managing stocks and shortages (reminiscent of concerns during the Covid crisis). In 1993, the emphasis was on promoting a minimal state in economic terms, minimal compared to what was done in the 1960s-1970s. It is worth noting that in 1992, the European single market was completed and the gradual distancing from plan directives began. Christian Blanc's report starts on a very contemporary note, stating that state intervention should aim for 'competitiveness and social cohesion.' Subsequently, it speaks little of industries and even less of production.

2.3.1 The New Deal from the Covid Crisis

The pandemic highlighted that certain products and medical protection equipment were no longer manufactured on French territory. The high global demand for these products led to shortages due to supply-demand mismatches, and producing countries imposed export restrictions that worsened the situation for non-producing countries. As we will see later, the demon of deindustrialization predates the pandemic but took on a deadly dimension during the Covid-19 pandemic.[10]

The pandemic revealed the interdependence between countries in production and the extent of the fragmentation of value chains for even essential products. It became apparent that superior purchasing power might not be sufficient to access goods and services produced by others.

Many governments have proposed policies to support relocation. Loudly affirmed by Donald Trump's administration under the slogan "Make America great again," the Covid-19 pandemic made this political injunction for relocation contagious.[11] Japan budgeted a $2 billion fund to help companies reorganize their supply chains; Thierry Breton, the then European Commissioner for the Internal Market, stated that the resilience of European value chains needed to be reconsidered and the construction of production capacities in fundamental sectors like pharmaceuticals should be envisaged. Even the very globalist President Emmanuel Macron declared on March 31, 2020, during a visit to an SME in Angers, "our priority today is to produce more in France" (Guillou 2023a).

The calls for reindustrialization in the French political debate materialized in the government's 2020 recovery plan, which aimed to satisfy the economic patriotism of public opinion and to revive industrial investment, particularly in strategic activities. Several industry support funds were created to subsidize investment projects. One of these funds was specifically dedicated to relocation, targeting the financing of extensions or the creation of production capacities to replace activities previously deployed abroad.[12]

Relocation characterizes a shift of production units abroad while maintaining the objective of serving the domestic market. This is most often based on the level of production costs, from labor costs to raw material costs, including taxation, access to skills, and infrastructure, which are judged, in a sufficiently sustainable manner, to be more advantageous than domestic costs. To motivate relocation investments by companies, it is necessary not only to finance the fixed cost of capacity investment but also to modify the past trade-offs that led to relocation. The decision is therefore reversible only if this cost advantage disappears in favor of domestic location advantages. Thus, subsidies and other regulatory measures must create sufficient advantages to justify the re-implantation investment, but there must also be operating (supply) and market (demand) conditions that create sustainable profitability conditions. The problem is that these conditions did not exist

[10] It is worth noting that more industrialized countries have also suffered from shortages due to the fragmentation of value chains, and that the absence of the discovery — and not the production — of a vaccine in France has nothing to do with deindustrialization. The French company SANOFI is a leader in vaccination, but it was not positioned in messenger RNA technology.

[11] Both Peter Navarro, special economic advisor to Donald Trump, and Robert Lighthizer, the trade representative, proclaimed the end of the globalization of production.

[12] The issue of relocations is not new. In 2012, the Ministry of Economy commissioned a study on the subject. The summary report (*Relocalizations of Industrial Activities: Synthesis*) published in 2013 highlighted the multiplicity of factors that define the economic environment and influence the decision of location.

before the relocation decision (assuming it was made rationally). Can policies quickly change these conditions, whether it be taxation, availability of production factors, or infrastructure?

Regarding the client market, it motivates foreign location if the export cost is too high compared to local production on the client market. But relocation, which involves substituting domestic production units with foreign production units, will only be sensitive to the relative market dynamics. Relocation can be envisaged while maintaining significant foreign outlets, but this requires investment in distribution networks and freight costs.

As investments have irreversible costs, reinvesting in France is a long-term decision. Companies that relocate generally retain assets in France. Often, aids accelerate capacity expansion plans that were already in the pipeline. They reduce the wait-and-see attitude of actors during periods of uncertainty. In practice, relocation will only occur if the structural conditions of industrial activity in France have changed, and not because companies have temporarily benefited from a subsidy.

The policy of financing relocation involves high subsidies that commit public finances over a decade (the minimum to amortize capacity investment). The return through the payment of direct taxes and by stimulating growth (generation of income, jobs, and demand for suppliers) is rightly expected provided that the operation becomes profitable. It is therefore important that the aids only concern the installation, to let private investors judge the sustainability of the operation.

In response to the shock of the Covid crisis, millions of euros have been put on the table in specially dedicated funds to create a relocation movement.

The €100 billion recovery plan announced on September 3, 2020, indeed provides for funds managed by the Public Investment Bank for industrial recovery, reindustrialization, and relocation. The "competitiveness" axis is endowed with €35 billion. A fund is specifically dedicated to relocations in strategic sectors such as agri-food, health, electronics, essential industry inputs, and 5G. Some funds are specifically dedicated to aeronautics and automotive. Additionally, in 2021, aid for investment in the transformation towards the industry of the future was created.

These are €1 billion out of the €100 billion plan that are directed towards these funds for the industry. It is striking, as highlighted by the Cour des Comptes in its report, that a recovery plan with a cyclical vocation defines objectives relevant to a more structural policy. The funds have taken different names but all indicate the long-term component: resilience, strategic sectors, modernization of the industry. The funds are managed by the BPI, which studies the files of companies wishing to access the financing of their investment. The eligibility rate is 25%.

The Cour des Comptes (2023b) 's report does not give a very positive assessment of the financing of relocation projects implemented through the creation of the Relocation Fund. More than 500 investment projects (531) have been selected, leading to a public subsidy of €838 million. Selected companies are mostly SMEs that were economically rather solid compared to the non-selected candidates. But only 33 of the 531 projects were completed in 2023. For the Court, it seems difficult to judge the system put in place by the recovery plan for at least three reasons: the lack of clear monitoring criteria, the fact that the system has taken on variable contours since 2020, with slightly modified objectives in each successive finance law, and a system that has merged into the France 2030 plan. Moreover, the objective of relocation has gradually faded in favor of an objective of modernizing the productive apparatus.

The question is whether these subsidies are merely windfall effects. In economics, a windfall effect means that the company seizes the subsidy even though it would have acted the same without the incentive. However, the selection process is such that it selects viable projects, and

undoubtedly a good use of public funds is to select viable projects that would have been viable without the subsidy.

At this stage, the extent of relocations is therefore low. It is necessary to compare these 500 projects with the approximately 120,000 exporters who are the pool of companies that could relocate. Similarly, the €680 million in relocation investments should be put into perspective with the total investment of non-financial corporations in 2019 of €321 billion and the incoming investments of foreign companies of €30 billion and just as much from French companies investing abroad.

The economic logic of these measures aimed at reindustrialization is not always very clear. Financing through subsidies assumes that the government, and therefore the citizens, bears part of the investment cost of settlement. This is based on the logic that the main obstacle is the initial investment rather than the difficulties of operating in the French market. If the latter are deemed supportable and sustainable, then the subsidy accelerates the investment decision but does not provoke it, as the discounted future income stream includes the amortization of investments. The subsidy is also a means to alleviate the financial constraint that SMEs face when investing. But in this case, a guaranteed or subsidized loan could also play this role. The subsidy to generate a learning curve is not the justification advanced here since it involves relocating companies that have already learned and the question is about the location of their operations.

2.3.2 France 2030

The latest tool launched by the government of Jean Castex in 2021 at the initiative of Bruno Le Maire is an investment plan in specific sectors or technologies. It was President Emmanuel Macron who finally presented the roadmap associated with these investments by outlining 10 priorities to guide investments by 2030. *France 2030*, presented on October 12, 2021, is yet another list of priorities, with the novelty lying in the importance of objectives related to the environment (six of the ten priorities), including investments in nuclear energy. However, the plan includes areas already receiving public attention. With a budget of €54 billion over 5 years, the plan seems to cover all future technologies and is paved with good intentions such as "better production," "healthy food," or "inspiring the world" (Table 2).

The *France 2030* plan has taken over from the 2020 recovery plan. Having a more structural objective, it better embraces the goal of economic security and industrial sovereignty. The term relocation is no longer used, but the government speaks of industrial and technological policy. However, the financing through call for projects is maintained under new objectives such as "critical materials" or "resilience and agri-food capacities." The role of BPI France remains central.

A little over 2 years later, Emmanuel Macron announced new development axes around natural hydrogen for decarbonization or artificial intelligence. He reported on 3000 projects and €27 billion in committed credits.

This list adds to the 34 roadmaps of Arnaud de Montebourg and the 20 strategic sectors of the Potier (2020)'s report. In the France 2030 list, batteries and semiconductors were mentioned. But nothing about public infrastructure and education where the public intervention is expected.

The difficulty with this dirigisme is the vulnerability to rent-seeking effects and the dependence of policy on private interests. Can we, however, see the vision of a *strategic State*?

Table 2: France 2030

Mieux produire	Produce in a better way
Réinventer le nucléaire	Re-invent nuclear energy generation
Hydrogène vert	Green Hydrogen
Décarboner l'économie	Decarbonize the economy
Numériser, Robotiser	Enhance Digital and Robots penetration
Développer les véhicules électriques	Develop Electric Vehicles
Avion bas carbone	Low-carbon Airplanes
Alimentation saine/révolution agro-alimentaire	Healthy Food/agro-revolution
Santé	Health
Inspirer le monde/Culture	Inspire the world / Cultural Values
Spatial	Space
Grands fonds marins	Deep Seabed

The expression is often used to envision a long-term vision that the State must adopt, anticipating future needs and tensions. The long term is associated with the strategic State. Being strategic means being able to respond well to an adversary who is not yet present. Which political bodies are capable of thinking long-term? Which bodies are audible in a society focused on immediacy and that only thinks long-term in the regret of the dissatisfaction of its immediate needs?

The appreciation of governments' long-term commitments can only be understood in light of industrial history, which is revealed through its entrepreneurial champions and technological projects that project towards the future. It is therefore not by chance that in terms of industrial policy, technology and national champions receive particular attention.

Section 3. The Gods of Industry: Technology and National Champions

Champions and technology are deified as levers of economic sovereignty.

3.1 Champions on a Pedestal

The success of national champions is often taken as a flag of the success of industrial policy. Conversely, industrial policy is blamed for not having been able to create champions in certain areas. What is meant by a national champion? It is a company with a national headquarters and international reach, in other words, a multinational. Its international reach reveals its market

Table 3: Fifteen first French Multinationals per capitalization in 2019

Company	Headquarters	Industry	Share of foreign employment
Total SA	France	Petroleum	0.66
EDF SA	France	Electricity, gas and water	0.21
Stellantis NV	Netherlands	Automotive industry	0.27
Orange SA	France	Telecommunications	0.41
ArcelorMittal	Luxembourg	Metals and metallic products	n.a
Sanofi	France	Pharmaceuticals	0,54
Christian Dior SA	France	Textiles and apparels	0,79
Airbus SE	France	Aeronautics	0,54
Engie	France	Electricity, gas and water	0.16
Renault SA	France	Automotive industry	0.73
Unibail-Rodamco-Westfield	France	Real Estate	0,70
Vinci SA	France	Construction	0.55
Danone Groupe SA	France	Food and Beverages	0.65
Compagnie de Saint-Gobain	France	Construction	0.76
Schneider Electric	France	Electric equipment	0.54
Air Liquide	France	Chemicals	0.62

source: DATA on Multinationals, CNUCED, 2021.

dominance and thus its competitiveness in the field in which it operates. However, an additional characteristic is often necessary for the public to bestow the title of champion: the activity must have symbolic significance for national pride and/or national sovereignty. For instance, who would identify Vinci (construction sector) and the real estate company Unibail among the 15 largest French multinationals by market capitalization?

Over the last three available years (2019-2021), France's representation in the ranking of the top 100 multinational companies by market capitalization (UNCTAD, 2020, 2021, 2022) is between 13 and 15. Its score is slightly above Germany and the United Kingdom, which each have between 10 and 12 companies in this ranking.[13]

In Table 3, we can identify the 15 French multinationals ranked among the top 100 multinationals by market capitalization worldwide. Note that Peugeot became Stellantis and domiciled its headquarters in the Netherlands in 2020, while ArcelorMittal has its headquarters in Luxembourg. Strictly speaking, these two are no longer French multinationals.

The top 15 French multinationals in 2019 and 2020 are well-known champions. Experts and observers would also include defense companies like Dassault, Thales, or Naval Group; transport equipement companies like Alstom or Naval Group, travel company, Air France; food distribution companies like Carrefour; and construction companies like Saint Gobain. Note that this ranking excludes banking and financial activities, specifically companies like Axa, Crédit Agricole, BPCE,

[13] China has between 8 and 10; the United States, between 18 and 20; Italy, 3 and Japan, 9.

and BNP Paribas.[14]

In the UNCTAD ranking, the five most represented sectors are i) automotive; ii) extractive industries; iii) electricity, gas, and water; iv) pharmaceuticals; and v) telecommunications. It is easy to identify that these are sectors in which France has historically had a comparative advantage, except for the extractive industries sector.

More generally, champions are associated with the industrial history of Europe in the 20th century. The current century will likely see changes in specialization: information technology and platform multinationals are climbing the rankings. In 2021, this ranking clearly shows the preeminence of the old economy and, contrary to the characterization of Europe as a service economy, the strong presence of industry. Even France, which has 15 multinationals in this ranking of the top 100 worldwide in 2019, counts 12 that belong to industry. This is partly because the size of companies—here market capitalization—is proportional to their age. It is also because public capital has historically participated in the initial development of many of them. This presence of public capital, both past and present, generally reinforces the national character of the champion.

Among rich countries, France is characterized by a high proportion of public capital in the economy. The latest report from the State holdings Agency (Agence des participations de l'Etat) in 2023 states that the French State is the majority shareholder in 85 companies, 10 of which are listed (excluding EDF, which has just been delisted), with a total public capitalization of €153 billion.[15] The State's presence is strong in companies that have historically been public monopolies because they are associated with public interest services and network infrastructures. It is also strong in defense industries, including Airbus (even though its headquarters are in the Netherlands, the French State owns 11%), Dassault (via the 46% owned by Airbus), Thales (25.7%), Safran (which absorbed Zodiac Aerospace, 11.2% owned by the State), Naval Group (formerly DCNS, 62% owned) as well as Nexter and MBDA. These champions generate trade surpluses and are drivers of R&D spending by French companies. Indeed, the top four (excluding Airbus) are among the top 1000 global R&D investors, with 68 headquartered in France. These four companies accounted for 8% of the R&D spending of the 68 companies in 2019, but more importantly, they concentrate public funding for private research.

France is not the only country where the State holds stakes in companies. Among the top 100 worldwide multinational companies in the global ranking, 19 are publicly owned, belonging to various sectors (voir Guillou 2023a, chapitre 1 page 11).

The problem with the rhetoric of champions is that it carries a lot of hypocrisy. On the one hand, a national champion is not necessarily a growth engine in terms of jobs, exports, or productivity. Although their size makes them job reservoirs, domestic job growth is often low compared to companies with less or no international reach. This is because these companies use the opportunities of their globalization to create jobs according to their needs and the growth dynamics of foreign markets. It is often claimed that French multinationals have a higher propensity to relocate than multinationals from other countries (Aussilloux et al. 2020). UNCTAD statistics allow us to compare foreign employment to total employment. This ratio is on average 55 % for France, compared

[14]These four last companies are among the top 25 foreign investment investors in 2022, according to the 2022 annual report on the French balance of payments published by the Banque de France.

[15]Note that 2023 is the year of the simplified public tender offer which led the State to take full ownership of the capital. Activity report of the State Holdings Agency, September 2023.

to 48% for Germany, Italy, and the United States, and 53% for Japan. The ratio is much higher for the United Kingdom, Belgium, Switzerland, Ireland, and the Netherlands, which have strategies to attract multinationals that increase their population well beyond historical national champions. While the ratio varies from one multinational to another, on average, French multinationals have more foreign jobs than their German, Italian, American, or Japanese counterparts. Of the two French car manufacturers, Renault has the most foreign jobs relative to its total employment.

This development of foreign employment is consistent with their growth logic and with the escape from French fiscal and regulatory constraints. It could also be determined by the specialization of French multinationals and their size. The larger a company is, the more its growth occurs in third-party client markets beyond the exhausted domestic market; the larger and more productive a company is, the more it will invest abroad.

Cotterlaz et al. (2022) show that French multinationals, although significantly contributing to exports, have been responsible for the recent deterioration of the French trade balance. The authors suggest that a strategy of relocating production capacities was implemented from 2000 to 2018. Contributing significantly to exports due to their size and the concentration of exports in France, any change in location strategy has a significant impact on the trade balance.

On the other hand, a champion is synonymous with market power concentration. This can be justified by high fixed costs that define the configuration of a natural monopoly. However, this concentration of power always presents a risk of rent-seeking behavior (abuse of power, insufficient motivation for innovation, high pricing, and declining quality). What allows escaping this behavior is the internationalization of the champion, but this makes it very sensitive to non-strictly national logics, thus losing its national characteristic. Finally, it is misleading to believe that the existence of a national champion is due to a government or policy. Subsidies and protections create fragile companies. There are few examples of champions born from public decision-making outside of natural monopolies where public capital was historically present. Of course, public procurement is a growth element that can be critical in building champions, especially in defense. Public procurement creates outlets that allow the company to grow. But public procurement must retain the attributes of private demand: being able to arbitrate between different offers, limiting specifications to reasonable levels for the manufacturer who must have the means to turn to less demanding customers, and being associated with social demand that allows public decisions to be set in the long term and reduce uncertainty related to political alternation.

Support policies for champions face criticisms inherent to the limits of political decisions, which are highly vulnerable to capture by special interests (Olson 1965) or limited rationality regarding future technologies. Champions are most often formed during industrial restructurings that respond to market and industry dynamics. It is at this moment that acquisitions occur, and concentration creates champions. This is true in many sectors (automobiles, aerospace, rail transport, agrochemicals...), leading to questioning the role of European competition policy, which is often accused of stifling merger attempts in Europe. We will return to this later. However, it is rare for industrial policy, thus a political impulse, to be the origin of the construction of a champion ex-nihilo. Very often, the champion emerges from a pre-existing public company. More generally, a growing company knows how to capture clients and markets, both public and private. The dynamics of the champion are primarily business dynamics and very often also a matter of innovation.

3.2 Technology, the New Horizon of Industrial Policy

Ravix & Deschamps (2019) show in the introduction to their book that industry and innovation are historically closely linked, even questioning the separation of industrial policy and innovation policy. However, as we have defined industrial policy, nothing justifies, a priori, that the orientation of specialization should respond to an objective of increasing technological content. Thus, one might want to increase the share of agriculture, develop an entire sector (and all its stages more or less conducive to innovation), or orient production processes towards low-carbon technologies, or develop a financial and service economy. In other words, industrial policy is not necessarily identical to scientific policy and/or innovation policy.

But, as soon as industrial policy is associated with a competitiveness objective, that is, increasing global market shares, it is imperative that support measures push for innovations and investments in technology. It is indeed at this price that, on the one hand, the economy becomes more productive (process and/or organizational innovation), and on the other hand, the quality of its production (product innovation) increases, two conditions for gaining market shares.

Once it is recognized that production processes are increasingly characterized by increasing returns (due to incorporated technology that involves high fixed costs) and that the economy is irreversibly open, the competitiveness objective accompanies any economic success because it is under this condition that the market size will be increased, allowing in return to exploit economies of scale and create a virtuous circle of investment and growth.

The productivity objective has been relegated to the background in recent years.[16] But productivity is a fundamental component of competitiveness. Since the pandemic, the technological dimension of industrial policy has been strengthened. This was certainly already perceptible before the pandemic, the European context was extremely favorable (see above), and China's voluntarist policy—notably with the China 2025 objective—which relegated Europe to third place in many areas, made technological advancement an unavoidable goal. According to Pisani-Ferry et al. (2016), the amounts invested in innovation support by public actors have doubled in constant euros in 15 years (2000-2015). The pandemic has intensified economic tensions and concerns of economic, digital, and technological sovereignty. Digital multinationals have consolidated and increased their power over the economy, and digitization has become a priority of policies (cf. NGEU, supra).

French industrial policy has had and continues to have a strong technological component. Its results, however, call for intensified efforts. But it is important to grasp the limits of industrial policy concerning technological objectives to assess how far the policy can enhance competitiveness.

3.2.1 Strong Technological Component of French Industrial Policy

Assigning to industrial policy objectives to promote technology, research, and innovation has theoretical foundations. Investments in research and development must be supported by fiscal incentives or subsidies to compensate for their under-dimensioning relative to the social optimum.

[16] This shift to the background stems from the difficulty in measuring productivity and the numerous paradoxes surrounding this measurement. Richard Gordon's idea of secular stagnation highlighted the change in the era of technological progress. However, the promises of artificial intelligence revive the hope for productivity gains greater than those of the past two decades.

The intervention of public authorities in financing innovation is indeed based on the theoretical consensus of the insufficiency of business R&D investments relative to the socially optimal amount. This consensus, established since the 1950s, is based on the fact that the non-appropriation of the results of scientific research reduces the private incentive to invest in research to the extent that would maximize collective utility (Nelson 1959). The solution of public financing is therefore imperative, but the amount of optimal public financing is always difficult to resolve (Guillou et al. 2022).

Among OECD countries, France is characterized as more interventionist, meaning that the government is traditionally more involved in conducting innovation policy. According to OECD (2014), the share of public financing of domestic R&D expenditure was 50% in 2010 (including the Research Tax Credit), and it is between 56% and 58% in 2018.[17] For Germany and the United Kingdom, this share was around 30% in 2010. Undoubtedly, the public financing of defense industry R&D plays a role, but its importance has decreased. Moreover, the share of structural funding for public research remains high relative to other countries, suggesting a stronger institutional grip on research policy (Guillou et al. 2022).

The scientific dimension of French industrial policy is also the result of the long-term sectoral efforts of public intervention in defense and nuclear (voir Guillou 2023a), whose technological content requires scientific investments. This orientation, which began in the 20th century, is not contradicted by the new intervention instruments implemented in the 21st century, such as competitiveness clusters (Gaffard 2005).[18]

The competitiveness clusters were established at the initiative of DATAR (a public administration in charge of infrastructure and urban plans in regions) as part of a broader strategy for regional development. The concept was officially endorsed by the Interministerial Committee for Regional Planning and Development (CIADT) on September 14, 2004. These clusters aim to bring together industrial, innovation, and research stakeholders within a specific territory to foster synergies and create a conducive economic and scientific ecosystem for innovation. Public funding is provided following a project selection process in response to a call for proposals. In July 2005, CIADT labeled 67 projects, followed by 5 new clusters in July 2007, with a budget of 1.5 billion euros allocated until 2008. According to Ravix & Deschamps (2019), these clusters, while conceptually aligned with well-known policies of industrial clusters or local production systems, marked a departure from the centralizing tradition of French industrial policy.

Five years later, the "Investments for the Future" plans (Plans d'Investissement d'avenir or PIA) represent a blend of centralized decision-making and partially decentralized execution, reinforcing the technological dimension of public intervention in the economy (Levet & Mathieu 2013). In 2009, following the economic crisis, President Nicolas Sarkozy established a commission to identify national priorities to be financed by a major loan announced before the Parliament on June 22, 2009. The Juppé & Rocard (2009) commission delivered its report "Investing for the Future: Strategic Investment Priorities and National Loan" on November 19, 2009, recommending an investment of

[17] In addition to the 20 billion euros of public research funding, there is between 8 to 10 billion euros of private research funding, according to estimates of public R&D subsidies, plus the research tax credit, bringing the total to 52 billion euros in 2018.

[18] A competitiveness cluster is defined as "the combination, within a given territory, of companies, training centers, and research units engaged in a partnership approach aimed at creating synergies around innovative projects, possessing the critical mass necessary for international visibility."

35 billion euros, with 16 billion directed towards higher education, research, and innovation, and the other half targeting innovation and the transformation of lifestyles and production methods.

The PIA initially focused on higher education, aiming to build research and teaching hubs that could rank highly in international standings (publishing in prestigious journals and winning awards) while fostering growth ecosystems where researchers, large industrial groups, and technological SMEs/ETIs collaborate. The 35 billion euros program also targeted industrial sectors and SMEs (6.5 billion), sustainable development (5.1 billion), and the digital economy (4.5 billion). On February 22, the General Investment Commission (renamed the General Secretariat for Investment in 2017) was created under the Prime Minister's authority to manage the Investments for the Future. This led to the creation of the National Industry Conference, replaced by the National Industry Council in 2013. A sectoral policy was then launched. In July 2013, the government of Jean-Marc Ayrault launched PIA 2, with 12 billion euros, including 3.6 billion for Higher Education Research Innovation (ESRI), particularly for Idex. On March 12, 2015, President François Hollande announced a third investment plan of 10 billion euros (2.9 billion euros for ESRI). In 2020, as part of the 100 billion euros recovery plan, PIA4 was allocated 20 billion euros. The PIAs have become a new modality of industrial policy without much public awareness. This approach introduced a multi-year dimension to industrial policy spending, which is beneficial given the medium to long-term nature of industrial policy. However, it also creates a lack of clarity regarding the associated budgetary effort.

Another cornerstone of French innovation policy is the Research Tax Credit (CIR). This old and resilient fiscal measure, established in 1984, has undergone several reforms, with its current significance (approximately 6-7 billion euros in tax expenditure) attributed to the 2008 reform (see for a description of the instrument Guillou & Salies 2015). Benefiting nearly 20,000 companies, the CIR represents a total tax credit equivalent to 0.26% of GDP, compared to 0.21% in Canada and 0.05% in the United States. Given that R&D spending is concentrated in the industrial sector, whose GDP share is comparable to that of Canada and the US, this highlights the generosity of the French tax credit per company.

3.2.2 Mixed Results Amidst R&D Internationalization

In 2021, business R&D expenditure in France (DIRDE) amounted to 33.3 billion euros (55.5 billion euros for total domestic expenditure). Personnel expenses averaged 62% of the business R&D expenditure. The manufacturing sector, as previously noted, includes the most R&D-intensive companies, with 68% of DIRDE conducted by the manufacturing industry. This sector receives 79% of public funding, with 32% allocated to the aerospace industry, which accounts for 10% of DIRDE.

It turns that research efforts are primarily driven by businesses, which conduct nearly two-thirds (65.6%) of R&D activities in France. Business R&D spending has grown significantly more than public sector spending over the past decade, partly due to the CIR reform. Public sector research expenditure was 17.5 billion euros in 2021, mainly from research institutes (53%). In constant prices, public research spending has decreased since 2017, while it has stagnated in current prices.

France ranks fifth among the six largest OECD countries in terms of domestic R&D expenditure (DIRD) as a percentage of GDP, behind South Korea (4.55%), Japan (3.21%), Germany (3.04%), and the United States (2.79%), and only ahead of the United Kingdom (1.66%).

Despite having one of the most generous R&D tax credits among OECD countries, France does not rank among the most innovative economies. In the 2020 edition of the European Innovation Scoreboard, France is in the "strong innovators" group, the second of four performance intensity groups. Additionally, its innovation index slightly increased from 2012 to 2019.[19] However, the French economy does not excel in any particular dimension, whether it be the attractiveness of the research system (dominated by Luxembourg), SME innovation (dominated by Portugal), innovation linkages and collaborations (dominated by Austria), or any other defining indicators.

Regarding the intensity of innovation measured by the number of companies that innovate, the French economy lags behind other technological powers. Innovation, as defined by the Oslo Manual, is measured at the company level, and information on innovation intensity is currently self-reported.[20] Thus, it is based on this manual that the Community Innovation Survey deployed in the European Union is constructed. The results of this survey provide a percentage of innovative companies by country. France's rank is far behind the top 5, regardless of the sector. In 2018, the percentage of innovative companies in France was 50% across all market sectors, compared to 70% in Germany. France ranks only twelfth within the European Union and is below the eurozone average. This result is not related to its specialization structure, as its rank is not better in services, with Luxembourg placing it in thirteenth place with a percentage of 48%.

Patents are another indicator of an economy's innovation activity. In 2019, France filed 10,163 patent applications with the European Patent Office. This is much less than its commercial partners and technological competitors. If we relate the number of patent applications to the number of researchers, France's global rank (5th in terms of wealth) is maintained. Among the top 10 technological fields by number of applications, it ranks better in the fields of transport technology, pharmaceuticals, biotechnology, and specialized machinery other than ICT (4th). Of the 10,163 patent applications filed in 2019, 999 — almost 1/10 — were in the field of transport technology. The second most requested technological field is "electrical machinery and apparatus, energy" with 658 applications. In the ranking of the top 100 applicants at the EPO, the first French applicant is 30th, which is the Commissariat à l'énergie atomique et aux énergies alternatives (CEA), the second applicant is Valeo (aeronautics), which is 37th; Safran (48th) and Thales (58th) follow, and the fifth is the Institut national de la santé et de la recherche médicale (INSERM) (83rd). Two public institutions (CEA and INSERM) are therefore among the top 5 French applicants at the EPO.

In summary, it is difficult to conclude that competitiveness clusters, PIA, and CIR are sufficient policies in view of the technological competitiveness and innovation challenges of the French economy. Although evaluations of these policies are always delicate (voir Levet & Mathieu 2013, Commission nationale d'évaluation des politiques d'innovation 2021, Hassine 2020), they do not completely conclude the absence of effects.[21]

[19] The other three groups are: Innovation Leaders, Moderate Innovators, and Modest Innovators.

[20] The Oslo Manual (OECD, 1992, 2010) establishes a framework for measuring scientific and technological activities. It defines product technological innovation as the development of a product offering objectively new services to the consumer, and process technological innovation as the development of new or significantly improved production or distribution methods.

[21] For the PIA (Investments for the Future Program), an evaluation committee was established in 2015 (Maystadt Committee), and a first evaluation report was published in 2016. Ten years later, it is clear that evaluations are conducted by objective (for example, by ADEME around sustainable development), which, from an evaluation perspective,

But these are long-term effects that aim to sustainably modify the innovation and education ecosystem. The latter is also too often forgotten in scientific policies, as highlighted very well in Jaravel (2023)'s latest book. The orientation of education towards scientific and engineering professions, especially for young girls, well before higher education, is crucial.

The PIA targets long-term objectives that exceed the political horizon of decision-makers. Generally, any industrial policy that embraces scientific objectives will suffer from two limitations. The first is that its horizon exceeds the political horizon and goes beyond the rationality of the political decision-maker. The second is that promoting externalities is a cooperative policy, while the goal is competitiveness, which is inherently a non-cooperative objective. David Edgerton, a historian of technology, reminds us that "only in techno-nationalist fantasies does national invention drive national economic growth. In the real world, global innovation leads to national growth, and national innovation leads to global growth." In this regard, China's considerable efforts in R&D create positive externalities for the entire scientific community. However, this optimism can turn naive if we fail to consider that these R&D efforts are first appropriated before being fully shared and can lead to problematic technological dependence when instrumentalized by states. Furthermore, the resources provided to researchers by states make research and researchers highly mobile assets, which can nullify public efforts invested in the educational system. It is also noted that the richer the countries are in companies investing in R&D, the more this expenditure per company relocates to other markets. This result is more related to the strategies of multinationals — the major investors who invest abroad — than to diminishing returns.[22] Scientific industrial policy sovereignty does not escape the challenges of globalization (Guillou 2023a).

Section 4. Challenges

The first challenge in defining industrial policy is procedural: it must be articulated within the European space, a set of constraints and opportunities. The success of French industrial policy requires a good understanding of its European resonance, meaning the leverage effects of the European market but also the limits imposed by common market rules. The other two challenges relate to the quality of specialization choices. These choices cannot ignore either climate issues or artificial intelligence.

4.1 Articulation with the European Union

French industrial policy is strongly constrained by European rules, as seen with the legislation on public aid, but this is also true for all market regulations. However, it is also amplified by the European dimension. Indeed, the European scale is a lever for amplifying the effects of industrial

is logical but does not allow for an assessment of the overall relevance of the "PIA" policy tool.

[22] A 2019 study by Strategy & PWC analyzing the R&D expenditures of the 1000 largest publicly traded companies — "Global Innovation 1000" — confirms that the driver of expenditures is shifting significantly to Asia and that Europe is no longer the preferred recipient of R&D spending. European groups are increasingly outsourcing their R&D to Asia, investing more and more outside Europe — +46% — and less and less in France — -20%.

policy. Investment in national specialization choices must find coherence not only with European regulation but also with the outlets and competition of the European market.

4.1.1 European Regulation as a Framework for Industrial Policy

The EU is a necessary passage for the success of any industrial policy, but it is sometimes a narrow passage between European competition policy and national strategies. Until the advent of the first Important Projects of Common European Interest (IPCEI), authorized state aid to companies was mainly deployed in two fields: environmental protection and support for R&D&I (see subsection 1.1). The regulation of aid responds to the objective of the single market and seeks to prevent competition between states. It aims to ensure a level playing field for European companies and to prevent the richest states from not only granting a discriminatory advantage to resident companies but also from draining capital investments and thus production capacity to their territory. According to Article 107 of the Treaty on the Functioning of the EU (TFEU), any public aid intended for companies, as previously defined, must be notified to the European Commission if it exceeds 300,000 euros over 3 years (*de minimis* rule since 13 December 2023).

Sustainable development goals have strongly influenced the orientation of European industrial policies (see below). The TFEU integrates environmental protection as a requirement for the definition and implementation of Union policies in its Articles 11 and 191 to 193.[23] The Green Deal of 2019 sets quantified objectives, notably achieving carbon neutrality by 2050. The "climate" law, in force since July 2021, which aims to comply with it, sets a reduction of -55% in CO2 emissions by 2030 compared to 1990 levels. The "Fit for 55" package, which is linked to this law, then designed the Carbon Border Adjustment Mechanism (see below) and the end of the sale of petrol or diesel cars by 2035.

In addition to environment and R&D&I, three other major fields of exemption are: aid to Small and Medium Entreprises (SMEs) and aid to sectors in difficulty or regional aid. These categorical exemption fields are gathered in the General Block Exemption Regulation (GBER), the latest of which was adopted on June 17, 2014.

It should be noted that aid to energy companies and more generally aid to network companies (telecommunications, water and electricity, public transport, rail transport) are not included in the exemptions. We will return to nuclear energy later. In terms of network activities associated with public service missions, or in European terminology, services of general economic interest, they are subject to special rules, but the EU has gradually subjected these activities to a more competitive organization requiring market opening (see for a discussion on the process, Fitoussi 2003).

State aid statistics published by the European Commission show an increase in aid granted by European states (see subsection 1.1). From 2000 to 2019, the average annual growth rate of aid (in current value) from the French government (1.7%) is equidistant from the European average (1.4%) and the growth rate of German aid (2.1%).

Article 107 provides that the Council, on a proposal from the Commission, may decide on the fields of exemption from European control by category. It also provides that, depending on

[23] First, the Amsterdam Treaty of 1997 recognized the European Union's objective to promote "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Then, the Lisbon Treaty of 2007 assigned the European Union a role of promotion and exemplarity on the international stage to combat climate change.

economic circumstances, strict application suspensions and modified rules may be established to allow greater support for the economy. Frequent periods of derogation from the strict application of state aid regulations have followed to allow more flexibility for states in implementing support plans in the event of economic shocks or recovery plans. This was the case in 2009 during the financial crisis for aid concerning the banking sector; then during the 2020 pandemic, a temporary framework for state aid was put in place, followed in March 2022 by a temporary crisis framework to address the energy crisis, and finally, in March 2023, it was expanded to a crisis and transition framework to take into account climate transition objectives and the Green Deal industrial plan.

Regarding the control of mergers and acquisitions, it is difficult to see a real barrier to the creation of national and/or European champions. The control of mergers with non-European actors often falls within the framework of foreign investment control, which has been strengthened across Europe since 2020.

There is indeed the Alstom-Siemens merger project, which failed due to the European Commission's rejection decision on February 6, 2019. It was interpreted both in France and Germany as a missed opportunity to create a European champion. The European Commission was then criticized for underestimating Chinese competition, particularly that of CRRC, by focusing too exclusively on the European Economic Area market. Many observers criticized the decision, and Bruno Le Maire, then Minister of Finance, and his German counterpart Peter Altmaier, called for a revision of merger control rules. The latter even wrote a text advocating a more proactive industrial policy (Altmaier 2019). However, few notable developments have occurred. The Commission did launch a reform project of its control, which resulted on April 20, 2023, in several texts allowing a simplification of merger control procedures in less contentious cases, but the new texts do not specifically address the issue of potential competition.[24]

Although there may be a form of self-censorship by European companies anticipating European control, it is most often the states, not the European Commission, that hinder the creation of European champions because they are too attached to their own national champion. For example, in shipbuilding, the French and Italian states were hardly accommodating to bring about the merger project of Chantiers de l'Atlantique with Fincantieri, and the merger project was abandoned in 2021.

In fact, it is mainly for what regards aid to companies that European policy has changed. It has indeed systematized the use of the Important Projects of Common European Interest (IPCEI) framework to allow states to support clusters of private companies in a project associated with a technology or sector deemed strategic. Already provided for in Article 107 of the TFEU, IPCEIs can make state aid compatible. But their transformation into an industrial policy tool is recent.

The legal framework governing IPCEIs was clarified in 2014 (European Commission 2014) and amended after consultation in 2021 (European Commission 2021). These projects aim to "address significant systemic or market failures and tackle important societal challenges." Assuming that private investments are insufficient to meet these objectives, IPCEIs effectively involve public investment, which can be classified as state aid. If they do not fall under R&D&I or environmental

[24] It should be noted that Alstom has rather followed a growth trajectory since this failure, having been able to absorb the signaling and rail divisions of the Canadian company Bombardier in 2020. Alstom is now the second-largest rail group in the world with a turnover of 16.5 billion euros in 2022 and 80,000 employees worldwide, according to the 2022-23 activity report.

Table 4: IPCEI List - 2018-2023

IPCEI	year	State Aid	Private Financing	# countries	# firms
Microelectronics I	2018-2024	1,75	6	5*	29
Battery I	2019-2031	3,2	5	7*	17
Battery II	2021-2028	2,9	9	12*	42
Microelectronics II	2023-	8,1	13,7	14*	56
Hydrogen (Hy2Tech)	2022-	5,4	8,8	15*	35
Hydrogen (Hy2Use)	2022-2036	5,2	7	13*	
Next Generation Cloud	2023-	1,2	1,4	7*	19

*France participates to the project.

aid, these aids require derogations from common market law.

As Eisl (2022) points out, this framework derogates from state aid rules and raises questions about the EU's market integration policy. It introduces budgetary differentiation, as only some member states pool resources to complete an industrial project deemed a priority by the European Union. However, it is clearly stated in the texts that for a project to be eligible for the IPCEI framework, its "benefits must extend to a significant part of the Union and not be limited to the member states providing funding" (European Commission 2014). Additionally, the community aspect is clearly established by two conditions: i) the European Commission, or a delegated body, participates in the co-management of the project, and ii) the project includes co-financing by an EU fund. The eligibility criteria for the project are then assessed based on the distorting effects on the common market of the state aid provided.

The first IPCEI was launched in 2018, focusing on microelectronics. Since then, five more IPCEIs have followed: Batteries I (2019), Batteries II (2021), Hydrogen I (Hy2Tech) (July 15, 2022), Hydrogen II (September 22, 2022), and a second project on microelectronics (2023), followed by cloud infrastructure (2023).

On June 8, 2023, the Commission approved a new IPCEI in the microelectronics industry "aiming to support research, innovation, and industrial deployment of microelectronics and communication technologies across the semiconductor value chain: from materials and tools to chip design and manufacturing." This IPCEI is an extension of the 2018 project and also a response to the American CHIPS and Science Act. Its total budget, combining private and public funding, is expected to be around 22 billion euros. As with other IPCEIs, France is participating in this latest project to support its electronic strategy.

As part of the France 2030 project, a dozen French companies are involved, with a total investment of 7 billion euros, including funding for partnerships with research institutes and 2.9 billion euros in aid for the joint factory of STMicroelectronics and the Chinese company GlobalFoundries. This aid was approved by the European Commission on April 24, 2023, and is part of the IPCEI framework established on December 18, 2018.

France is involved in all IPCEIs, and its policy of supporting the battery, hydrogen, and microelectronics industries aligns with the European IPCEI framework. Finally, there are no European regulations that direct public procurement towards local bidders. The European Union signed the WTO Agreement on Government Procurement (GPA) in 2012, committing to non-discrimination

against companies from signatory countries. These include 21 countries besides the EU, such as the United States and Canada, but not China or Russia.[25]

However, according to a recent report by the European Court of Auditors (2023), only 5% of public contracts in the EU are awarded to non-local bidders on average. This average is driven by Ireland, Luxembourg, and Belgium, where the rate exceeds 10%. France has the lowest proportion (1%). These proportions refer to the number of contracts, not their value.

According to public procurement statistics reported by the EU to the WTO and the *Trade Policy Review* by the World Trade Organisation (2022), European public procurement amounted to 2,393.5 billion euros in 2020, of which 528.8 billion euros were subject to the WTO agreement on public procurement. This represents a proportion of 22%, averaging 18% from 2014 to 2016. In other words, about one-fifth of European public procurement is covered by the WTO agreement. This proportion is similar for the United States.

Member states, like many other countries, practice de facto a certain level of discrimination. The awarding of public contracts, although heavily regulated, involves all the attributes of influence levers, whether on the side of public buyers or bidders (see Guillou et al. 2024). Besides legally established preference systems, many implicit or explicit barriers exist, leading to a national bias in the distribution of contracts between national and foreign bidders. This observed discrimination may be due to the nature of the goods ordered, the complexity of specifications for non-locals, higher transaction costs associated with dealings with the administration for non-nationals compared to local companies, or the political cost of excluding national bidders. In other words, there is an anti-selection of foreign candidates who may refrain from bidding, especially on small or medium-sized contracts. Labels are also a way to impose restrictions on the quality and specifications that offers must meet. The imposition of a label or certification can be justified for reasons of physical, health, or territorial protection. The definition of a label, if done in partnership with local actors, can act as a means to discriminate against foreign actors.

However, conversely, even countries with discriminatory laws, such as the United States, fail to satisfy all their public procurement needs solely with local suppliers (see Guillou et al. 2024). Additionally, a significant portion of public procurement is not fulfilled through competitive public tendering processes, making it susceptible to domestic bias or, conversely, to circumventing local content rules. The information report by National Assembly deputies Latombe and Warsmann (Assemblée Nationale 2021) outlined all the mechanisms that allow for deviations from the principle of equal treatment. This pertains to specific sectors: defense, network activities (water, energy, transport), and innovative purchases (below 100,000 euros). Geographical allotment, for execution reasons, also favors local businesses. Recently, the carbon content mechanism has been added, which, for now, remains strictly associated with subsidies for purchasing electric vehicles. Since the distance between the place of production and consumption is a major determinant of carbon content, the eligibility rule incorporates a bias in favor of European offers.[26]

The European philosophy is, therefore, first to respect international agreements and then to ensure reciprocity. A new instrument (international procurement instrument or IPI) was agreed upon by the European Parliament and the Council on March 14, 2022, allowing for the demand of reciprocal access. Access to European public procurement can be denied to companies from

[25] This agreement is a substitute to the agreement of 1994.

[26] https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000049133395

countries that do not offer the same access to their public procurement markets. The Commission will be responsible for applying an IPI measure to bidders from countries that do not offer reciprocity. The instrument will be applicable from 15 million euros for public works and concessions and from 5 million euros for goods and services contracts. This instrument had been proposed since 2012 but was repeatedly rejected. Then, the regulation on foreign subsidies, which has been in effect since July 12, 2023, extends state aid control to foreign companies. These companies are required to notify their participation in public procurement procedures if they have received financial contributions from their home state.[27] The international environment and Chinese protectionism have overcome the last European members' hesitations. The EU does not protect itself initially but demands reciprocity. For the mechanism to be effective, the reciprocity study must be conducted in advance; otherwise, it will significantly slow down public procurement procedures.

For small businesses, the European Small Business Act, passed in 2008, provides simplified access to public procurement through an online simplified procedure for SMEs but does not grant them priority rights to public procurement. In contrast, in France, the 2008 Economic Modernization Law, which establishes a Small Business Act (Article 26), offers innovative SMEs privileged access to public procurement. The temporary measure (until December 2021) reserved up to 15% of the average amount of high-tech, R&D, and technological study contracts for SMEs (see OECD 2014, page 221). The figures from the French Economic Observatory of Public Procurement show a fairly constant proportion of SMEs in contract awards in terms of number (58% in 2013 and 2022) and value (27% in 2013 and 2022) (Guillou et al. 2024). Aditionnally, the National Pact for Growth, Competitiveness, and Employment of 2013 mandated that at least 2% of public procurement be sourced from innovative companies. These measures targeting SMEs fall within the scope of European exemptions specific to small and medium-sized enterprises.

4.1.2 How to Align French Specialization with European Specialization

European specialization remains predominantly focused on the old industries that emerged at the end of the 19th and early 20th centuries, such as steel, automotive, energy, chemicals, transport services, pharmaceuticals, and agri-food. The European Union is a leading export power.

In 2022, China was the world's largest exporter of goods, ahead of the United States and Germany. Germany is a major player in EU trade but alone does not surpass either China or the United States. Five European countries are among the top 10 exporters of goods, and five others are among the top 10 exporters of commercial services (World Trade Organisation 2023). The EU ranks second globally in goods exports and first in commercial services exports (extra-EU). It had a trade surplus of 61 billion euros in 2021.

Certain sectors dominate global trade due to the importance of global value chains in their organization and the growing demand for their products. These include the pharmaceutical industry, telecommunications equipment industry, and automotive industry. A country's position in these industries is crucial for its standing in global goods trade. In terms of global export percentages, Europe leads in many sectors: agriculture, agri-food, automotive, and pharmaceuticals. It ranks

[27] This regulation was first applied in February 2024 during a Bulgarian public procurement for railway transport. The EU demanded an investigation into the Chinese bidder, a subsidiary of CRRC, on the grounds that it was heavily subsidized.

second in manufactured goods, steel, and textiles and clothing (though far behind China).[28]

Its industrial productive strengths are more marginal or even absent in 21st-century sectors associated with electronics, computing, and computational technologies. Today, it faces strong competition in traditional industries both in terms of price and quality and technological content. Some 20th-century industries are experiencing technological disruptions, such as the automotive industry (electrification), space (SpaceX model), energy (renewable energies), and pharmaceuticals (biotech), which require European production to adapt urgently. In services, Europe's economic power is also rooted in the 20th century, a period that saw the rise of financial services, administrative, organizational, and legal skills, and research quality. The EU dominates service exports. However, this dominance does not prevent its market from being coveted and conquered by many foreign players, particularly in the platform economy and cloud services.

In 2022, the European Union spent 352 billion euros on R&D, corresponding to 2.22% of the EU's GDP. Over 10 years, spending increased by 0.14 percentage points (2.08% of GDP in 2012). This remains well below Japan (3.34%, 2021) and the United States (3.46%, 2021), while China reached the European ratio as early as 2019 (around 2.24%).

There are significant European disparities, with rates ranging from 3.44% for Belgium to 0.44% for Romania, but the weight of the most R&D-intensive countries fails to lift the European average. Despite R&D spending being a priority since the Lisbon Agenda launched in 2000, private R&D expenditures have not taken off in Europe. In terms of the number of researchers per million inhabitants, the European Union ranks fourth (4,258) after South Korea (8,714), Japan (5,455), and the United States (4,821). China reports only 1,580.[29] However, when observing the performance of large multinationals, European spendings pale in comparison. In the ranking of the top 2,500 global R&D investors, Europe still had 577 companies in 2017, with spending of $200 billion, representing 27% of the total value. By 2021, it had only 361 companies in the ranking, with spending representing just 18% of the total.

In the frontier technologies listed in the UNCTAD (2023) report, it appears that in 14 of the 17 identified frontier technologies, the United States and China dominate the production of publications and patents. China particularly stands out in green technologies and robotics.[30] According to Auktor et al. (2020) in terms of patents in green technologies, France and Germany are not lagging behind the United States but are behind China. The latter has significantly increased its patent filing activity since the 2000s. This is confirmed by the study by Bellit & Charlet (2023), focusing on twelve breakthrough innovation technologies in the industry. According to this study, Europe is among the top four in 11 out of the 12 studied technologies but not in the top 2.

In artificial intelligence, the European landscape is mixed. On one hand, the weakness of its productive fabric in digital technology downgrades the EU in rankings based on performance indicators (patents, publications, R&D spending...) because digital giants invest massively; on the other hand, the quality of its scientific research does not completely exclude it from the AI ecosystem. The European research centers competing globally are Swiss or British; France and Germany are still absent. We will return to the AI challenge later, as it appears to be a common

[28] The steel industry ranks third in the European production value by sector, following dairy products and aerospace.

[29] Figures for 2020. World Development Indicators, 2023.

[30] The UNCTAD report identifies 17 frontier technologies of which internet of objects, artificial intelligence, green hydrogen or electric vehicles.

challenge for the entire EU.

In defense, the European Union struggles to advance industrial projects as defense issues are sensitive national sovereignty topics. However, this industry is among those where the integration of the European market and the pooling of supply and demand have leverage effects crucial for the sector's future. The Russo-Ukrainian conflict has led most European countries to increase defense budgets. In 2022, according to SIPRI figures, the European zone experienced the highest growth in defense budgets (+13% in real terms), reaching $480 billion, but only France and Poland meet the 2% NATO requirement. The European Union overall spends 1.5% of its GDP on defense, while the United States spends 3.7%.[31] However, the EU is also an export force in this industry, notably thanks to France and Germany. Productive forces remain very scattered, almost as much as the levers of public procurement. While the US budget exceeds $1,000 billion, public defense spending is scattered among European member states, and venture capital funds do not invest enough in defense.

Moreover, in defense, public procurement is as important as the commercial forces of French diplomacy. Currently, while there is a common external tariff and a common commercial policy, there are no European representatives responsible for selling the European brand. Yet European brands exist and will exist; a European sales force should be considered once there is a European diplomacy. The European Defense Fund is an important step to integrate European industrial forces, which, unusually for Europe, transit through research and development. Adopted on April 29, 2021, the fund is endowed with 7.9 billion euros for the 2021-2027 period. It will finance the R&D of industrial programs to consolidate a defense industrial and technological base and create more interoperability of equipment systems (compatibility of weapon and military equipment systems). Recall that Europe has 178 weapon systems compared to about thirty in the United States. The fund was initially only open to companies from the European Union or EFTA, and projects had to include at least three companies from three different countries. Very recently, France, which was first against, acknowledged to accept non-EU countries to claim to the fund, notably US and english ones.[32]

This also contributes to the desire to strengthen the EU's strategic autonomy. It should be noted that the ITAR (International Traffic in Arms Regulations) requires that a manufacturer of defense equipment incorporating one or more American components obtain US authorization to export this equipment. The challenge of the EDF is therefore also to reduce dependency on the United States. This dependency is very binding and handicapping. It is linked to the NATO agreement, which provides for American protection in exchange for the purchase of American equipment. Thus, if Germany has planned a 100 billion euro fund for its defense (Scholz government), it has served to buy American F35s to the detriment of the European Eurofighter, despite the future combat aircraft project (SCAF) involving France, Spain, and Germany.

Overall a major trade player, the European Union consists of countries with trade surpluses like Germany, the Netherlands, or Belgium, and deficit countries like France, Greece, Spain, and Poland. As shown by Creel et al. (2022), France stands out among the major European countries

[31] In 2022, world expenditures amount to bn 2240 dollars up from a yearly 3.7% rise (SIPRI, 2023). The United States dominate expenditure and export (bn 800 dollars). China keeps on augmenting its expenditure and ranks 2nd with bn 238 dollars. South Korea is reinforcing its presence in the pool of important actors.

[32] This change is not without relation with the Donald Trump victory for the next Presidency mandate.

and founding members with a significantly larger current account deficit.

In 2022, China was the third-largest client of the European Union and its largest supplier. The EU's bilateral trade balance with China has been in deficit since 2012, reaching around 400 billion euros in 2022. Buying 9% of European exports, China ranks behind the United States (20%) and the United Kingdom (13%). However, the EU buys nearly 21% of its imports from China. The following suppliers are the United States, the United Kingdom, Russia, and Norway.[33] France had a deficit of 25 billion euros in 2022, slightly larger than Germany's 23 billion euros. In 2023, Germany's deficit with China, its largest trading partner, significantly worsened, reaching nearly 85 billion euros.

What concerns Europeans today are the imports of electric vehicles. French concerns have long been held in check by Germany and its commercial and economic ties with China. However, competition in the electric car market has become so intense that the EU eventually launched an investigation into subsidies granted to the entire electric vehicle sector in China, subsidies that allow for lower prices in Europe. Launched in September 2023, the investigation, which can last 18 months, finally lead to raising the tariff on electric vehicles from China up to 45%, decision taken on October 30 to be last during the next 5 years.[34]

We observe that French specialization is not very different from European specialization: the largest export sectors are aerospace, agri-food, steel, chemicals, and pharmaceuticals. France stands out in energy, defense, and luxury sectors, including beverages.

France is indeed the third-largest global exporter of defense equipment by volume (SIPRI, 2023) and has the second-largest defense budget in the European Union after Germany. Like many other European countries, it has increased its defense budget. The Military Programming Law (LPM) plans to increase the annual budget from 43.9 billion euros in 2023 (Initial Finance Law of 2023) to 53.7 billion euros in 2026.[35]

The R&D intensity of the French economy is close to the European average. It has 4,926 researchers per million inhabitants, placing it above the EU average but below Germany, which has 5,393. France ranks fifth among countries in terms of R&D spending in billions of PPP dollars and thousands of FTE researchers but ranks behind Scandinavian countries and the Netherlands in percentage of GDP, placing tenth.

However, when focusing on defense and aerospace companies, France has four companies among the top 1,000 R&D investors, excluding Airbus, whose headquarters are in the Netherlands. These include Safran, Thales, Naval Group, and Dassault Aviation. In the early 2000s, Zodiac Aerospace (acquired by Safran in 2018) and Latécoère were also included.

Spending in this sector represents 7% of the expenditures of the largest French investors but only 2% in the United States and less than 1% in Germany. It is 16% for the Netherlands due to the presence of Airbus.

French specialization and its trade deficit do not resonate with Europe; it is not a problem for Europe. We understand that European concerns do not perfectly match French concerns. In

[33] Source: Eurostat, data 2022.

[34] Up to this decision, Chinese car imports used to be charged a duty of 10%. In June 2024, four individual companies, BYD, Geely, SAIC and Tesla had to face additional tariffs from 7.8 to 35.3 according to the level of subsidies they received. Other companies which cooperated by revealing their subsidies' amount were charged a 20.7 % tariff.

[35] The military programming law, "loi de programmation militaire" for 2024-2030 passed on the 1st August 2023 plans a budget of 413.3 billion euros for the 7 years.

industries of the future, its attempts at sectoral policies have so far resulted in failures: Bull, Alcatel, Minitel, Qwant, cloud services. Successive governments have clearly not found the right recipe. France's industrial policy must now rely on IPCEIs and strengthen its strengths in the defense, transport, and nuclear energy industries. The agri-food sector is also strongly anchored in the common European agricultural policy, but France has negotiating power due to its weight in agricultural production and the agri-food industry. Its technological positioning needs to be strengthened for it to become a driver of European innovation again, in addition to the quality of its scientific research. Nevertheless, its companies and skills make it an essential candidate for all IPCEIs validated by the European Commission. The French economy is therefore part of the European industrial policy orientations but needs to speed up on innovation.

4.2 The Climate Challenge

Industrial policies have turned green. Rodrik (2014) already advocated for this in an article ten years ago. He demonstrated that underinvestment in green technologies resulted from a dual underestimation of social gains: on one hand, the social gain associated with the positive externalities of technology, and on the other hand, the social gain associated with the reduction of negative externalities from pollution. Given that some green technologies are highly experimental, the level of uncertainty and risk associated with investments is significantly higher than standard technology, justifying even more public support.[36] According to Rodrik, a green industrial policy is one that internalizes climate issues. Furthermore, it is a policy of investment in order to mastering green technologies.

These market failures are the basic justification that led to addressing environmental issues through industrial policy (voir Guillou 2023b). The greening of industrial policies is a very clear shift in Europe, and this has also been recently confirmed in the United States since the Inflation Reduction Act (see Box 1). Climate issues can no longer be ignored, and the decarbonization of production processes is an irreversible direction that is likely to disrupt comparative advantages.

In France, energy policy has, early on, conditioned industrial policy by directing support towards nuclear technologies. Consequently, this strong specialization has placed industrial policy in a close relationship with the environment through energy. However, it is only very recently that the issues of industrial decarbonization have become prominent. This late awareness, at the crossroads of a critical deindustrialization dynamic (see above), places French industry and the entire productive apparatus under tension between a greening objective and a competitiveness objective.

4.2.1 The Choice of Nuclear Energy

The choice of nuclear energy has been structuring, of course for energy policy, but also for industrial policy. Indeed, this choice, stemming from a defense policy and a desire for energy autonomy, directed public support towards a high-tech sector (voir Levêque 2013). This energy policy can be seen as an industrial policy, as it constrained the energy mix and thus the energy specialization, and

[36] The major issue is that these positive and negative externalities are global. Consequently, the free-rider behavior of one country towards others that invest in green technology is widely adopted.

it built a comparative advantage notably distinguished by champion companies (EDF, Engie) but also a significant technological knowledge base in the energy field.

The energy mix in France has allowed maintaining one of the lowest CO2 emission rates per unit of GDP in Europe. The choice of nuclear energy has been an assumed industrial policy. Not only has the state massively invested in the nuclear sector through public enterprises, but it has also financed the research in nuclear energy as part of defense activities. The CEA (*Commissariat à l'énergie atomique et aux énergies alternatives*) concentrates nearly a quarter of public funding allocated to research organizations, with approximately 2.5 billion euros in 2013 and the highest budget per employee among all public research organizations.[37] It is also notable that the CEA is the top French patent applicant in the ranking of the top 100 applicants at the European Patent Office. The latest statistics from the National Institute of Industrial Property (INPI) show that the CEA has consistently been among the top four applicants over the past ten years (2012-2022), alongside Safran, Stellantis, and Valeo. It ranked third in 2022 with 672 patent applications.[38]

French companies have long benefited from the lowest energy costs in Europe. With over 70% of electricity coming from nuclear power, the price of electricity has constituted a comparative advantage for the French economy over the past 20 years. Comparing France to its partners for consumption levels between 70,000 and 150,000 MWh, there is a clear difference when considering prices including taxes (TTC) and excluding taxes (HT). Excluding taxes, European prices have been much closer over the entire period, and while France remains below, it converges towards the level of German prices in 2022.[39] As Mini & Bordigoni (2022) show, the price differences in electricity between France and Germany are mainly explained by tax differentials. Thus, the cost of electricity excluding taxes has been higher in France than in Germany since 2016, with Germany benefiting from a low marginal cost of renewable energy (financed off-market), low coal prices, and carbon pricing via the European quota system.

In France, the mechanism of Regulated Access to Historic Nuclear Energy (Arenh) resulted from the price advantage of nuclear energy.[40] Each electricity supplier is entitled to a certain amount of nuclear electricity according to a framework agreement with EDF. The Energy Regulatory Commission then sets the amounts allocated based on a closing coefficient and the consumption of the supplier's customers. Given the production cost of nuclear energy, since 2012, Arenh has

[37] According to a survey by the Ministry of Research on research organizations, 20 research organizations were listed in 2013, with the top 5 receiving 84% of the budgets. In order of budget importance in 2013, the 20 organizations are: CNRS, CEA, INRA, INSERM, CNES, ONERA, INRIA, IFREMER, CIRAD, IRD, IRSTEA, ANDRA, IRSN, IFSTTAR, BRGM, CSTB, IPEV, INED, LNE, INERIS. More recent data is not available.

[38] The CEA ranks 30th in this list, with the second highest applicant being Valeo (aerospace), ranked 37th; followed by Safran (48th) and Thales (58th), and the fifth is the National Institute of Health and Medical Research (INSERM) (83rd). Thus, two public institutions (CEA and INSERM) are among the top 5 French applicants at the European Patent Office.

[39] Taxes include not only VAT but also other electricity-specific taxes such as: i) the contribution to the public electricity service, ii) the tariff contribution for transportation, iii) the tax on final electricity consumption, and iv) the contribution to the support of renewable energies. This last tax has been particularly high in Germany since its introduction in 2000 (known as the EEG surcharge) and has been increasing until 2021. In France, the contribution to the public electricity service (CSPE) was reformed in 2015.

[40] The Arenh mechanism was established in 2011 and is set to end in 2025. This mechanism stems from the NOME law (New Organization of the Electricity Markets) enacted in 2010.

been sold to alternative suppliers at a price of 42 euros per MWh. The volumes allocated in 2022 increased by one-fifth. In 2013, around 40 TWh were requested, and demand has been above 140 TWh since the end of 2019. The demand rose to 160 TWh in December 2021 (for 2022). Since the supply is 100 TWh, a capping mechanism forces suppliers to procure the remaining quantity from the market at much higher prices.[41]

Despite this nuclear advantage, a nuclear phase-out seemed to be on the horizon during François Hollande's presidency. In 2015, the closure of 14 out of 58 reactors was decided. Hollande's presidency, which notably hosted COP 21 in 2015 leading to the Paris Agreement, aimed to reduce the share of nuclear in electricity generation from 75% to 50% by 2020. Nicolas Hulot, Minister of Ecology in the first government of President Emmanuel Macron's first term, had to concede a later date to meet this new energy mix. Amid energy price tensions following Russia's invasion of Ukraine, President Macron reaffirmed the government's interest in nuclear energy during the presentation of the France 2030 strategy on October 12, 2021.

The *France 2030* investment plan, with 54 billion euros over 5 years, includes the production of small reactors. It aims to "promote the emergence of a French offer of small modular reactors (SMR) by 2035, and supports breakthrough innovation in the sector." Specifically, 6 new EPRs are planned for the next 10 years. The nuclear acceleration bill passed in March 2023 simplifies administrative procedures to launch these EPRs and removes the goal of reducing the nuclear share to 50% by 2035 as an energy source.

The continuity of nuclear efforts had allowed the French economy to establish a dominant position in nuclear energy production and low-cost decarbonized electricity. However, efforts weakened around the 2000s, and besides the bankruptcy and dismantling of Areva, EDF faced deployment and maintenance difficulties, worsening its financial situation.

The political wavering that questioned a real comparative advantage can be regretted, as it weakened the French economy's ability to face the energy crisis born from the Russo-Ukrainian war. However, this wavering also reflects the democratic shift in French citizens' energy preferences.

Today's challenge for France is likely the lack of European support and the weakened internal political consensus that existed from the 1970s to the 1990s. Hesitations and moderate commitments do not make for good industrial policy. The European position is crucial as energy regulation is largely determined by European bodies, and French energy companies need the European market. The European Commission's aid regime excludes nuclear from the scope of aids not subject to notifications. While European public aid rules are indeed a mark of European industrial policy, nuclear is not among its targeted sectors. In 2019, during the definition of green investment typologies under the new Commission's carbon neutrality policy, French authorities laboriously achieve a shift in the typology, allowing investments in gas and nuclear to be classified as "transitional energy sources" for achieving carbon neutrality. Ultimately, the green taxonomy for directing investment financing, revealed in early 2022, classified nuclear and gas as transitional energies.

The French argument is that while nuclear is not a renewable energy, it is low-carbon and should not be excluded from decarbonization plans and strategies to achieve carbon neutrality. Under the

[41] Starting January 1, 2023, the price was supposed to increase to 49.5 euros according to the law passed by the National Assembly, but the Senate blocked the price at 42 euros. However, an additional 20 TWh allowed for an increase in the quantitative cap in 2022 at a price of 46.20 euros.

new green industry financing rules discussed in March 2023 ("The Net Zero Industry Act"), nuclear fission was initially introduced as a "strategic net zero industry." This designation allowed for faster aid allocation procedures, preferential treatment in public procurement, and tax credits. However, after tense discussions, nuclear was removed from the list of strategic industries. The nuclear debate re-emerges with each European energy-related text adoption, questioning whether nuclear combustion qualifies as a "low-carbon" energy. For example, will hydrogen produced from nuclear energy be considered "green," allowing access to European financing? Another question is whether nuclear energy production can be included in renewable energy production targets, which the French want to extend to low-carbon energy production.

Regarding the French political consensus, it seems, if not total, at least bipartisan, enabling majorities to initiate public investments. Another political consensus has emerged around industrial decarbonization.

4.2.2 The Imperative of Decarbonizing the Productive Fabric

The choice of nuclear energy has likely delayed French investments in renewable energies compared to other European countries. However, as seen, the carbon neutrality goals for 2050 cannot be achieved with nuclear energy alone. Diversifying low-carbon sources and decarbonizing production processes are necessary.

Industry, and more broadly the entire productive fabric, must meet the decarbonization challenge. Transport, heating, and industry are the three major sources of fossil energy consumption, directly or indirectly via electricity produced by fossil fuel combustion. While the French economy emitted 403.8 million tonnes of CO2 equivalent in 2022, industry was responsible for 18%. According to INSEE data, manufacturing and construction emitted 73 million tonnes of CO2 equivalent, and the energy industry 44.6 million tonnes. Manufacturing has contributed most to emission reductions since 2000, mainly due to the slowdown in manufacturing production.

Since the Russo-Ukrainian war, France, like the rest of Europe, has faced soaring energy prices. The cost of energy has become the major competitiveness issue for industry, while environmental regulations have only tightened. Industry must face the dual challenge of sustainably high fossil energy prices and the need to invest to reduce dependence on these energies. Electrifying production processes is the major project for the coming years. As Pinto et al. (2023) show, the process of electrification has been strongly linked to wealth growth and development. As the decarbonization of the economy will rely on decarbonized electric energy, this past trend will continue. Mastering decarbonized energy and extending its use will involve the electrification of transport, industry, heating, and other economic activities. The first step to eliminating fossil fuels is to replace their direct use with electricity, known as the electrification process. The second step is to green all the electrons produced.

According to Pinto et al. (2023), electricity generation doubled between 1990 and 2014, and the associated CO2 emissions nearly doubled as well. This means that the carbon content of electric energy worldwide has hardly decreased. Therefore, there is a real challenge in crossing the curve of electricity generation with that of its carbon content. Electricity demand will accelerate due to the substitution of fossil fuels (electrification) and more electricity-intensive consumption modes (electronics, robotics, artificial intelligence). To reduce CO2 emissions from electricity generation, the carbon content must decrease at a faster rate than electricity generation. The latter is expected

to more than double by 2040 (25 years from 2014), so the carbon content must drastically decrease by more than 3.2% per year.[42]

In France, electricity represents 28% of the energy used in final consumption, and this electricity is 92% decarbonized. To reduce emissions while electricity consumption increases, the share of electricity in the energy used by industry must increase. Thus, the industry must swap fossil fuels for electrons.

Leading industries towards a decarbonization path is not simple, as the alternatives to fossil energy are hydrogen or heat pumps. Carbon capture and storage represent an alternative in the absence of substitution. Electrifying furnaces is an option that is gaining traction but requires major innovations to produce high temperatures. Heat pumps will likely be a first solution for moderate temperatures, but innovative processes will be necessary to go beyond. These are medium-term objectives that require investments. The incentive to make these investments partly depends on the relative cost of energies.

However, governments have considered that it was first necessary to help the industry through the shock of fossil energy prices. The French government has implemented aids for small businesses to limit price increases. The tariff shield targets companies with fewer than 10 employees and a turnover of less than 2 million euros, capping the electricity price increase at 4% in 2022. An aid window for paying electricity bills was also created in 2022 and extended until 2023.[43] In 2023, very small businesses benefited from a capped electricity price of 280 euros per MWh, a price the state obtained from suppliers. Additionally, the 2023 tariff shield capped the electricity price increase at 15% from February 1, 2023, until the end of 2023.

Industries such as cement, steel, and chemicals are among the most polluting per unit of value added, but other sectors, particularly those producing transportation means, are also significantly impacted by emission reduction policies. Given French and European objectives, the French automotive sector is transitioning to electric vehicles, a shift not without risks. Electric vehicles accounted for 20% of vehicle sales in France, according to the International Energy Agency (IEA, 2022), which translates to 310,000 units or 4.6% of global sales. The trade balance is notably negative, which is also true for batteries.[44]

The transition is driven both by the shift to electric propulsion and changes in automobile usage. New generations are less inclined to obtain driving licenses, and per capita highway travel is decreasing. Major cities are adopting policies that, if not hostile to cars, at least favor alternative mobility options.

Finally, industrial emissions also stem from the energy industry. How does France position itself in terms of green industry? Green industries are not among France's comparative advantages. Among the twelve breakthrough technologies analyzed by Bellit & Charlet (2023), eight concern green technologies. While the European Union, often thanks to Germany, is well-positioned in wind technologies, France stands out mainly when focusing on patents from public institutions. It ranks third globally in photovoltaic technologies. The hydrogen sector may also stand out, but it

[42] This is the average annual growth rate that electricity consumption will experience if it doubles by 2040, over the next 25 years.

[43] The aid is conditional on the electricity bill having increased by more than 50% compared to the 2022 average and that this bill represents more than 3% of turnover, with a cap of 4 million euros.

[44] See Guillou (2023), L'industrie européennes des véhicules électriques doit-elle craindre le protectionnisme vert américain ?, OFCE blog Post.

is subject to regulatory uncertainties regarding the underlying energy sources for its production. Despite significant public investment in energy, French companies have not achieved dominant positions in renewable energy technologies.

4.2.3 Recent Policies aiming at decarbonizing industries

The objective of industrial policy to decarbonize industry is relatively recent in France. Pre-Covid reindustrialization plans did not particularly emphasize decarbonization, likely due to the choice of nuclear energy, which was associated with lower electricity prices and low CO2 emissions. However, post-Covid geopolitics, the shift in trade as an instrument of international relations, and the Russo-Ukrainian war have brought new attention to energy and its consumption by industry. While the issue of industrial CO2 emissions was not unknown, it was not as prominent as it seems today. Everything essentially relied on European regulation and its key mechanism: the European emission quota system established in 2005.

This European system is central to the decarbonization of European industry. It targets the most polluting industries while providing compensation mechanisms. The carbon quota system operates on the principle of the right to pollute. Industries are allocated rights based on the maximum CO2 quantity targeted by the European market. It is then up to the industries to sell or buy more rights according to their needs.

The price of carbon is determined by the tension between supply and demand. During the Covid crisis, the price dropped due to decreased activity. When the price is high, heavily polluting industries are incentivized to invest in decarbonization.[45] Carbon rights are concentrated among a small number of companies in specific sectors and sizes. The system entered its fourth phase in 2021 and will evolve with the implementation of the Carbon Border Adjustment Mechanism (CBAM) starting in 2026. Until 2021, free quotas were distributed; these are set to disappear as CBAM is implemented.

In France, decarbonization of industry became a policy focus during the recovery plans to address the pandemic crisis. For instance, the 2020 plan for the aeronautics and air transport industry, amounting to 15 billion euros (including loans, guarantees, and investments), included "environmental optimization," meaning investment commitments towards a "cleaner" aircraft.[46]

On November 8, 2022, the French head of state met with leaders of the most energy-intensive industries. These industries are also the most polluting because the energy used in industrial processes mainly involves heating and high temperatures achieved through fossil fuel combustion. A decarbonization plan was announced, focusing on 50 industrial sites that emit 10% of the country's total emissions. The plan proposed doubling aid from 5 to 10 billion euros by 2030. France Relance already planned 1.3 billion euros for decarbonizing industrial processes, and France 2030 added 1 billion euros.

[45] The European Union Emissions Trading System (EU ETS) was established in 2005. The revenues from the initial rights payments go to the issuing states. Auctions for new rights are organized, with the proceeds financing the Innovation Fund and the Modernization Fund.

[46] The modernization fund dedicated to the aeronautics sector was endowed with 100 million euros in 2020 and an additional 100 million euros in 2021 and 2022. This modernization primarily implies environmental optimization. See Guillou and Faure (2020), "The Public Bailout Parachute to the Rescue of a Free-Falling Aviation Sector," OFCE blog post.

The decarbonization plan materialized on May 16, 2023, in the Green Industries bill. Adopted on October 10 and 11, 2023, the law aims to "make France the leader in green technologies necessary for decarbonization and green existing industries." The law includes incentive mechanisms to increase investments in green industries, directing savings, conditioning aid, and orienting public procurement. An additional investment of 23 billion euros is targeted by 2030, combining public and private efforts.

This plan combines horizontal instruments, such as tax credits associated with decarbonization investments (which reduce emissions from production processes), and vertical instruments, subsidizing companies developing green technologies (wind, photovoltaic, heat pumps, hydrogen, etc.). Between 5 and 23 billion euros will be spent within this framework. If these billions are spent, the French effort will not pale compared to the amounts planned by the American IRA (see Box 1 and, Guillou 2023b). However, mobilizing stakeholders is crucial for the plan's implementation and effectiveness. It is also important to keep in mind that unanticipated cascading effects are always possible when the transition and adaptation period is short (Gaffard & Martin 2023).

Notably, this plan has taken on a protectionist tint by conditioning the ecological bonus on the calculation of a vehicle's carbon footprint to be eligible. In 2022, the ecological bonus cost approximately 2 billion euros. Since local production of electric vehicles in France is far below consumer demand and the need to replace the vehicle fleet is urgent due to European 2035 targets, the government sought to avoid the ecological bonus exclusively financing foreign, particularly Chinese, jobs. The principle of awarding the ecological bonus is based on evaluating the CO2 content of the product targeted for purchase, which will be subsidized by the bonus. The carbon content, in tonnes of CO2 equivalent, depends on six production components: steel input, aluminum input, other materials, the battery, assembly, and transport from assembly to distribution.

In conclusion, decarbonization is a challenge to be met, but it is less urgent in France than in the rest of Europe, given the weight of polluting industries and industry in the economy. Electrification or "defossilization" of transport and heating modes should likely be prioritized, and investments in mastering green technologies must intensify. However, no clear dominance appears in mastering green technologies. Rather than targeting all these technologies, it might be preferable to prioritize one renewable energy source to develop alongside investments in nuclear energy.[47]

4.3 The Challenge of Artificial Intelligence

Artificial Intelligence (AI) is a General Purpose Technology with a high potential for replication and enhancing human intelligence. This technology is therefore intended to substitute human working hours. However, it is a complex technology still reserved for an elite of tech companies. With a high potential for productivity gains and new functionalities for citizens' well-being, its use must spread as widely as possible in the economy. But the task is not simple and the role of the state in achieving this cannot be ignored.

[47] The accepted CO2 thresholds depend on the size of the electric vehicle. The scheme is managed by ADEME, which is the authority that will determine whether the vehicle is eligible for the bonus or not.

4.3.1 The Nature of the Challenge for Industrial Policy

Why consider AI technologies as a specific challenge that the productive system must address and that industrial policy must tackle? For two main reasons: firstly, they have a high disruptive potential in production methods, particularly due to their effects on employment; secondly, they offer productivity gains that will give those who master them a major competitive advantage and, due to increasing returns, will increase inequalities between companies. More than any other technology, AI has a strong disruptive power on work and production modes.

How can the appropriation of these technologies by the French productive system be measured? AI is neither a sector nor a uniform technological asset, making its measurement a challenge in itself. Its penetration into the economy can be approached through two dimensions: the personnel dedicated to its use and the digital inputs necessary for its deployment. These are two broader statistical targets but an intensification of AI will definitely impact these two targets. Indeed, to produce AI, digital workers are required. Then, supercomputers and semiconductors dedicated to these supercomputers are needed.[48] Finally, cloud infrastructure and services are also necessary. There are also the data on which AI is trained. The main producer of chips used by supercomputers is the American company NVIDIA. It has experienced unprecedented growth over the past two years, reaching a market capitalization of 1 trillion dollars in 2023 and achieving new heights in 2024 in response to increased demand for its H100 chips.

AI mastery can also be approached by the number of AI-related patents filed. The primary difficulty in this area is identifying the technology domain. A study by Deperi et al. (2023) on patent data shows that France lags behind other European countries in the number of AI-related patents filed. France is mainly present in international rankings through its public institutions.

In the UNCTAD (2023) report, artificial intelligence is one of the 17 breakthrough technologies analyzed. Unsurprisingly, China and the United States far surpass Europe and even more so France in terms of patents. China, the United States, and South Korea have filed more than half of the AI patents from 2000 to 2021. Only the United States and probably China have an exaflop supercomputer. The United Kingdom ranks third in AI-related publications from 2000 to 2021. The CNRS is among the top three public institutions concentrating affiliations recorded by these publications (along with the Chinese Academy of Sciences and Carnegie Mellon University in the United States).

In AI, as in many breakthrough technologies (Bellit & Charlet 2023), France stands out more in public research than in private research. This at least has the advantage of a potential pool of AI engineers who will be increasingly in demand in the coming years (Alekseeva et al. 2021). However, according to the latest research status from the Ministry of Higher Education and Research (MESRI 2023), in terms of AI publications (in a strict definition) in 2021, France ranks ninth, behind Germany, the United Kingdom, and even Italy. The United States, China, India, and South Korea occupy the top four spots, concentrating more than 56% of AI publications.

It is therefore urgent to encourage private actors to seize this new technology. It holds a reservoir of optimization for human tasks and rationalization of production, supply, and sales processes. This duplicative effect will also play on green technologies and accelerate the transformation towards

[48] Progress in AI is parallel to the computing power of computers. "Floating points operations per second" or FLOPS is the unit of measurement for computer power. The number of FLOPS has increased by a factor of 10^8 in 10 years. An exaflop is one quintillion (a billion billion) operations per second.

more energy-efficient processes.

Although the productivity effects of AI might initially result in a deterioration of productivity due to disruptive effects in work reorganization, the J-curve that is emerging will undoubtedly be more extended. The period of deterioration will be shorter or less severe because the diffusion of AI is already underway via the web infrastructure and the qualifications to use it are potentially already in place. Positive effects are already being observed. Brynjolfsson et al. (2023) show from a professional experiment that the introduction of AI through a conversational assistant significantly increased worker productivity, with the effect being stronger for less qualified workers.

4.3.2 The Risk to Employment

The progress and democratization of AI—especially with the market introduction of large language models like ChatGPT—have sparked a new cycle of concerns about the transformation of the labor market and job displacement. Ten years ago, in 2013, Oxford researchers Frey & Osborne (2013) were very alarmist, predicting that 40% of jobs were threatened by automation. A decade later, despite a major economic shock, labor market tensions show more of a worker shortage than the predicted massive job displacement. Yet, a new report by Goldman Sachs in April 2023 (Briggs & Kodnani 2023) presents another grim outlook, this time in response to AI penetration, predicting that 75% of American industrial jobs would be modified by AI, with a quarter of them facing potential substitution.

However, being affected by AI does not mean that jobs will disappear. The extent of modification depends on the sequence of tasks that make up the job. Aghion et al. (2017) show that the impact of AI on jobs depends on the intensity of its penetration in the concerned job. As long as there remains a residual task that must be performed by humans, the job will gain in productivity but will not disappear. The authors show that growth will be hindered by residual human tasks that cannot be improved by technological progress.

The IMF also argues for a technological disruption whose effects will be broader on jobs than previous technological disruptions. Cazzaniga et al. (2024) show that, unlike previous technological revolutions, AI will also massively affect skilled jobs. The IMF study (Cazzaniga et al. 2024) proposes an index of readiness for AI adoption by country. This index includes a measure of digital infrastructure, an index of policies on human capital and the labor market, and an index measuring ethics and regulation. France ranks seventh among the 125 countries covered by the study, behind Singapore, the United States, Germany, Japan, the United Kingdom, and Australia.

Everything will depend on the degree of substitutability or complementarity that AI will have with human tasks. According to Erik Brynjolfsson, it is essential to avoid the Turing trap, which would consist of trying to make AI a copy of human intelligence.

From a policy perspective, the industrial policy of promoting AI use to increase productivity gains and prevent companies from falling behind their competitors must confront a policy of job protection. A vast AI training campaign is a way to reconcile these two imperatives.

4.3.3 What Support Policies?

If we consider that mastering AI technology will be the source of future comparative advantages, it is difficult to ignore its development by economic actors. However, it must be recognized that, in

terms of industrial policy, there are currently more incentives to invest in research for decarbonization than in artificial intelligence. Governments' caution towards this technology, whose potential is admittedly daunting, ultimately reflects the lack of popular support. This leads to relatively inaudible communication about public efforts. However, the advances of foreign companies, particularly American ones, challenge the economic sovereignty of states, which are increasingly mobilizing.

As mentioned earlier, the productive fabric increasingly includes digital inputs necessary for mastering these technologies, but it is difficult to say whether this growth rate is sufficient to be at the innovation frontier, creating comparative or competitive advantages.

Like for the green industry, French policy is bound by the European legal framework. This framework both imposes constraints on innovators—such as the AI Act—and encourages investment—such as the Chip Act. Recently, European Commission President Ursula von der Leyen advocated for the creation of a European AI research center with a budget of 100 billion euros over half a decade. [49] This is a very ambitious proposal, considering that the European research budget Horizon Europe for seven years amounts to 95 billion euros. However, it shows an awareness of Europe's lag in this area.

In France, since the Villani (2018)'s report in 2018, there has been little talk of artificial intelligence in economic support plans until the report of the Artificial Intelligence Commission (2024) Commission de l'intelligence artificielle (2024), a commission established in 2023 under the presidency of P. Aghion and A. Bouverot. The Villani (2018)'s report did lead to a national AI strategy launched in 2018 and some initiatives like the Health Data Hub to collect health data for training algorithms. This strategy is now part of the "sovereign and secure digital technology mastery" component of France 2030, with a budget of 1.5 billion euros out of 56 billion euros. The Artificial Intelligence Commission report (2024) (Commission de l'intelligence artificielle 2024) recommends an investment of 5 billion euros per year over the next five years. Will we see a shift in innovation policies in favor of AI?

So far, few resources have been mobilized compared to the amounts deployed in the private sector.[50] Identifying public and private investments in AI is still very confusing, as financial investments (company acquisitions), material investments (digital infrastructure), and intangible investments (intellectual property purchases, R&D, or software investments) overlap. It is undoubtedly necessary to distinguish between AI infrastructure (servers, supercomputers, data centers) and investments in algorithmic research or databases. The former are the most substantial and are currently primarily the domain of American companies. Additionally, companies are investing in co-developing AI models or creating departments to develop AI usage in their fields. However, increasingly significant sums are being poured into AI-related companies. Ian Hogarth, an expert and financier in the field—and since June 2023, President of the AI Foundation created by the British government—estimates that $23 billion has been cumulatively invested since 2012 in a small number of organizations, with $11 billion in the first three months of 2023 alone. Significant amounts also flow through defense. In the United States, the Stanford AI Index estimates private

[49] *Von der Leyen gives nod to €100 billion CERN for AI proposal*, Jacob Wulff Wold, Euractiv, 25 Juillet 2024, https://www.euractiv.com/section/digital/news/von-der-leyen-gives-nod-to-e100-billion-cern-for-ai-proposal/

[50] After a strong surge in AI investments and the valuation of companies closely involved with AI (2022-2024), the enthusiasm has significantly slowed down, with some observers concluding that the AI bubble burst in the summer of 2024.

AI investment at $62.5 billion in 2023. Since then, investment announcements have continued to grow. For example, of the $56 billion in capital expenditures announced by Microsoft for 2024, about $20 billion is intended for AI. Investments are concentrated in the United States, consistent with the concentration of new AI models: 61 of American origin in 2023 compared to 21 from the European Union and 15 from China, according to the AI Index Report.[51]

Consistent with these figures, Di Biaggio et al. (2024) show that AI-related patents from the European Union represent one-third of the number of US patents. In terms of publications, the EU's lag is smaller, with European publications representing 90% of the US total. These figures suggest that the lag in private investment is not compensated by superior public research performance, and even though public research holds its own in international rankings, additional public research efforts will be necessary to match US performance.

Even if the enthusiasm around AI in the past two years may seem exaggerated relative to current needs, investments will lead to a significant increase in the necessary AI infrastructure.

Regarding public policies, they can primarily support research or establish platforms for collecting public data. Some states also invest in AI infrastructure, such as building supercomputers or cloud servers. This was the case in 2012 when the French government subsidized existing French companies to create a French cloud. Numergy and Cloudwatt brought together two groups of companies, the former associating Bull and SFR and the latter, Orange and Thales.[52] Doubts quickly arose about the necessity of funding two solutions rather than one, especially with relatively modest means of 225 million euros each. The state then contributed 75 million euros through the National Digital Society Fund and a participation from the Caisse des Dépôts using resources from the Grand Loan ("Grand emprunt"). The government of François Fillon decided to fund the two entities instead of one, as the companies could not agree. Three years later, revenue forecasts were far from being realized (100 times lower than announced), and the government sought to disengage. Misjudgments of market growth and actor needs led to poor strategies regarding product development. Politically, focusing on large telecommunications players without leveraging existing cloud sector actors favored economic weight over specific expertise. Eventually, Orange bought Thales' and the state's shares, and SFR acquired Bull's and the state's shares. Cloudwatt deactivated its platform in early 2020, with Orange offering a new solution, *Flexible Compute*, instead. It's hard to say if the Cloudwatt venture was useful for developing this service. Ultimately, by 2019, neither company succeeded in creating a cloud service as envisioned by public policy.

In the absence of a company offering cloud services from its own infrastructure, the French government turned to regulating cloud computing services to meet sovereignty requirements, particularly regarding the extraterritoriality of US law. The government established a specific label for cloud computing services, SecNumCloud, which sets security requirements that cloud providers must meet for public administrations to use their services.[53] This certification allows providers to

[51] https://aiindex.stanford.edu/report/

[52] Everything began under President Nicolas Sarkozy in 2009 with the Andromède project, which was endowed with 150 million euros and aimed to create a large data hosting center. Dassault Systèmes, the leader of the Andromède project, initially joined the Numergy venture but later exited. Dassault Systèmes subsequently launched its own cloud operator, Outscale.

[53] The certification was designed in 2016 by the National Cybersecurity Agency of France (ANSSI) and includes technical and legal criteria. It was updated in March 2022. It was consistent with the highest level of security

gain a privileged position in tendering processes and can be seen as support for the French sector, as their nationality might give them an advantage in obtaining certification. As of June 2024, four French providers—Outscale, OVH, Worldline, and Cloud Temple—have obtained certification for their infrastructure services (IaaS), while Oodrive has been certified for its software (SaaS). Whether the market share of French actors has benefited from this certification at the expense of foreign actors will be difficult to determine. Quantitatively, adopting this label at the European level could give French actors a regulatory advantage.

More recently, under *France 2030*, a "cloud computing" component directs 1.1 billion euros of public support to stimulate cloud computing research. Part of this public funding comes from European sources (444 million euros) and is part of the Important Project of Common European Interest (IPCEI) on cloud computing established in December 2023. However, shifting French cloud ambitions to the European level has not resulted in creating a European cloud provider (voir Guillou et al. 2024). The ambitions around the GaiaX project, initiated by France and Germany in June 2020, have gradually faded. GaiaX is now a professional association acting as a forum to harmonize cloud services. French influence is exerted through imposing its SecNumCloud security label in European cybersecurity legislation (EUCS). However, more liberal member states oppose establishing stringent security constraints, arguing it would hinder European competitiveness and fearing American retaliation, as their actors would be primarily targeted by such high standards.

The AI support policy (pilar 2) must accompany a regulation (pilar 1) that is expected to become increasingly strict regarding AI uses, particularly generative AI. The threats posed by AGI to humanity will be under more and more intense regulatory control. Here again, the European legislator is at the forefront. It has to boost the second pilar. Regarding supercomputers, the European Union does not have one with power equivalent to that of the United States. Commission de l'intelligence artificielle (2024) call for the European Union to act as a contracting authority and finance public procurement, but the EU struggles to raise funds as much as in the United States or China (European Court of Auditors 2024).[54] In January 2024, a pack of measures to support European IA ecosystem was launched. The *AI innovation package* precisely plan to make any supercomputer public and open access to SMEs and startups through a financing based on a selection of projects..[55] Renda (2024) supports the proposal of the Confederation of European AI science laboratories to create a similar center such as the CERN, the multi-countries center for nuclear research.

In terms of private investment amounts, Europe also lags far behind the United States. The main challenge for public authorities is to create an ecosystem more conducive to synergies and the absorption of European scientific expertise in AI. The European Union concentrates a significant amount of AI expertise, as shown by Di Biaggio et al. (2024). However, mastering a set of technologies within the AI system does not necessarily ensure enhanced competitiveness in this field if synergies between the various mastered technological segments do not occur. So far, French ecosystem seems promising due to dynamic public research and some promising young companies like Mistral AI. However, the market is still too young to boast a leading position, and

established by the proposed European cybersecurity regulation until the latter was watered down. The certification is obtained for each service offered by a provider, not for a particular actor.

[54] https://www.eca.europa.eu/ECAPublications/SR-2024-08/SR-2024-08_FR.pdf

[55] AI Innovation Package, https://ec.europa.eu/commission/presscorner/detail/en/ip_24_383

macroeconomic budget constraints, which future governments will struggle to avoid, will hinder the public investment capacities necessary for a clear industrial policy in favor of artificial intelligence.

Section 5. Conclusion

French industrial policy has been a major component of the economic policies of French governments since the post-war period. The modalities of intervention have evolved towards more horizontality and indirect intervention, through incentives or decentralized agencies. However, the presence of issues related to specialization, innovation, and industry has been consistently observed in the definition of industrial policies.

How can we characterize French industrial policy up to today? It has favored the lever of technology and the strengthening of its champions. It has been prolific in speeches and forums, remarkable where the state has been consistent (bipartisan policy), involved, and a market maker (nuclear energy and defense). The state cannot replace private actors, but if it wants to seriously affect productive specialization, it must take responsibilities and risks comparable to private actors in terms of duration and intensity. It must therefore have the skills, engineering, and continuity of involvement guided by a long-term objective and consistent needs.

Has French industrial policy been conditional in the sense of Mazzucato & Rodrik (2023)?

In general, French industrial policy has been relatively unconditional, except in the energy and defense sectors. Its innovation policy primarily relies on the Research Tax Credit (CIR), which is not conditional. Recent policies (France 2030, Green Industries) offer tax credits and subsidies to stimulate investments. The condition is based on the quality of the investment rather than external behaviors (employment, societal or educational objectives, etc.). It appears that the amounts of direct aid are increasingly significant. However, if the 53 billion euros of *France 2030* are spent by 2030, this corresponds to 7.5 billion euros per year, which is only slightly more than the CIR, which is not conditioned on sector or technology.

At first glance, French industrial policy seems more interventionist and ambitious in its objectives than that of its European partners. French governments believe—or make believe—that they can influence specialization. The specialization dynamics of the French economy have certainly responded more to other determinants than those arising from industrial policy. One reason for the weak leverage of this policy relative to the intense political activism surrounding it is likely found in the modest amounts committed due to the diversity of pursued objectives. Besides its dispersion, the announced and planned amounts are always very substantial but rely on loans, guarantees, and assume strong mobilization of private actors, which conditions the scope of industrial policies.

Greater efficiency will undoubtedly come from a greater concentration of resources, particularly around decarbonization and AI, in conjunction with the engagement of private actors while aligning with the dynamics of European regulation and markets.

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ABOUT OFCE

The Paris-based Observatoire français des conjonctures économiques (OFCE), or French Economic Observatory is an independent and publicly-funded centre whose activities focus on economic research, forecasting and the evaluation of public policy.

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