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(Laurea Magistrale)

Master Thesis

The European Union's response to the Inflation Reduction Act

The economic theory behind a green industrial policy for Europe

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INTRODUCTION

The Inflation Reduction Act (IRA), approved on the 7th of August 2022 by the US Senate, provides for $392 billion in subsidies and tax benefits for American companies using clean technology. This includes trade-distortive subsidies and local content requirements prohibited under the WTO.
The EU, fearing that industry might relocate to the USA to benefit from these provisions, is willing to respond to this protectionist approach by extending the temporary framework for state aid rules, and increasing subsidies for the green industry, as suggested by Ursula Von Der Leyen at the World Economic Forum in January 2023.

These events have newly triggered the debate over the first-best policy to approach the EU green industrial policy. The European Union has mostly focused on a strong top-down industrial policy [1] based on public intervention to boost clean tech, although preserving an emission trading system that is based on the polluters pay principle. This approach lies on the idea of the entrepreneurial state, which calls for governments' intervention in the economy to solve great societal challenges when spontaneous market-based solutions fail to emerge.

Indeed, being climate change a global negative externality, the social cost of pollution is not incorporated in the market price of individual activities and products. Hence, the free market does not produce the socially optimal quantity of polluting products. While it is commonly agreed that policy intervention is required to address such a complex global externality and reach a socially optimal equilibrium, what measures should be taken remains upon to debate and it may differ across countries too.

Some observes, for instance, fear that the current European Union's response to the Inflation Reduction Act in the US is too much focused on easing state aid rules and increasing subsidies to the EU industry to improve global competitiveness and investments in clean technology. According to this niche of literature, this strategy would impose a cost on society that is too high with respect to a green transition that is based on a market-based approach and the polluters pay principle. Public authorities often lack the ability to identify technologies, sectors, or firms that should be subsidised. This results in distorting incentives that can undermine maintaining a level playing field for business.

[1] Industrial policy can be defined as "government efforts to shape the economy by targeting specific industries, firms, or economic activities. This is achieved through a range of tools such as subsidies, tax incentives, infrastructure development, protective regulations, and research and development support" (Agarwal, 2023).

While facing the challenges posed by the US decisions is somehow necessary (short of convincing the US to remove the most protectionist traits of the policy), replicating the US interventions in the EU may be inefficient and risky.

This thesis investigates the economic theory behind both interventionist and market-oriented approaches to the EU transition towards a greener economy. The first chapter analyses the Inflation Reduction Act, a regulation that marks a historical shift in the US approach to climate policy. Given the amount of resources provided in the regulation, its climate and fiscal impact will be investigated. The second part of the chapter will then concentrate on the IRA's potential impact on trade and on the EU economy. Specifically, the impact on the Chinese-dominated clean technology supply chains and the Electric Vehicle industry in the EU will be dealt with greater attention.

The second chapter will shed light on the status of State aid policy in the European Union, with a focus on measures dealing with the deployment of clean energy sources and technologies, such as energy subsidies and other policy instruments to support the decarbonisation of the economy.

The third chapter will present the economic theory behind the debate over the role of the state in the economy. Three main schools of thought will be analysed: on the one hand, proponents of the Entrepreneurial State support a stronger role of the state in the economy, especially in the green transition. On the other hand, other scholars favour a market-based approach to address societal challenges. A third school of thought can be identified in those who try to bridge the two contrasting views by proposing a solid collaboration between the private and the public sectors.

In the fourth chapter, it will be argued that a market-based approach of the state is more economically efficient in addressing the green transition. The EU is implementing inconsistent and costly policy instruments in climate policy. Hence, the literature presented in this chapter will show that a cost-effective climate policy should shift away from energy subsidies and focus on applying the polluters pay principle, which requires the state's effort to implement a carbon price, be it with a carbon tax or an emission trading scheme, that reflect at best the negative externality that carbon emissions impose on society. Being CO_2 emissions a global externality, the EU should pursue a foreign policy that strengthens its relationship with allies such as the US, which the IRA and the EU response might jeopardize, as well as acknowledging the need to get as many countries as possible on board with climate policy. This might suggest the creation of a climate club that through trade sanctions can incentivise countries to comply with emissions-reduction policies.

FIRST CHAPTER

The Inflation Reduction Act and its implications for the EU economy

The Inflation Reduction Act (IRA) is the biggest climate mitigation policy that has ever been approved in the United States. Consistent with the US administration's goal of becoming a net zero economy by 2050, it provides around $392 billion in tax credits and direct expenditures over the period 2022-2031 for producers and consumers who invest in clean technology. US President Joe Biden has presented the regulation as an opportunity for the US to lead the global clean energy economy, as well as create jobs for Americans and address the impact of pollution on disadvantaged communities (The White House, 2023). After years of pressure on Congress from interest groups that have opposed restricting an intensive carbon economy, the IRA has been finally signed into law. By accommodating interest groups to get the necessary votes in Congress, the measure comes with significant government intervention to protect local firms from competition.

In what follows we shall introduce in greater detail two main groups of measures, that is tax credits and direct expenditures provided for in the IRA. As the overall orientation of the Act can be understood only by analysing its specific features, entering the details of the provisions will prove necessary to explore its potential impact.

1.1. Tax credits

About two-thirds of the funds ($271 billion) provided by the Inflation Reduction Act are in the form of tax credits. A tax credit is a provision that reduces a taxpayer's final tax bill. As tax credits in the US can be exchanged among individuals and institutions, the taxpayer's expected tax bill does not represent a limit to the actual support the provision can offer.

This section aims to analyse the content of the 7 climate-related categories of tax credits in the IRA.

Clean Energy Production and Investment Tax Credits: The IRA modifies and extends the Production Tax Credits (PTC) and Investment Tax Credits (ITC) for renewable energy through 2023 and 2024 by allocating around $131 billion. The PTC is awarded per megawatt-hour of electricity output from low-emitting energy sources, whereas the ITC is based on a percentage of the investment cost. To receive the tax credits, certain requirements regarding wage, apprenticeship, local content requirements and location in an energy community need to be met. For instance, the tax credit is 5 times higher ($27.5/MWh) if the project meets specific labour requirements and an award of a 10% increase for both tax credits is given if the products used are domestically produced. Firms and facilities can choose to receive the ITC or the PTC depending on their eligibility to the requirements and depending on the most valuable option.

Production Tax Credit for Carbon Capture and Sequestration: The IRA aims at making carbon capture a viable economic option for industries. The Congressional Budget Office (CBO) estimates to allocate $3 billion on this project by 2031. Industries that capture carbon dioxide and meet certain labour requirements can get $85/ton for stored CO_2 or $60 for CO_2 utilisation. Direct air capture plants specifically built to capture carbon will receive $180 per ton of captured and stored CO_2. Rather than taxing the emission of CO2, the US prefer incentives to dispose of it, thereby violating the idea that who pollutes has to pay.

Nuclear Power Production Tax Credit: a production tax credit of up to $15/MWh is accessible to nuclear power plants that satisfy specific labour and wage requirements. Further conditionalities of the amount of the credit depend on electricity revenues and if the plant has already received subsidies from other Federal or State programs.

Clean fuels: transportation and industrial fuels are also targeted by the IRA. It sets a credit value of 1$/gallon if labour requirements are met, which can be increased depending on the carbon emissions intensity. Furthermore, a new credit for clean hydrogen and a credit for sustainable aviation fuel of $1.75/gallon is implemented.

Clean Energy and Efficiency Incentives for Individuals: About $40 billion are destined for individuals who invest in equipment (heat pumps, solar energy, energy efficiency insulation, etc…) for clean energy and energy efficiency investments. The tax credit amount varies depending on energy savings, building type and household income. There are caps for single investments and total annual credits, but there are no caps on the total amount of credits (Bistline et al, 2023).

Clean Vehicles: The IRA sets a consumer tax credit of $7,500 for buying hydrogen or electric vehicles, under certain conditions. Half of the tax credit is available for vehicles having a battery meeting the critical minerals sourcing requirement. A minimum sourcing requirement is set for minerals extracted or processed in the United States or a country with a Free Trade Agreement with the United States. The other half of the credit is eligible for vehicles having battery components being manufactured or assembled in the US. The minimal local content requirement threshold is 50% in 2023, until reaching 100% in the period between 2029-2032 (Bown, 2023, p.11). A maximum household income is also set for receiving the credit. An additional $4000 tax credit is introduced for previously owned electric vehicles, with the requirement of being no older than 2 years old, an income requirement for the buyer, and a sale price below $25000.

Clean Energy Manufacturing: The IRA provides a 30% tax credit (with a 10$ billion cap) for the construction of clean energy manufacturing facilities.

1.1.2 Direct expenditures

In total, the Federal Government allocated around $121 billion for direct expenditures. They consist of funds directly transferable to a taxpayer. The specific details of the programs are yet to be defined; hence the descriptions below are, at most, indicative.

Agricultural & Forestry Conservation and Sequestration Project: $20 billion are destined for agricultural and forestry conservation programs that improve carbon storage or decrease greenhouse gas emissions.

Energy Loans: the most consistent direct expenditure consists of a $100 billion Energy and Infrastructure Reinvestment Program, which has the goal of replacing emissions-intensive energy infrastructure.

Energy Efficiency: The IRA provides $10 billion for energy efficiency programs, which aim to induce less energy consumption with the same output.

Industrial Decarbonization: $5 billion are allocated for projects to reduce emissions in the industrial sector, which is highly emission-intensive.

Other: other funds involve a "Green Bank", which allocates $27 billion for clean energy projects that benefit low-income and disadvantaged communities. The rest of the funding involves a Methane Emissions Reduction Program, which establishes a tax on methane emissions (Bistline et al., 2023).

1.2 The climate impact and the federal cost of the IRA

Before evaluating the possible economic impact of the IRA on global trade and the European Union, it is worth considering how the U.S. economy can be affected by the provision.

Overall, most of the literature (Kleimann et al., 2023, Bistline et al., 2023 Jenkins et al., 2022, Cole et al., 2023) agrees with the fact that the IRA will help significantly lower greenhouse gas emissions in the U.S. by reducing the costs of investment in clean energy projects. However, some scholars (e.g., Bistline et al. 2023, Bown 2023) fear that putting too much emphasis on a subsidy approach, rather than focusing on taxing carbon, might have broad negative macroeconomic implications. Specifically, the fiscal capacity of the state and the trade sector might be particularly affected, given the high burden on taxpayers' finances to fund the IRA and the significant protectionist approach of the measure, as it will be made clear in section 1.3.

This section resumes some of the estimations made by various scholars on the climate impact and fiscal costs of the IRA.

1.2.1 The climate impact

Princeton University's REPEAT project report "The Climate and Energy Impact of the Inflation Reduction Act" (2022) estimated the impact on CO_2 emissions reduction of the IRA by comparing it with three main scenarios: i) Frozen Policies scenario, which considers the impact of federal and state policies at the beginning of Biden's administration in January 2021, ii) a Net-Zero Pathway scenario, which is a pathway in which US greenhouse gas emissions are 50% below 2005 levels by 2030 and net-zero by 2050, and iii) Current Policies scenario, which includes the Bipartisan Infrastructure Law, a bill signed into law in November 2021 which contains some provisions for CO_2 abatement in the transportation sector (Jenkins et al, 2022).

To get a perspective of the tons of CO_2 emissions in the US, 2005 levels were at 6.6 billion tons, and 2021 levels at 5.6 billion. The report estimates that with the Current Policies pathway, a level of 4.8 billion tons in 2030 would be reached (that entails a reduction of 27% below the level in 2005). With the IRA, the projection is at 3,8 billion tons in 2030, 42% below the 2005 levels, a figure that would close two-thirds of the gap between current policy and the 50% below 2005 target for 2030. Specifically, the deployment of clean electricity and electric vehicles would reduce emissions in

2030 by 360 million metric tons (Mt CO_2) and 280 Mt CO_2 respectively. Carbon capture projects would contribute to 130 Mt CO_2 reduction. The other provisions contained in the IRA would contribute to reducing emissions by 210 Mt CO_2 collectively. These figures however do not include the dynamic effect of the additional GHG emission reductions coming from the easier framework for climate ambitions set by the IRA, which could enhance further regulation in CO_2 abatement.

Regarding energy expenditures, the report estimates that the IRA would lower expenditures by 4% in 2030 and by 8% in 2035. However, this model does not consider the lowered price for oil and gas driven by lower investment and consumption in these resources. The Report estimates that oil prices could decrease by 5% and natural gas by 10-20% between 2030-2035, *ceteris paribus*.
Solar and wind annual capacity would reach an average of 39 GW/year in 2025-2026 (two times the 2020 level) and 49 GW/year (five times the 2020 level) respectively. However, the report makes no reference to the ability for the US to produce the sufficient infrastructure for solar energy, given that the US is highly dependent on solar panel imports: in 2020, 89% of U.S. solar PV module shipments were imported from foreign countries (EIA, 2021). At the beginning of 2023, the Biden Administration lifted a tariff fee on PV imports from Southeast Asia alleged to be circumventing decade-old tariffs on China, assembling and reshipping Chinese-made components to the US (S&P Global, 2023). The rationale behind the tariff's lift is that a months-long investigation of the Commerce Department on the alleged wrongdoings (a final Determination on August 18, 2023, declared that solar cells and modules were circumventing antidumping and countervailing duties on China) froze imports of PV from Southeast Asia, blocked projects in the US and could have triggered costly retroactive tariffs for US firms (Reuters, 2022a). Thanks to Biden's duty suspension, tariff fees will not be collected before June 2024, alleviating concerns for many importing companies. (White & Case, 2023a). This has resulted in higher imports primarily from Vietnam, which alone accounted for 30.4% of shipments to the US, followed by Thailand, Malaysia and Cambodia. In the period between 2011 and 2020 exports of raw materials and solar panel parts from China to the four named countries also surged (VOA News, 2022). Since one of the goals of the IRA (as later explained in section 1.3.1) is to break China's dominance in critical supply chains for the green transition, the US Administration should be aware of tariff circumvention on imports. As the example of solar modules shows, China can increase trade flows towards countries that are exporting such Chinese products to the US, thus circumventing US' duties on imports. Hence, trade flows between China and the US can be lowered, but Chinese dominance in the supply chain might not be hindered due to trade deflection towards third countries having preferential tariffs with the US.

For carbon capture, the model estimates that CO_2 captured for transport and geologic storage would reach 200 million tons per year by 2030.

Bistline et al (2023, p.19) estimated the emissions impact and the abatement costs of carbon of the IRA using US-REGEN, which is a model developed by the Electric Power Research Institute. It combines a model for the US electric sector together with a dynamic model of the US economy. This helps researchers to analyse the impacts of environmental and energy policies considering both the electric and non-electric sectors. According to the model, compared to 2005 levels, a 35% of CO_2 emissions reduction will be achieved in the whole economy by 2030, and 41% in 2050, compared to a reference scenario without IRA of 29% and 33% respectively. These estimates are more pessimistic about the emissions reduction path than those offered by the researchers at Princeton University. Moreover, the electric sector will decrease its emission only by 64% by 2030, compared to 54% without the IRA. The model estimated that to achieve the target of reducing carbon emissions by 40% by, as stated in the initial announcement of the IRA, the fiscal costs would be far higher than the CBO initially estimated. As far as CO_2 abatement costs (which is the cost of an intervention that will reduce GHG emissions by one metric tonne) are concerned, IRA tax credits would set an average abatement cost of $83 per metric ton for the power sector. Average estimates of the social cost of carbon are between $120 and 400$ per metric ton in 2030. This would make the abatement cost of IRA considerably lower than the estimated abatement cost for CO_2 for 2030 without the new measures.

Cole et al. (2023) conducted research on the impact of the Infrastructure Investment and Jobs Act (IIJA) and the IRA on Electric Vehicle (EV) sales, carbon emissions, and government expenditures. They estimated that the IRA's EVs emissions reduction impact will be -54 million Mt CO_2 by 2030, with an $80 abatement cost per ton of CO_2 avoided, considerably lower than current estimates (about $190). This estimate is in line with most of the literature, which agrees on the overall cost per ton being considerably lower than current and future estimates without IRA.

Such targets would be achieved through massive investments in clean technology spurred by the new regulatory environment. Goldman Sachs (2023) calculated that the IRA could encourage $11 trillion in infrastructure investments by 2050, and $2.9 trillion by 2032, with an average of $290 billion annually. Up to 2050, $6.6 trillion will be invested in the renewable power sector. The generation capacity of renewable energies will represent 44% of total capacity by 2030, and 80% by

2050. Forecasts show that $400 billion (corresponding to 1.3% of GDP) per year will be invested in decarbonization up to 2050.

The authors of these models underlined that their calculations are subject to considerable uncertainty in the future, as investments and markets will be affected by many other factors that are difficult to foresee and quantify at present. Among these external factors, one has to consider internal and external forces, such as forthcoming policy and regulatory changes, future technological changes, and consumers and producers' reaction to the provisions contained in the IRA. Most significantly, there are big uncertainties regarding the impact of the IRA on electricity markets' prices. Since the IRA can lower wholesale prices by providing tax credits (hence lower costs for electricity operators), producers can be incentivised to produce electricity even when its price is low or negative so to receive the tax credits (Bistline et al, 2023). This process may upset the signalling function of prices in the market for producers and consumers of energy, as well as impair the ability to balance resources for energy transmission and storage.

1.2.2 Fiscal costs

Overall, the IRA will most likely significantly reduce the CO_2 emissions of the US economy. However, this will come at a cost. The Congressional Budget Office (CBO) estimate of a total of circa $400 billion on the fiscal costs of the IRA climate and energy-related measures has not convinced most of the literature that has tried to project such costs. Independent measures range from 3 times to roughly 27 times of the fiscal costs the CBO has estimated, depending on the provision.

Table 1 below tries to summarise the main findings of the literature on the present and future projected public costs of the IRA:

Projections of IRA-related fiscal spending	
Credit Suisse (2022)	• Over $800 billion in total baseline federal spending, double the $392 billion estimated by the CBO • Total spending: over $1.7 trillion in the next ten years • Federal spending 3 times the costs estimated by the CBO for PTC, ITC, carbon capture, clean hydrogen, renewable and battery manufacturing • Advanced Manufacturing Provision (≈$30 billion estimated by the CBO) could reach $250 billion by 2030 • Credit 45Q for carbon capture and storage provision: CBO estimates a total of $3.2 billion and $340 million in 2030. Credit Suisse: total provision cost of $52 billion in the next ten years
Bistline et al (2023)	• Total budgetary effect of IRA: $900 billion through 2031, and $1.2 trillion by 2040 • Credit 45Q for carbon capture and storage provision: $100 billion through 2031 • Electric sector tax credits: $780 billion by 2040 and $460 billion between the period 2031-2040, against the $161 billion for the first 10 years estimated by the CBO • Clean vehicles tax credits: $390 billion by 2030, more than 27x the CBO estimate, which is $14 billion.
Cole et al (2022)	• Electric vehicles provision: $382 billion by 2031, against the $36 billion estimated by the CBO • Considering only rebates for electric vehicles ($3750 for a new purchase and $4000 for a used EV): $332 billion • Considering the 30% subsidy for charging stations: $4 billion
McDaniel (2023)	• Advanced Manufacturing Production Credit: 3 estimates based on the amount of credit (which depends on the amount of energy the US battery plants produce) for the period 2023-2032: 1) High estimate on US share of battery plant capacity: $196.5 billion 2) Medium estimate on US share of battery plant capacity: $152.8 billion 3) Low estimate on US share of battery plant capacity: $43.7 billion • All the estimated costs are substantially above the CBO estimate of $30.6 billion for the first ten years

Table 1. Projections of IRA-related fiscal spending (own analysis)

These cost estimates are mainly speculative due to the high level of uncertainty discussed before. About two-thirds of credits and incentives are uncapped, which means that potentially there are no limits to the resources being destined for recipients.[2] This implies that the federal spending for the IRA will be highly dependent on demand and units of production for clean technology and on how the EV market will react to the subsidy regime introduced. For specific provisions, such as the Advanced Manufacturing Production Credit, there will be tax rebates and direct payments (McDaniel, 2023). This would imply that incentives would not be targeted and firms not paying taxes could receive money, possibly rising substantially the fiscal costs and favouring businesses that are not contributing to public revenues.

The estimated fiscal costs of this approach vary greatly. From the literature, it emerges that the Congressional Budget Office has significantly underestimated the costs of certain provisions as the uncapped credits could encourage businesses to produce more, particularly in green manufacturing, carbon capture and clean hydrogen. Since production credits lower wholesale electricity prices, plants can have strong incentives to produce renewable energy even when the prices are low or negative, to still receive the credits (Bistline et al, 2023, p.28). This distortive effect can waste additional energy when it is not needed, and most importantly alter price signals for demand and supply.

What is evident in the IRA is that the United States has changed course in climate policy by significantly relying on the concept of the entrepreneurial state, which becomes the main actor in fostering innovation by choosing winners, fixing market imperfections, and protecting US businesses from competition with discriminatory subsidies. It is a climate policy that will lower energy prices, but will require significant government expenditures, which most likely mean rising taxes for citizens (or reducing other public services).

Lower costs for the US-based industry will also have substantial consequences at the global level. The European Union has explicated its concerns about the distortive effects of the IRA and announced appropriate actions to outweigh such effects. The next section analyses the implications for trade of the IRA and its impact on the European Union's economy.

[2] It should be however kept in mind that US fiscal policy is subject to a debt ceiling rule, which can potentially interfere with the uncapped nature of the IRA.

1.3 IRA's impact on trade and the EU economy

The IRA can affect global trade and the EU economy for two main reasons.

First, with local content requirements for EVs batteries, the US is trying to relocate the global supply chain for EVs inputs outside of China. The US already started a trade war against China in 2018 that accounted for a total of $450 billion worth of trade in goods, covering 2/3 of imports from China. With the IRA, the US intends to continue this approach, but to target specific sectors and products, such as critical raw materials which are fundamental components for EVs batteries. By subsidizing domestic battery production through the IRA, the Biden Administration hopes to break the Chinese supply chain dominance in the sector and protect at-risk jobs due to the transition from the Internal Combustion Engine (ICE) industry to the EVs industry, which requires assistance to displaced workers that will be negatively affected by the green transition. China has strongly subsidized its domestic EV industry by discriminating against foreign competitors, contributing to making it the world's largest EV market (The Wall Street Journal, 2017). The US government has decided to confront such a system of subsidies set up by China with a protectionist approach to avoid a specific EV industry China Shock, which could significantly harm the US automobile industry (Bown, 2023).

The EU is following the US lead on critical raw materials and presented the Critical Minerals Act, which aims at reducing the EU's dependency on Chinese imports of critical minerals. Specifically, the EU Commission proposed a plan to mitigate the risk of over-dependency on third-country suppliers. The goal is to avoid risks of supply chain disruptions that have hit the EU during the Covid-19 pandemic and the Russian aggression of Ukraine. Among other benchmarks for domestic capacities in extraction, processing and recycling along the strategic raw materials supply chain, the Commission sets the goal of not more than 65% of the Union's annual consumption of each strategic raw material at any relevant stage of processing from a single third country. The proposal also provides for monitoring requirements for certain large companies and their critical raw minerals supply chains, as well as the implementation of national measures for circularity requirements for critical raw materials. As far as international engagement is concerned, the Commission proposes to strengthen the EU's global engagement with reliable partners, especially with emerging markets and developing economies. Finally, the Commission suggests establishing a Critical Raw Materials Club to strengthen global supply chains and the WTO (European Commission, 2023a).

So far, no trade agreement has been signed between the EU and the US on critical raw materials and the related local content requirements. This means that although the competition is allegedly with China, the US and the UE end up competing one against the other in an attempt at promoting their economic resilience and reducing interdependence-related risks.

Second, the IRA undermines the global trading system and risks triggering a change in the EU approach towards the green transition. US trade partners will likely see their international competitiveness harmed by the green subsidy schemes of the IRA. This will likely trigger retaliatory measures such as tariffs and discriminatory subsidies to protect domestic businesses, leading to a potential escalation. The EU will be particularly affected by these measures as it has tried over the years to become the leading economy in addressing the green transition by relying on taxing carbon, phasing out free allowances in the Emissions Trading Scheme and setting up a carbon border adjustment mechanism that put a price on imported goods that are produced outside of the EU with looser carbon climate policies. This approach is based on pricing carbon without harming competitiveness and a level playing field for firms. However, the subsidy approach of the IRA makes US energy cheaper and potentially harm the EU competitiveness. If the EU decides to protect its industry by responding with a protectionist approach based on subsidies and loosened state aid rules for companies, it could shift away from the market-based approach of carbon pricing, possibly threatening also the level playing field for firms in the Single Market (as will be seen in Chapter 4). Moreover, if the EU let the Member States adopt national subsidy schemes, states with higher fiscal capacity will benefit from others that lack fiscal space to fund such programmes. This would end up in the Member States discriminating one against the other (Bown, 2023).

1.3.1 Clean-energy supply chains and China's dominance

At the centre of the transition away from a carbon-intensive economy lie concerns about the fragility of the supply chains due to the dominance of China in both critical minerals and EVs production. The Covid-19 pandemic and the Russian aggression of Ukraine have exposed the vulnerability of global value chains to the risks of idiosyncratic and purposeful disruptions in the provision of certain strategic inputs. Moreover, as certain minerals (e.g., rare earths) are fundamental inputs for battery production and other clean high-tech technologies, import dependency from China has alerted Western governments. In addition, the 2015 "Made in China 2025" policy has made electric vehicles exports booming thanks to import tariffs to protect local firms from foreign competitors. Betting on the existence of long-lasting competitive advantages of the leaders in this industry, US authorities decided to intervene to provide incentives to enhance domestic production. As of February 2023, the value of EV exports by China has reached ≈$23 billion, against about $6 billion for the US and $26 billion for the EU, which leads the value of exports of EVs at the global level. However, by focusing on low-priced EVs China leads the total volume of exports, which exceeded 1 million vehicles in February 2023, against 600.000 for the EU and 100.000 for the US (Bown, 2023, p.8). These figures show that the US plays a minor actor in the export of EVs on the global stage.

The weaponization of gas provisions has been implemented by the Russian Federation against the European Union after the invasion of Ukraine, and this has intensified concerns about the vulnerability of various supply chains. An additional concern regards multinational companies, in particular the Chinese firms that are controlled by the State: concentrating imports from China can lead both to excessive market power exerted by foreign companies and also to the kind of geopolitical risks discussed before. To break Chinese dominance, the IRA aims to reduce national security vulnerabilities coming from China's influence in critical minerals supply chains.

Given the difficulty to assess the actors that have ultimate control over critical minerals production, which is often different from the location of producing firms, Leruth et al. (2022) developed an approach to measure the level of control of shareholders. They use the concept of Sources of Control (SOC) to assess what subject(s) has the last say over a company. According to the authors, this model would help policymakers in assessing the risks of reliance on foreign suppliers, which often lack transparency in declaring who controls them, especially if they are SOE (state-owned enterprises). In what follows, we will use the data on SOC to discuss, product-by-product, the issues with critical minerals supply chain introduced in more general terms above. As it will be clear soon, China dominates the market all along the global supply chain.

The focus of the following data is on the location of production (the first country in which the value chain starts), the share in global reserves of the mineral, the top companies producing the mineral and their share of global production. Finally, by examining the SOC (sources of control) the attention is concentrated on who controls the company in practice.

For cobalt, Chinese SOCs control about 24% of the active market and China, together with the Glasenberg family from South Africa, are the largest players. The US and the EU have basically no presence in cobalt production.

In the copper market, China is third (8.4%) behind Chile (27.8%) and Perú (10.4%) as the top producing country (the US is in fifth position with 5.8%). Copper production is more dispersed across the globe, hence there is a lower level of concentration in a few firms. Nevertheless, China controls the largest share of copper production with 11.2% (SOCs), because it controls most mining firms also abroad.

Regarding lithium, China is the third-producing country in the world with 12.6% of total production. However, China's SOCs manage 33.1% of the total market share and 50% of the production of the largest firms. The US has about 15% of the total market share, but it operates mostly through passive funds and the government has no control whatsoever.

In both nickel production and reserves, China is not at the top. The top producing countries are Indonesia (with 39.4% of global production and 22.1 of global reserves), the Philippines (12.5% and 5.1%) and Russia (8.9% and 7.9%). China holds 3.9% of global production and 2.9% of global reserves. Even though China appears to score low, Chinese company Jinchuan Group is the world's third largest producer of nickel. Both the US and the EU have no relevant presence in nickel production.

The main source of concern for the US is China's dominance in rare earth elements (REE) production and reserves. In 2020, China held 44,000 metric tons of REEs, doubling the 22,000 metric tons of Vietnam in the second spot, while the US settles at 1,800 metric tons. The world's top two producers are China Northern Rare Earth Group and China Southern Rare Earth Group, which totally account for 61.6% of global output. Mountain Pass, a US-based company, contributes to 15% of global output (Leruth et al, 2022).

From these figures, it emerges clearly that in critical minerals reserves and production, the US and the EU are in a weak strategic position against China. In the IRA, the subsidies and sourcing requirements for EVs are aimed at limiting Chinese dominance in the sector. The goal is to incentivise the transition away from Chinese market power in the critical minerals global supply chain. The US plans to diversify inputs for batteries to break overdependence on one single, and potentially dangerous, country. As National Security Advisor Jack Sullivan has underlined "We'll keep investing in our own capacities and in secure, resilient supply chains (...) we are leveraging the Inflation Reduction Act to build a clean-energy manufacturing ecosystem rooted in supply chains here in North America, and extending to Europe, Japan, and elsewhere" (The White House, 2023b).

1.3.2 The IRA and the implications for the EU economy

In designing the IRA, the US Administration planned to invest in clean technology as well as protect jobs during the green transition and shift away from Chinese domination of critical minerals supply chains and EVs exports. However, in doing so it did not consider (or it ignored) the spillover effects that subsidies and local content requirements can have on close trade partners, such as the European Union. Attracted by the subsidy regime and lower energy costs, EU-based car producers may be incentivised to relocate to the US, making the EU industry lose large exports and competitive firms.

The first sign of such a process is Tesla announcing that it would relocate a production site in the US after having planned to build it in Germany. The car company motivated the choice by referring to the tax breaks provided by the IRA (Euractiv, 2023).

The main concern for the EU is Section 30D, which refers to the EV consumer tax credit for consumer vehicles. The credit is available for EVs that are assembled in the US, while half of the credit ($3,750) is available for vehicles with batteries that are recycled in the US or critical minerals extracted or processed in the US or a country having a Free Trade Agreement with the US. The problem for the EU is that it does not have an FTA on EVs with the US. A breakthrough in the legislation, however, has been announced by the Biden Administration in December 2022, that can also mildly modify the implications of the Act through implementing and delegated acts. For instance, leased vehicles under 6,350 kg (≈14,000 pounds) were exempted from local content requirements, income and price caps and can qualify for Section 45W (consumer tax credit for commercial vehicles). This could positively affect the impact of the IRA on the EU car industry, especially for luxury brands whose exports into the US would suddenly be available for the tax break (Bown, 2023). The impact of such measures is however difficult to predict, and it will depend on consumers' demand of leased vehicles. If consumers decide not to lease, constraints of section 30D would still apply to the European car industry.

Openness to find solutions to problems of the IRA has been showed by the US. When the EU lamented the IRA, the Biden Administration agreed to establish a task force on the matter with the European Commission (Bown, 2023). It also placed the IRA on the agenda of the US-EU Trade and Technology Meetings, a forum used to discuss transatlantic trade which has so far focused on new technologies, human rights and trade. The IRA has not yet been discussed in the meetings, with the next one being scheduled at the end of 2023 (European Commission, 2023c). Biden has further assured flexibility in the application of IRA provisions, which is however unlikely given that Republicans won the majority at the House of Representatives and would block any reforms. The chances of amends to the IRA are further undermined with the upcoming 2024 US elections, which can result in a change in the Administration and a return of the Republicans. In the last few years, they have been even more protectionist in trade policy, and this can potentially reflect on the future implementation of the IRA.

Further questions remain unanswered regarding the IRA, various trading partners and the development of a EVs supply chain of inputs outside of China. Western governments should pursue a dialogue to address the overdependence on China's inputs for batteries, something on which the EU appears to lag behind, as it falls short of mining and critical minerals production, and it imports 100% of its REE supply from China (European Commission, 2023b). To diversify its imports, discriminatory measures would be needed against Chinese producers, such as tariffs, subsidies or strict environmental, social and governance (ESG) standards that China cannot meet, as well as further investments in mining and diversification of supply from other countries at higher costs (Bown, 2023, p.29). This path appears to be started with the Critical Minerals Act, but the real implementation of the proposals is yet to be discussed and approved at the EU level. Clearly, the EU faces a trade-off between promoting the rule-based multilateral system and adopting restrictions aimed at strategically discriminating across suppliers.

Indeed, not only the European Union is facing a competitiveness struggle on EVs, but the IRA is undermining the already fragile multilateral trading system. The IMF, OECD, World Bank and WTO (2022) have found that at the international level in the period 2009-2021, subsidies were the most frequent form of intervention by governments: 45% of all types of measures. In the period 2007-2019, countervailing duty investigations into alleged subsidy programs increased sharply, from 11 in 2007 to a peak of 47 in 2018. It is worth noting that most of the subsidy programs are in the largest trading economies of China, the EU, and the US. Being subsidies widespread, growing and poorly targeted, they tend to lead to unilateral trade defence measures which distort even more trade and investment and disrupt other economies too. The IMF, OECD, World Bank and WTO (2022) suggest governments to cooperate more on subsidies by clarifying and strengthening disciplines to bring greater transparency, openness and predictability to global trade. As far as the environmental challenge is concerned, climate change requires further cooperation to understand the impact of subsidies across all sectors.

The IRA fits well in this trend of growing subsidy regimes that can hinder the multilateral trading system. The IRA does so for two main reasons.
First, with the IRA, the Biden Administration has continued Trump's administration's policy of trade distortionary measures that are inconsistent with WTO rules. Some voices in the EU (Reuters, 2022b) have called for a WTO dispute targeting local content requirements. On the one hand, this would reaffirm the EU's commitment to stick to the WTO rules-based system (Kleimann et al, 2023) and send the message that the international rules for global trade are still relevant. On the other hand, WTO dispute settlement is highly dysfunctional (Bown, 2023) and would risk fragmenting the unity that Western governments should pursue in times of polarisation against authoritarian states such as China and Russia. Hence, it would be politically costly to follow this path.

Second, in approaching the net zero transition by relying on strong incentives from the state, the US Administration is making the EU doubt its climate policy. With reduced industrial competitiveness, the EU may respond by subsidizing its industry and retaliating against US subsidies. Excessive US exports may motivate the EU to impose tariffs and subsidize its own industry to boost competitiveness. This would start a spiral of retaliatory measures that can hinder the global green transition at a moment in which trade on critical minerals and a cooperative approach are necessary. So far, the EU green industrial policy has been characterized by a more efficient policy to address climate change, which is taxing carbon. To offset the IRA, the EU risks switching towards a less efficient protectionist approach by extending the temporary framework for state aid rules and increasing subsidies, as reported at the Global Economic Forum 2023 by European Commission President Ursula Von der Leyen. This strategy not only undermines the multilateral trading system, but it imposes higher costs on society that can be avoided by adopting a market-based approach, as will be further discussed in Chapter 4.

SECOND CHAPTER

State aid rules and subsidy regimes in the EU green industrial policy

After having analysed the content and motives of the Inflation Reduction Act and its implication for the EU economy, this chapter will shed light on state aid measures, energy subsidies and other public support programmes in the EU. First, this chapter will briefly analyse the EU historical approach towards state aid. Second, it will present the Temporary Crisis and Transition State aid Framework (TCTF) and the Net-Zero Industrial Act, measures that loosen state aid rules and provide higher public support for green technology, which mark an historical change in the EU approach to subsidy regime and approach in its green industrial policy. Third, it will provide quantitative data on the amount of expenditure for state aid measures during the decade 2011-2021. Fourth, this chapter will concentrate on the rationale behind energy subsidies and will present the overall trend in energy subsidies from 2015 to 2021 in the EU. Finally, it will provide an overview of the literature that has compared the EU and the IRA green subsidies.

This chapter serves as a starting point for Chapter 3 and Chapter 4. The former will investigate the economic theory behind two contrasting approaches towards a green industrial policy: the concept of the entrepreneurial state against the market-based approach. Chapter 4 will then critically analyse the trajectory the EU is taking in loosening state aid rules and what this implies for the integrity of the Single Market. Understanding EU policies and the quantity of aid disbursed for energy, transport, electric vehicles, and clean technology more in general is essential to delve deeper into the economic theory at the heart of the EU green transition.

2.1 EU State aid policy

Since its creation with the Treaty of Rome in 1957, the European Union has always been concerned with securing a level playing field for business by setting rules that prevent national authorities from attributing an unfair advantage to some firms. Short-sighted governments tend to select specific sectors or firms and subsidize them so to keep them in the competitive market. State aid, usually referred to as subsidies, can take the form of grants, interest relief, tax relief, state guarantee or holding, or the provision by the state of goods and services in preferential terms (Baldwin and

Wyplosz, 2021, p.272). The European Commission defines state aid as “an advantage in any form whatsoever conferred on a selective basis to undertakings by national public authorities”. Since market integration increases competition among companies leading to bigger, fewer and more efficient firms, governments may protect domestic producers from competition through State aid. But If firms become accustomed to the state’s intervention, they will be disincentivised to innovate and become efficient, as well as making the taxpayers pay for the resources the State needs to keep them in the market. In a deeply integrated market like the European Union, Member States differ in the ability or willingness of subsidizing loss-making firms. This creates an unfair advantage for the subsidized firms because it makes restructuring more difficult for others that do not receive the subsidies (Baldwin and Wyplosz, 2021, p.268). This picture can be overly simplistic because the cost for workers switching jobs and unemployment due to the restructuring of the market are not considered. However, the welfare surplus stemming from more efficient companies due to long-term liberalization outweighs the cost of subsidizing inefficient firms that operate at a loss.

But in the European Union, unfair state aid regimes would be intolerable most importantly from a political perspective. Public support for European integration would have been likely opposed if countries were faced with unfair international competition after entering the Single Market. For this reason, the Treaty of Rome (officially named Treaty establishing the European Economic Community) laid the founding rules to avoid anti-competitive behaviour by firms and unfair state aid (Baldwin and Wyplosz, 2021). Specifically, Article 92 (1) states that “Save as otherwise provided in this Treaty, any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods shall, in so far as it affects trade between Member States, be incompatible with the common market” (Treaty establishing the European Economic Community, Article 92.1).

State aid measures adopted by Member States must be notified to the Commission, which is then responsible for overseeing the competition policy and can initiate investigations for alleged wrongdoings. This role was conferred upon already in the Treaty of Rome Article 93, which defines the supervisory role of the Commission in checking for the correct application of state aid rules within the common market: “1. The Commission shall, in co-operation with Member States, keep under constant review all systems of aid existing in those States. It shall propose to the latter any appropriate measures required by the progressive development or by the functioning of the common market. 2. If, after giving notice to the parties concerned to submit their comments, the Commission finds that aid granted by a State or through State resources is not compatible with the common market having regard to Article 92, or that such aid is being misused, it shall decide that the State concerned shall abolish or alter such aid within a period of time to be determined by the Commission (…)" (Treaty establishing the European Economic Community, Article 93.1 and 93.2). It is worth noting that by being present in the founding treaty of the European Union, the regulatory framework for state aid is one of the main pillars of the common market. It is a fundamental feature that has been always under strict surveillance by the Commission to avoid unfair advantages to some firms and ensure a level playing field.

It is worth noticing that the Commission can allow for some forms of state aid as long as the positive effects of the measures outweigh the negative impact of distorted competition. The second part of Article 93.2 in the Treaty of Rome allowed Member States to grant state aid if the decision is justified by exceptional measures (which is now defined in Article 108 in the Treaty on the Functioning of the European Union). Article 107.2 and 107.3 of the Treaty on the Functioning of the European Union define the circumstances in which State aid measures are allowed. As a rule of thumb, state aid is permitted if it has a horizontal approach (i.e., it targets all producers within a sector), is a cross-sector intervention, promotes growth and productivity (but does not give an unfair advantage to some firms) and facilitates restructuring through job protection. As a general trend, in the presence of an externality (which arises whenever an economic transaction impacts third parties without being reflected in the market price, such as CO2 emissions), the Commission's rationale is that government interventions are sometimes necessary to balance the economy. This has been the case first during the 2007-2008 global financial crisis and more recently during the Covid-19 pandemic and Russian invasion of Ukraine, which have been managed by the EU through the creation of temporary frameworks allowing governments for exceptional interventions in the market to support businesses during lockdowns and protect them from skyrocketing energy prices. But the EU is resorting to exceptional measures in other areas too. In 2023 the Commission approved a package of measures to keep up with the competition stemming from the subsidy regimes introduced by the IRA and expanded the possibility for Member States to provide state aid to support the green transition. For these reasons, exceptional temporary frameworks for loosened state aid appear to have become a new working pattern in the EU. Sections 2.1.1 and 2.1.2 will present the new exceptional measures undertaken by the EU Commission.

2.1.1 State aid for a net-zero economy

On 9 March 2023 the European Commission adopted the Temporary Crisis and Transition State aid Framework ("TCTF") that loosens state aid rules to prevent businesses from relocating to the US as a reaction to the IRA (whose effect on the EU economy have been discussed in Chapter 1, section 2.3.2) and to support the transition towards a green economy. As part of the Green Deal Industrial Plan, a renewed industrial policy to promote net-zero technologies, the TCTF has been presented to bolster the transition to a net-zero economy, accompanied by the Critical Raw Materials Act, the Net-Zero Industry Act, which provides goals and a regulatory framework for the green transition (discussed in section 2.1.2), and the amendment of the General Block Exemption Regulation (adopted on 23 June 2023), aimed at easing the grant of aid by lifting the requirement of prior notification to the Commission to companies that invest in renewable energy, decarbonisation of industrial production processes, and accelerate investments in strategic sectors for transition to the net-zero economy (White & Case, 2023b).

The TCTF prolongs the possibility for Member States to adopt support measures for the green transition until 31 December 2025. Specifically, the measure simplifies granting of aid to small projects by lifting certain safeguards, expands the possibility of support to all types of renewable energy sources, support the transition to hydrogen-derived fuels and provides for higher aid ceilings. The Framework introduces new measures to accelerate investments in key sectors for a net-zero economy by granting higher support for SMEs and companies in disadvantaged regions, as well as giving the possibility to Member States to provide higher percentage of the investment costs if the aid is provided via tax advantages, loans or guarantees. The most innovative provision of the measure is the “matching aid”, which is targeting the danger of relocation to the US for businesses attracted by the subsidy schemes contained in the IRA (and similar provisions in other extra-EU countries). It consists of the possibility for Member States to provide higher support for individual companies when there is a risk of their relocation away from Europe and it takes the form of the equivalent amount of support the beneficiary would receive elsewhere, or an amount needed to incentivise the company to locate in the EEA if it were outside. To be eligible under the matching aid option, the company must respect several safeguards : 1) investments must be in assisted areas, as defined in the applicable regional map or 2) investments must involve projects across at least three countries, with a significant part of the investment taking place in at least two assisted areas 3) production technologies must be environmentally-friendly and 4) the aid cannot trigger relocation investment between EU Member States (Kleimann et al, 2023).

The eligible investments under the TCTF are:

i. Production of batteries, solar panels, wind turbines, heat-pumps, electrolysers, and equipment for carbon capture usage and storage (CCUS);

ii. Production of key components designed and primarily used as direct input for the production of the equipment defined under (i);

iii. Production or recovery of related critical raw materials necessary for the production of the equipment and key components defined under (i) and (ii) (Communication from the Commission, Temporary Crisis and Transition Framework for State Aid measures to support the economy following the aggression against Ukraine by Russia, 2023).

The table below shows the maximum aid that member states can grant to individual companies in different regions under the new TCTF according to the Regional Aid Guidelines, which has been revised and entered into force on 1 January 2022 to enhance regional development taking into account the green ad digital transition (Guidelines on Regional State Aid, 2021).

Maximum aid limits:

			Location of the investment[1]		
			Non-assisted areas	*c-Regions*	*a-Regions*
		Max. aid amount per undertaking per MS	EUR 150 Million	EUR 200 Million	EUR 350 Million
Max. aid intensities[2]	*For direct grants*	Large enterprises	15%	20%	35%
		Medium sized enterprises[3]	25%	30%	45%
		Small enterprises[2]	35%	40%	55%
	For tax advantages, loans or guarantees	Large enterprises	20%	25%	40%
		Medium sized enterprises[2]	30%	35%	50%
		Small enterprises[2]	40%	45%	60%

Table 2. Support possibilities for schemes under section 2.8 (European Commission, 2023c)

2.1.2 The Net-Zero Industrial Act

The TCTF should be read together with the Net-Zero Industry Act (NZIA), presented on 16 March 2023, which provides a regulatory environment in which the new state aid measures can be applied across the EU. The Regulation sets the goal of at least 40% of EU annual deployment needs in strategic net-zero technologies: ensuring that, by 2030, the net-zero technologies manufacturing capacity in the Union approaches or reaches a benchmark of at least 40% of the Union's annual deployment needs for the corresponding technologies necessary to achieve the Union's 2030 climate and energy targets. The technologies listed to be strategic are the following: solar photovoltaic and solar thermal technologies, onshore and offshore renewable technologies, battery/storage technologies, heat pumps and geothermal energy technologies, electrolysers and fuel cells, sustainable biogas/biomethane technologies, Carbon Capture and Storage (CCS) technologies, and grid technologies. For CCS technologies, it sets a target of annual injection capacity in CO2 storage of 50 megatonnes (Mt) CO2 by 2030.

The NZIA outlines a new governance system for Member States through the Net-Zero Strategic Projects, which may be granted priority status and shorter timelines. To be selected, the projects must follow three criteria: be technologically ready, must contribute to decarbonisation and competitiveness, and must contribute to the resilience of the energy system. The NZIA then proposes a set of policy instruments to support the net-zero manufacturing projects by: 1) Easing administrative procedures and facilitation of permitting 2) Establishment of the Net-Zero Europe Platform aimed at fostering discussion and exchange of information between the Commission and EU Countries and stakeholders 3) facilitating access to public procurement procedures and auctions and 4) supporting innovation through regulatory sandboxes. To cope with the shortfall of skilled workforce in the EU, the Regulation outlines the creation of Net-Zero Academies aimed at training a skilled workforce to strengthen the manufacturing capacity. Each academy will focus on one net-zero industry technology and will aim to train 100.000 learners each within three years of establishment (Regulation on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem, Net Zero Industry Act, 2023).

2.2 Subsidies for the green transition

The EU policy for the green transition and its reaction to the IRA are guided by an interventionist approach, as the loosening of state aid guidelines in the TCTF and the abandoning of a technology-neutral approach in the NZIA jointly suggest. The rationale of the Green Deal Industrial Plan is to strongly support the deployment of net-zero technologies, while at the same time protecting the internal market from the international competitiveness of China and the US by giving the opportunity to Member States to subsidize the clean technology sector. To better understand the context in which the renewed EU green industrial policy will be implemented, thus, it is worth recollecting the State aid measures and subsidy regimes of the past few years. Hence, section 2.3.1

will outline the recent trend in the amount of state subsidies spent by Member States with an approximate time frame of 10 years, namely between 2011-2021. Section 2.3.2 will then focus on one of the main pillars of the EU green industrial policy, which is energy subsidies. Section 2.3.3 will then concentrate on comparing, from a quantitative point of view, the EU and IRA green subsidies.[3]

2.3.1 Overall trend of State aid expenditure, 2011-2021

This section is based on the State Aid Scoreboard 2022, a report published annually by the Commission on the state aid expenditure reports provided by Member States. The data contained in the report comprises expenditures made by Member States from 01.01.2011 to 31.12.2021.[4] The data on State aid expenditures are expressed in constant prices (i.e., adjusted for inflation) and are presented in the so-called aid element, which does not represent the nominal amount of aid, but the economic advantage passed on to the recipients. For grants, the advantage normally corresponds to the budgetary expenditure, while for loans and guarantees the advantage is the lower interest rate and reduced guarantee fees paid by the recipients (European Commission, 2023d).

The easing of State aid rules in the EU comes at a time in which the trend over the last few years has seen rising expenditures by governments to support most economic sectors hit by large EU-wide shocks. Specifically, the 2020 Covid-19 pandemic has prompted the EU to allow full flexibility in the application of State aid rules with the view to supporting the economy during the lockdown periods (Communication from the Commission, Temporary Framework for State aid measures to support the economy in the current COVID-19 outbreak, 2020). This action is reflected in the total amount of State aid expenditures spent by governments, as can be seen in Figure 1.

[3] This comparison will be mostly indicative given the lack of substantial literature and difficulty in gathering data

[4] The Commission points out that the accuracy of the data remains in the responsibility of the Member States, which sometimes have provided provisional figures or estimates rather than the actual values.

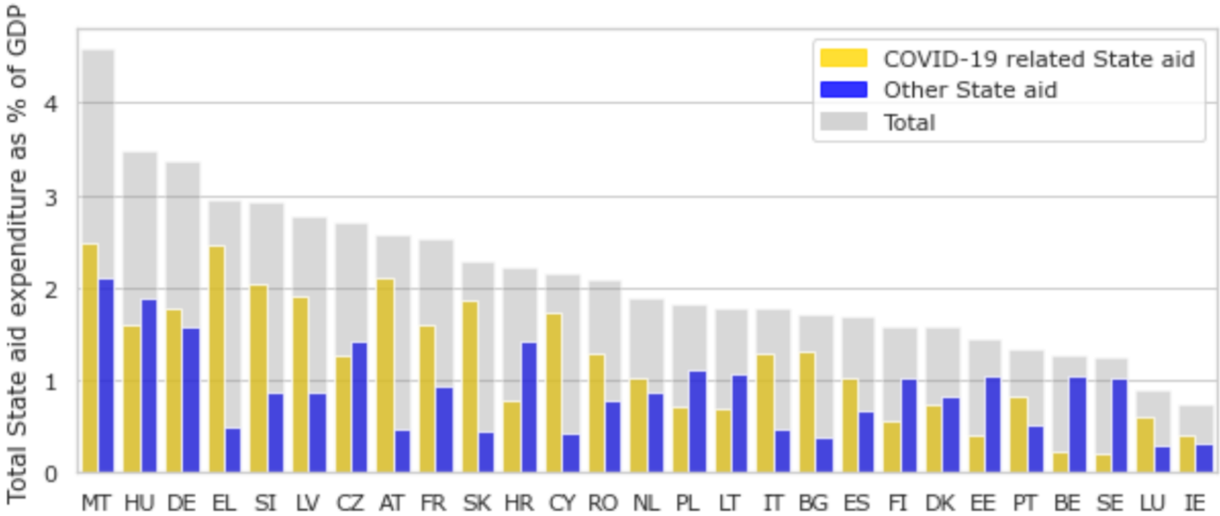

Figure 1. Total State Aid expenditure by Member States, as % of 2021 national GDP, breakdown between COVID-19 and other State aid measures (European Commission, 2023d)

In 2021, EU 27 Member States spent €334.54 billion, 2.3% of their GDP, on State aid. Total expenditures for COVID-19 measures amount to €190.65 billion, 57% of total spending and representing 1.3% of GDP. Figure 1 shows State aid expenditures for each Member State, expressed as a share of the country' GDP in 2021, divided between COVID-19 measures and other state aid measures.

The grey area in Figure 1 represents the overall total state aid expenditures as percentage of GDP. The countries that spent the most in 2021 are Malta (MT), Hungary (HU), and Germany (DE, which alone spent 121.21 billion, representing 36% of the total EU expenditures), which spent from 3.4 to 4.6 percent of their GDP on State aid measures. The countries spending the least are Sweden (SE), Luxembourg (LU) and Ireland (IE), which dedicated from 0.7 to 1.2 percent of their GDP on state aid. From the Figure it emerges a significant spending dispersion across Member States, both in the total amount of expenditures and in the COVID-19 related State aid measures. For the latter, represented with the yellow bar, Malta (MT) and Greece (EL) are the countries with the largest share of COVID-19 related measures (2.48% and 2.46% of their GDP, respectively). On the other hand, Belgium and Sweden (both approximately at 0.2%) have the lowest COVID-19-related spending.

Between 2011 and 2021, the EU experienced a growing trend in State aid expenditures. Even excluding the spike during the COVID-19 crisis in 2020 and 2021, in the period between 2011 and 2019, State aid expenditures in the EU doubled in size (from €77.3 billion in 2011 to €141 billion in 2021). The largest increase can be observed in Estonia (+319%), Lithuania (+260%), Slovakia (+229%), Germany (+206%), Malta (+160%), and Italy (+103%). Figure 2 shows this trend by representing the changes in total State aid expenditures (billions of Euros in constant prices) from 2011 to 2021 in each Member State.

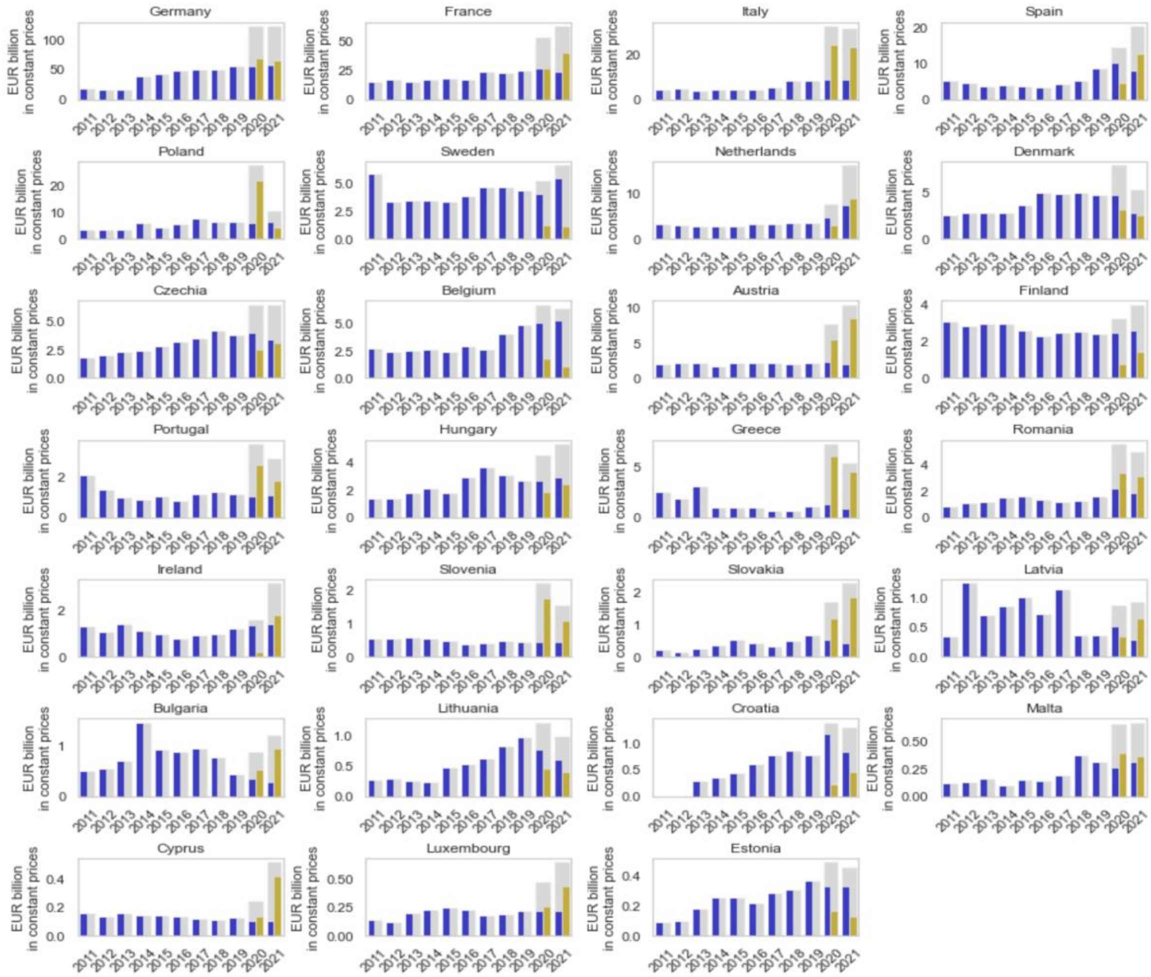

Figure 2. Evolution of State aid expenditures by Member States, 2011-2021 (European Commission, 2023d)

Figure 3 shows that a key factor contributing to the rise in State aid expenditure is the growing amount of aid allocated for environmental protection and energy savings. This includes aid in form of reductions in environmental taxes, investment aid for energy efficiency measures, renewable energy, environmental protection, energy efficiency promotion of electricity from renewable energy sources, and energy infrastructure. Particularly since 2014, when the first version of the General Block Exemption entered into force, Member States started spending considerable amounts of aid in activities that can be related to the green transition, mainly in renewable energy subsidies (section 2.3.2 will deal in detail with energy subsidies). Expenditures in this area decreased in 2021, mainly due to the need of redirecting some resources for COVID-19-related measures. In 2021, environmental protection and energy savings accounted for 21% of overall expenditure, while remedies for serious disturbance in the economy (COVID-19 measures) represented 57% of overall expenditure.

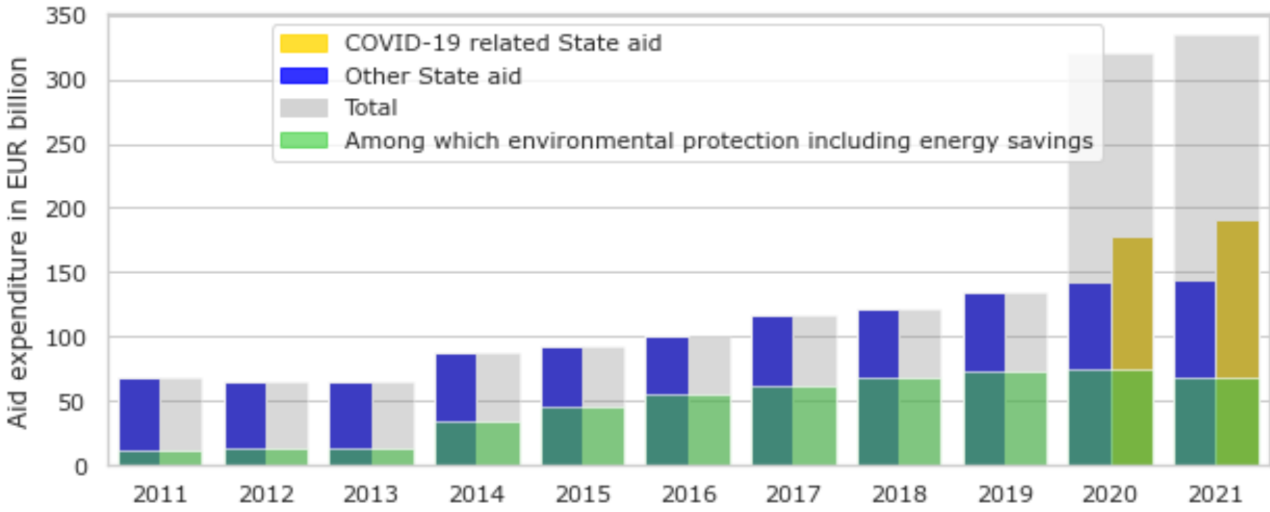

Figure 3. Evolution of State aid expenditure in the EU, 2011-2021, including environmental protection and energy subsidies (European Commission, 2023d)

Considering aid instrument used by Member States to support the economy, Figure 4 shows the share of total state aid expenditures by type of instrument as a percentage of the total. Direct grants and interest rates subsidies were the tools most used by Member States in the period 2011-2021 (up to 58% in 2021). Until 2020, tax advantages, direct grants and interest rate subsidies represented around 90% of total expenditure. In 2021, the most used forms of support were non-repayable instruments (direct grants and interest rate subsidies represented more than 50% in 21 Member States).

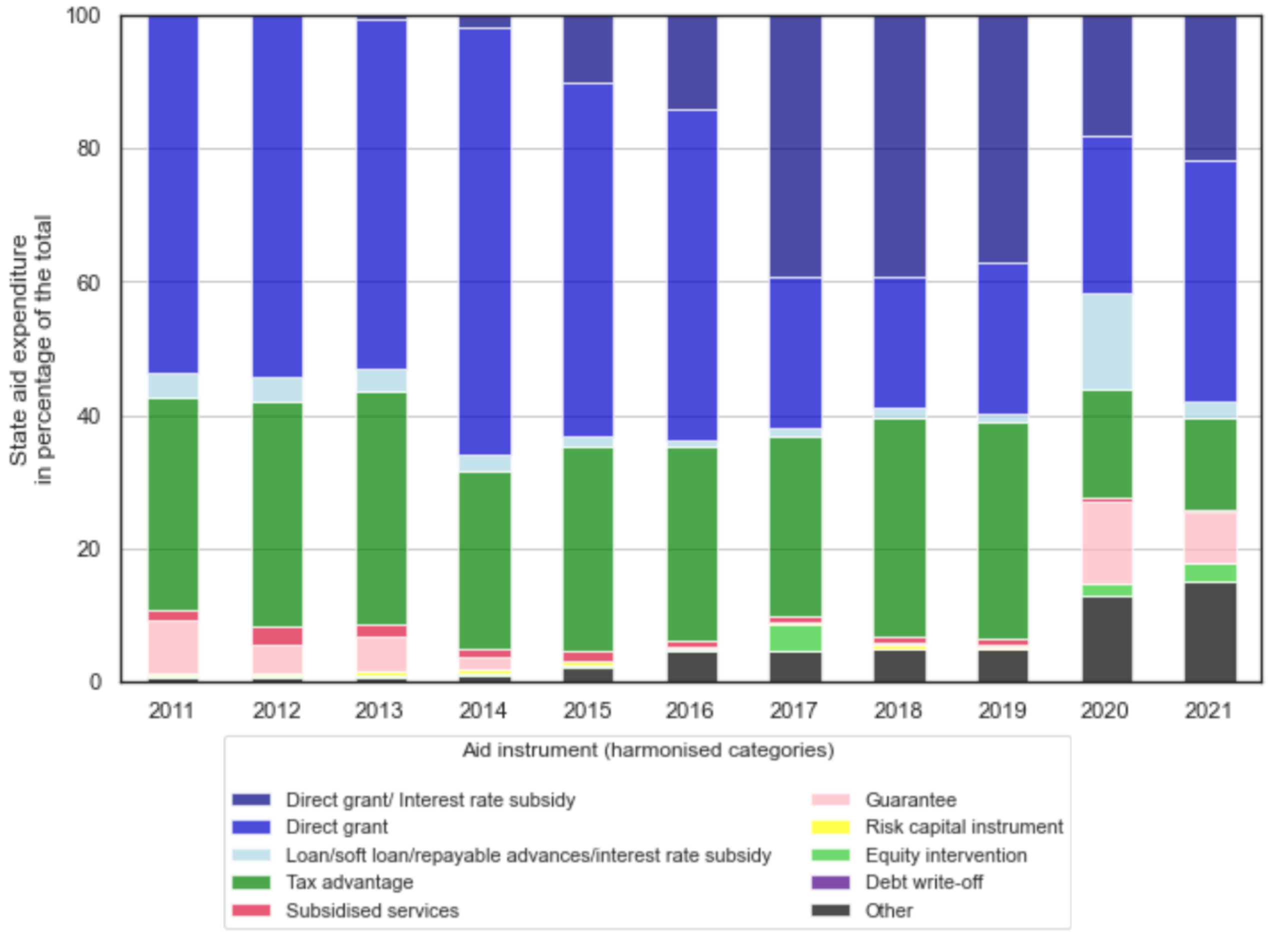

Figure 4. Share of total State Aid expenditure by type of instrument in % of the total, 2011-2021 (European Commission, 2023d)

2.3.2 Overall trend in energy subsidies, 2015-2021

To comprehend the direction of the EU with the renewed Green Deal Industrial Plan it is useful to provide an overview of the state-of-the-art energy subsidies in the EU. As Figure 3 in section 2.3.1 has shown, environmental protection and energy subsidies represented more than the half of total State aid disbursed in the EU from 2014 to 2019. After the COVID-19 crisis in 2020, the latest development in the EU green industrial policy are likely to increase further the disbursement of aid to foster the green industrial policy.

Before proceeding, it worth defining what energy subsidies are and the rationale behind them. Generally, a Pigouvian subsidy, or Pigouvian tax, is meant to modify the price of a product in order to incorporate the benefit, or external cost, that otherwise would not be mirrored in the market price. By doing so, private actors can internalize the benefits, or costs, of the externality associated with the product. Thus, private and social costs can be aligned and the market can produce the socially optimal amount of the good even in the absence of a social planner. Fossil fuels negative externalities deriving from air pollution and health-related issues are the widely targeted. Without some form of public intervention to incorporate the costs, fossil fuels would be indirectly subsidised because the producers and users of these energy sources would not pay for the negative externality they produce. Hence, an unpriced negative externality results in lower prices and higher production than the social optimum would require. On the other hand, in the case of renewable energy, subsidies can be justified because of their positive externality (namely, they do not pollute as much as fossil fuel energy sources would do): subsidies ensure that the market operates more efficiently than in their absence (Taylor, 2020).

Another reason to subsidize the deployment of renewable energy sources in this period of time is that it is a new industry, and when a new industry enters the market, it can benefit in the long run from learning-by-doing and economies of scale (the cost of production declines as output increases). Figure 5 and Figure 6 are graphical representations of a government intervention with a Pigouvian tax and Pigouvian subsidy that correct, respectively, for a negative and a positive externality in the energy sector (fossil fuel energy source and a renewable energy source, respectively).

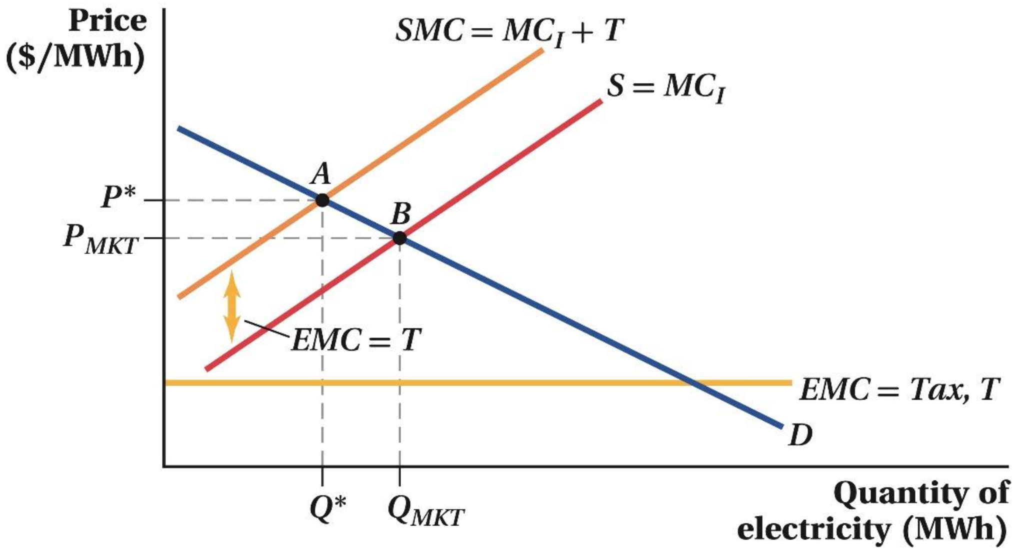

Figure 5. A Pigouvian tax corrects for a positive externality (Goolsbee et al, 2016, p.656)

In Figure 5 overproduction takes place at quantity Qmkt with price Pmkt (Point B) because the marginal costs of production (i.e., the red line) do not include the negative externalities. A Pigouvian tax (T) equals the external marginal cost (EMC) (not incorporated in the market price) and shifts the supply curve (S) up from marginal cost S = MC_1 to social marginal cost curve (SMC). With the tax, the industry ends up with producing the social optimal quantity at point A, which now incorporates the price of the negative externality.

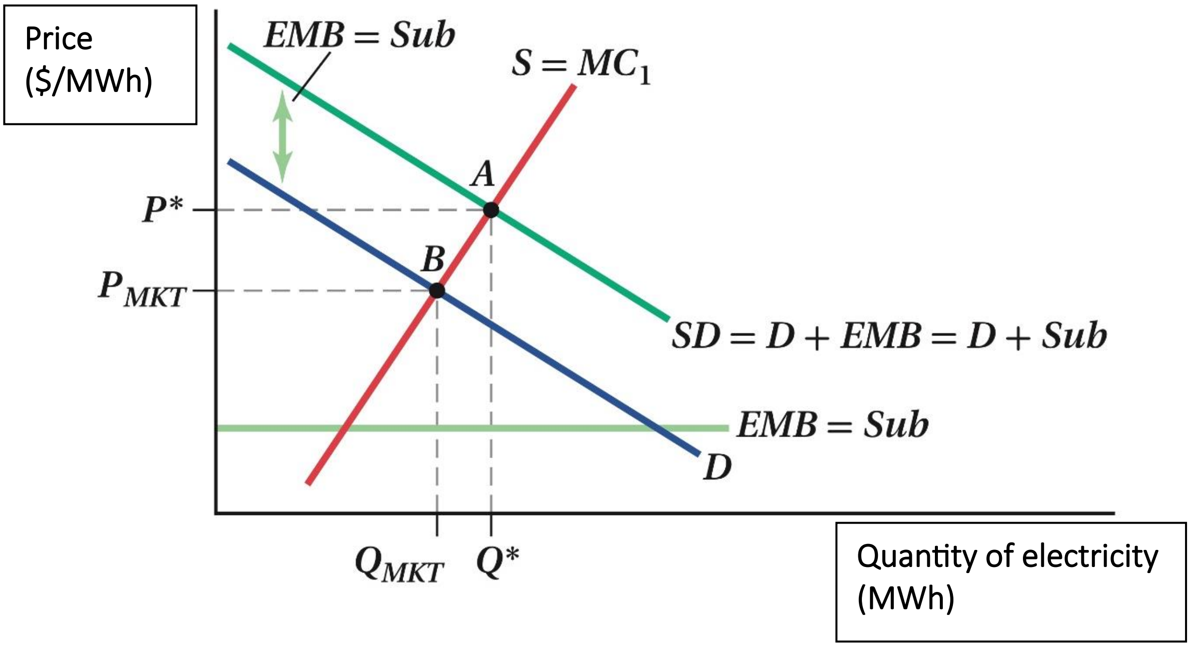

Figure 6. A Pigouvian subsidy corrects for a positive externality (Own elaboration on Goolsbee, 2016)

In Figure 6, without interventions, the market underproduces at quantity Qmkt at price Pmkt (suppose this refers to the quantity of electricity produced with renewable energy sources). A Pigouvian subsidy (Sub) equal to the external marginal benefit (EMB) shifts demand (D) out to social demand (SD). The subsidy increases demand and, at point A, there is a new- socially optimal- quantity produced Q* at P*.

After having understood the economic rationale behind energy taxes and subsidies, it is important to concentrate on how these latter are defined in the international context. Despite the global use of energy subsidies, there is no single definition of what they are. The most used definition at the global stage is the one given by the World Trade Organization (WTO) in the Agreement of Subsidies and Countervailing Measures (ASCM), mainly because the WTO has 164 members worldwide and covers both energy importing and exporting countries. It stipulates that a subsidy exists if a policy measure confers a benefit to an economic actor and if it constitutes a financial contribution or provides price/income support. As general subsidy types, this definition includes both direct and indirect transfer of funds and liabilities, government forgone revenues (tax expenditures and excise tax), the provision of goods or services below their market value, and income or price support measures (Hafner & Luciani, 2022).

Notwithstanding the apparent stringency of this definition, other international institutions offer different definitions. This results in different interpretations of which policies constitute subsidies and how their implications on prices are calculated. Hence, it is often difficult to compare the amount of energy subsidies estimated by different institutions. Table 3 shows some definitions of either state aid measures, or more directly energy-related state aid measures, offered by five important international organizations.

World Trade Organization (WTO)	"A financial contribution by a government or any public body within the territory of a Member" or when "there is any form of price support…(where) a benefit is thereby conferred"
International Energy Agency (IEA)	"Any government action directed primarily at the energy sector that lowers the cost of energy production, raises the price received by energy producers or lowers the price paid by energy consumers. It can be applied to fossil fuels energy in the same way"
Organisation for Economic Co-Operation and Development (OECD)	"Both direct budgetary transfers and tax expenditures that in some way provide a benefit or preference for fossil fuel production or consumption relative to alternatives."
World Bank (WB)	"A deliberate policy action by the government that specifically targets fossil fuels, or electricity or heat generated from fossil fuels."
International Monetary Fund (Imf)	"Pre-tax consumer subsidies arise when the prices paid by consumers, including both firms (intermediate consumption) and households (final consumption), are below supply costs including transport and distribution costs. Producer subsidies arise when prices are above this level. Post-tax consumer subsidies arise when the price paid by

	consumers is below the supply cost of energy plus an appropriate “Pigouvian” (or “corrective”) tax...”

Table 3. Different definitions of energy subsidies (own elaboration on Taylor, 2020)

The definitions in Table 3 are influenced by the mandate of the organisation, and the method of calculation can also vary according to different practices. Specifically, the European Commission usually prefers to refer to energy subsidies more broadly as State aid (see Section 2.1 for the European Commission’s definition). However, it often uses the OECD definition and approach when calculating energy subsidies (Taylor, 2020). The definitions can be divided in the way subsidies are created or conveyed (WTO and OECD), or in those that describe the way subsidies impact the sector (IEA and IMF). Other definitions can be categorized in those benefitting either producers or consumers: notably, the IMF and OECD definitions allude to the importance of both producer and consumer subsidies. Subsidies can target both fossil fuels and non-fossil energy sources. Only the IEA explicitly addresses subsidies for fossil fuels and non-fossil fuels, whereas the OECD only focuses on energy subsidies intended for fossil fuels.

For the analysis of the overall trend in energy subsidies in the EU for the past few years, this section will refer to the Final Report of the European Commission in association with Enerdata and Trinomics (a research centre and a research firm, both specialized in energy), entitled “Study on Energy Subsidies and other government interventions in the European Union – 2022 edition” (European Commission, 2022). In this report, energy subsidies are defined as “specific initiatives to keep prices for consumers below market levels (e.g. reduced tax rates on road transport fuels) or for producers above market levels (e.g. feed-in tariffs), or to reduce costs for consumers or producers by granting specific aid. Hence, the definition can be categorized in the ones above that concentrate on the benefits for both consumers and producers (e.g. IEA or OECD). Energy subsidies are then classified in four main categories: i) Direct transfers to recipients (grants, low-interest or preferential loans), both to consumers and producers ii) Tax expenditures: the amount of tax benefits received by taxpayers and forgone by governments (tax reductions, tax exemptions, tax refunds, tax credits and tax allowances) iii) Income or price supports: cross-subsidies, meaning the transfer of amounts of money from groups of people, technology, or territory to another group, usually financed through final consumers’ tariffs/prices. They include: capacity payments, biofuels blending mandates, renewable energy quotas with tradable certificates, differentiated grid connection charges, energy efficiency obligations, interruptible load schemes, contract for difference, feed-in premiums, feed-in tariffs, consumer price guarantees (cost support), consumer price guarantees (price regulation) and producer price guarantees (price regulation) iv) Research Development and Demonstration (RD&D) budgets: financial and/or other preferential mechanisms to support innovation.

The report collected data on energy subsidies in the EU from 2015 to 2021, to investigate progress made by Member States since the adoption of the Paris Agreement in 2015, which set the goal of limiting the temperature increase to 1.5°C above pre-industrial levels. Some data for the year 2021 are marked in the report as "to be confirmed" because there is some missing data. However, the authors included missing data based on their estimates (if a subsidy scheme was still ongoing in 2021, it is assumed that the subsidy amount is equal to that of 2020). All values are adjusted in euros of 2021 (real values) (European Commission, 2022).

As a general trend, in the last 7 years, energy subsidies have increased steadily from 2015 (€159 billion) to 2021 (€184 billion), with a yearly increase of 1.8% until 2020. Figure 7 represents this trend.

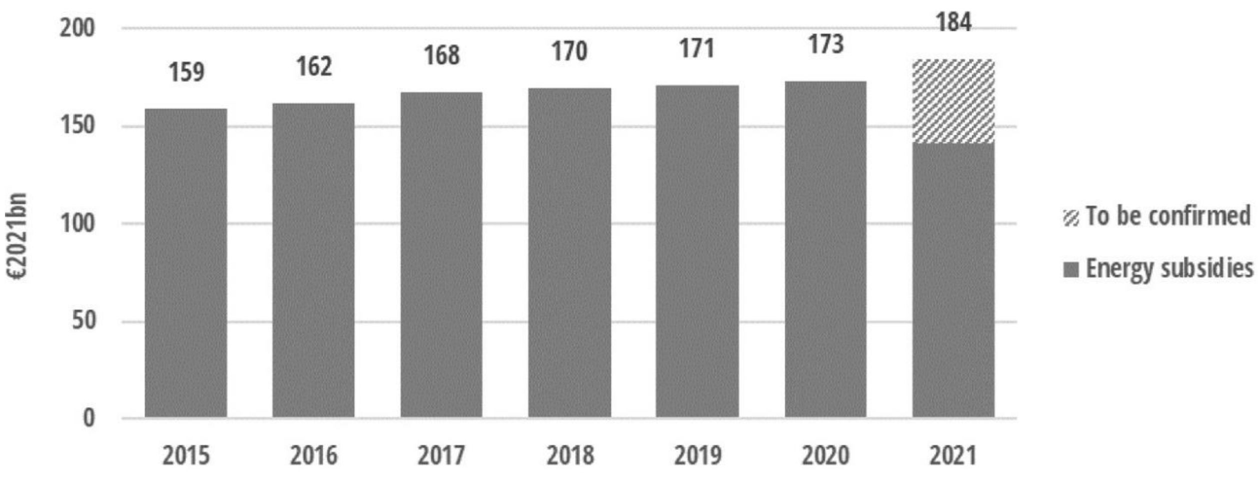

Figure 7. Energy subsidies in the EU, 2015-2021, in €2021 billion (European Commission, 2022)

Energy subsidies by source of energy. Figure 8 shows the trends by source of energy group. The most significant increase can be observed in energy efficiency subsidies (under the category "all energies") with about 62% increase from 2015 levels in 2021. Subsidies to RES (renewable energy sources) have increased mostly in 2020 (18% increase from 2015 levels), while subsidies to electricity have decreased moderately. Fossil fuels subsidies have remained stable until 2019, before decreasing by 5.5% in 2020.

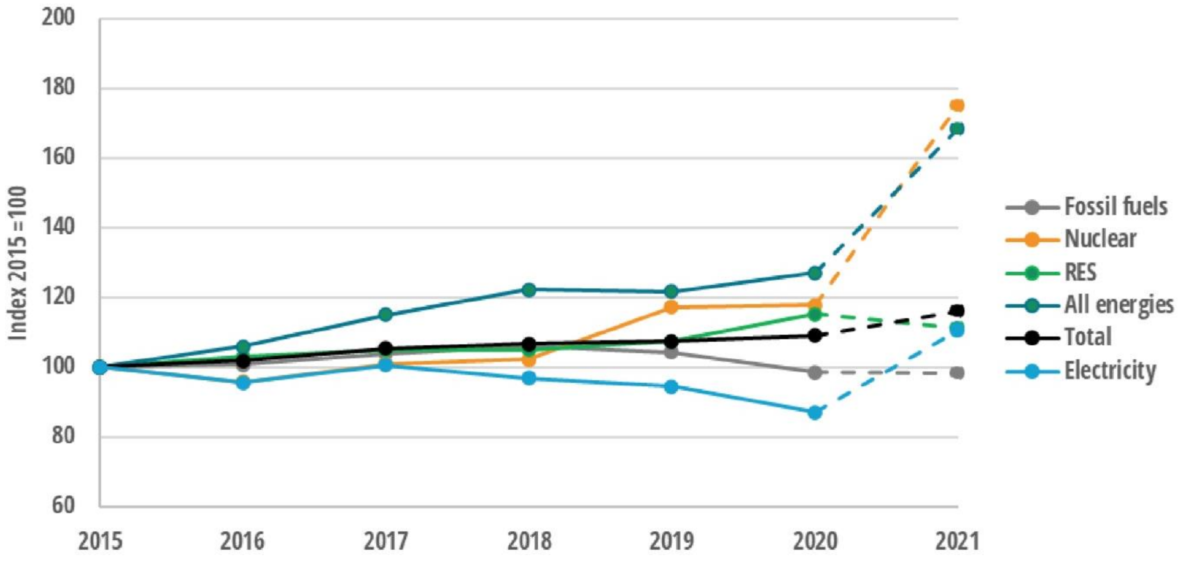

Figure 8. Energy subsidies trend by source of energy, 2015-2021, indexed with base= 2015 (European Commission, 2022)

Fossil fuels subsidies (FFS): Figure 9 represents the amount of fossil fuels subsidies spent in the EU, disaggregated for each economic sector. In the period between 2015 and 2021, the amount of FFS (fossil fuels subsidies) ranged from a €50 billion in 2020 to the highest value of €54 billion in 2018. In 2020 it can be observed a 5% decrease (-€3 billion) due to the lockdown measures and the consequent decrease in subsidies to the transport sector, which however have been increasing from 2015 (€10 billion) to 2019 (€13 billion). Overall, the economic sectors receiving the most aid are the energy industry (around €17 billion on average), industry (around €12 billion on average), and transport (around €12 billion on average) in the period between 2015 and 2020.

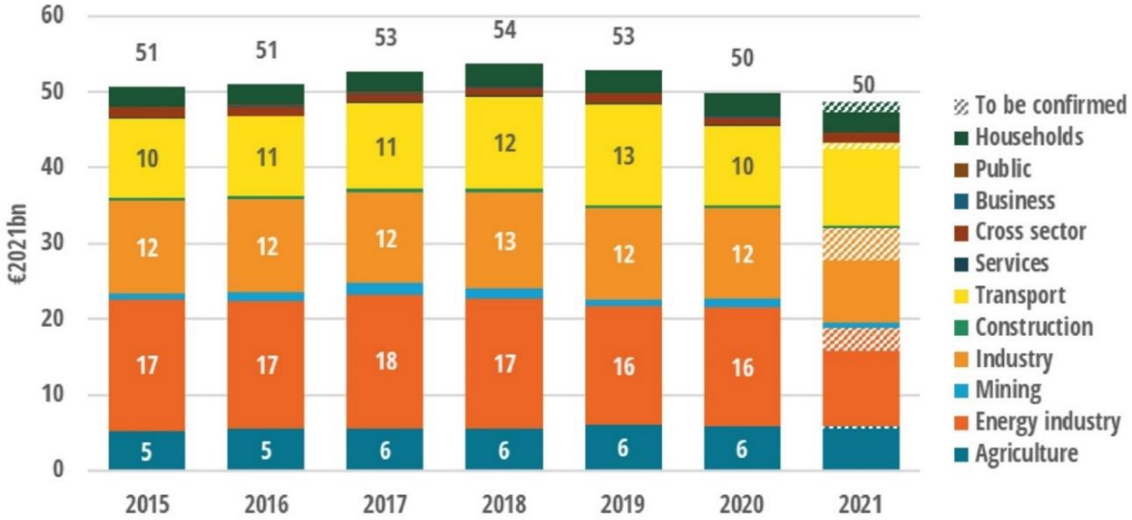

Figure 9. FFS in the EU by economic sector, 2015-2021, in €2021 billion (European Commission, 2022)

As regards the impact of FFS on the Member States' economy, Figure 10 shows FFS as a share of GDP, taking as a reference year 2015 (light orange diamonds), 2019 (dark orange diamonds), and 2020 (blue bars). On average, the share of FFS represented 0.35% of the total EU GDP in 2020 (it remained stable since 2015). Countries showing an increase in FFS in 2020 compared to 2015 are: Cyprus, Belgium, Bulgaria, Croatia, France, Italy, Sweden, Romania, Luxembourg, and Malta. Meanwhile, countries reducing most their FFS were: Greece, Ireland, Hungary, Latvia, and Lithuania. The spike in intensity is observed in 2020, most likely because of the drop in GDP in most EU Member States due to the pandemic.

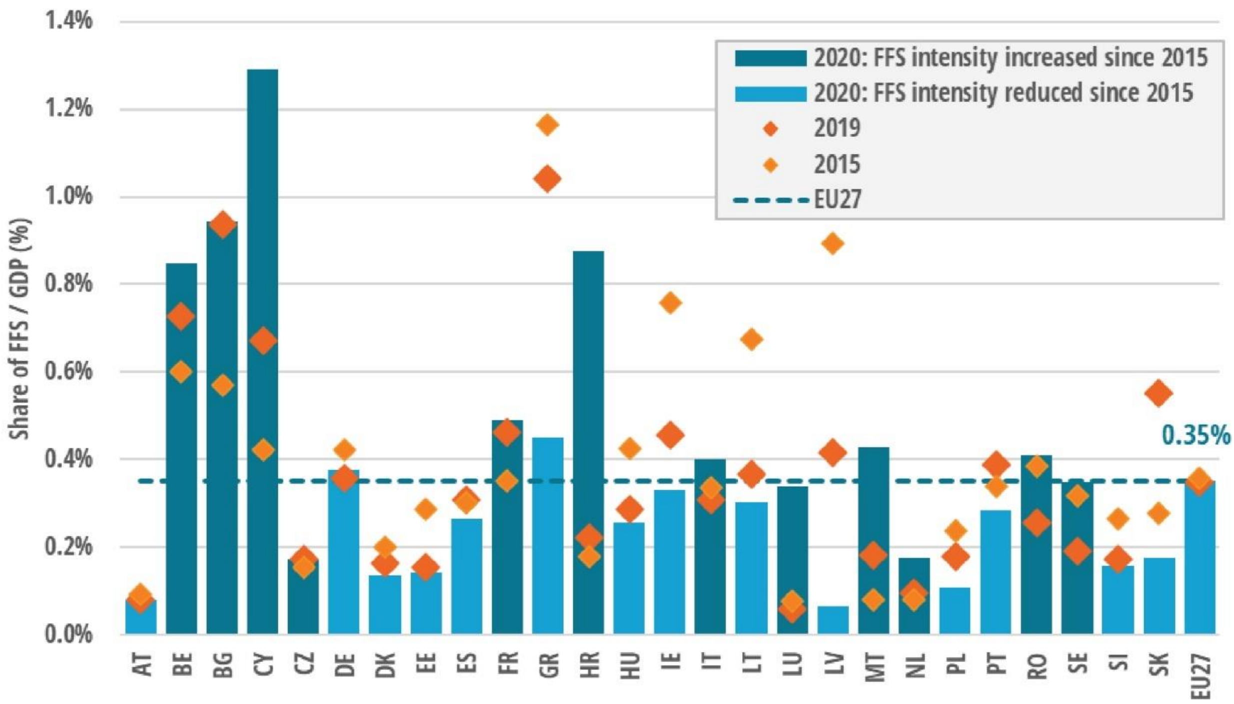

Figure 10. FFS as a share of GDP (%) in EU Member States, 2015, 2019 and 2020 (European Commission, 2022)

Among its goal towards reaching a net zero economy, the EU plans to phase out fossil fuels from its energy mix. This process is monitored by the Commission through the National Energy and Climate Plans (NECPs) first introduced in the Clean Energy for all Europeans package adopted in 2019. These plans are set to monitor the energy targets of the EU Green Deal in five main dimensions: i) decarbonisation ii) energy efficiency iii) energy security iv) internal energy market v) research, innovation and competitiveness (Regulation 2018/1999 on the Governance of the Energy Union and Climate Action, 2018). NECPs must be submitted by each country every two years. The authors of the Commission's 2022 Final Report (European Commission, 2022) acknowledged that they faced several difficulties in gathering data on the phasing out plans for FFS, given the constant evolution of policies, and the lack of clarity and transparency. In general, many countries have defined ambitious targets in phasing out fossil fuels. However, only a few countries have translated such ambitions into laws or clear plans of action. Moreover, end-dates for FFS are often unknown or not published. All this makes it difficult to understand whether the EU is on track with its climate targets. Figure 11 represents the share of FFS on total energy subsidies in 2020. Of the total €50 billion FFS in 2020, for €41 billion (80%) the end-date is unknown or unplanned after 2030. More of the 80% of the total are composed of 7 countries: France, Germany, Italy, Spain (these four are the biggest economies in the EU), Belgium, Ireland and Greece. In 6 countries (Cyprus, Ireland, Belgium, Czech Republic, Poland and Bulgaria) FFS represent around 50% of their total share energy subsidies.

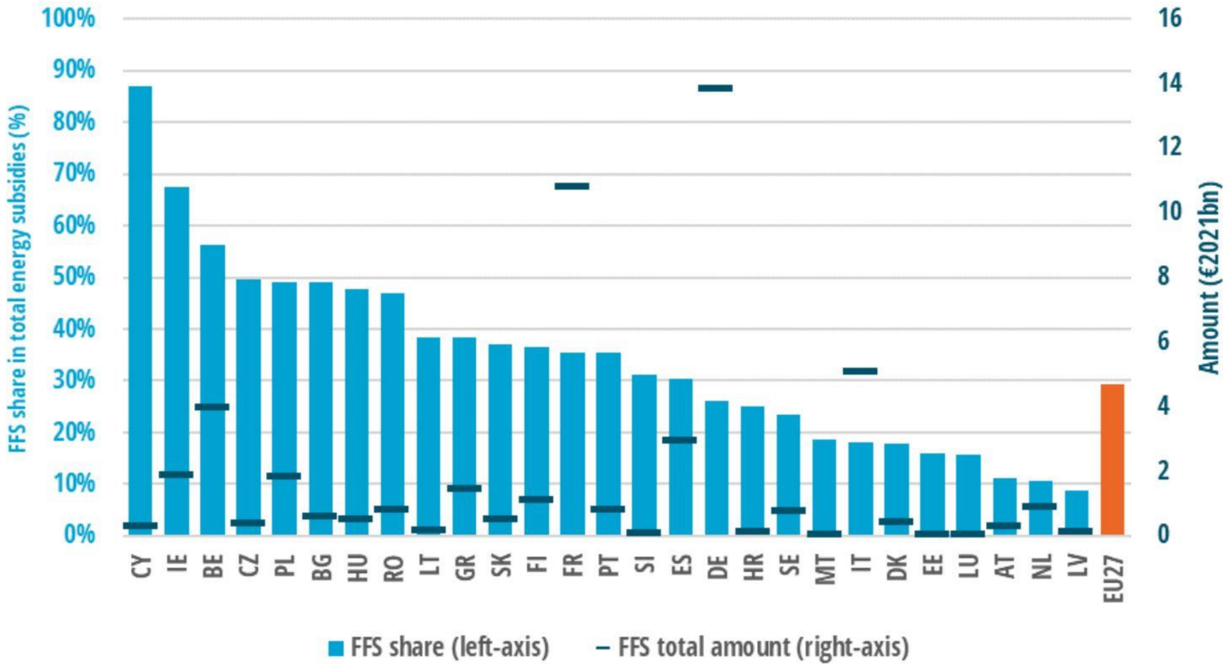

Figure 11. FFS amounts, €2021bn, and FFS as a share of total energy subsidy, in %, in 2020 (European Commission, 2022)

Renewable energy subsidies: Together with the goal of phasing out FFS, the EU has planned to support renewable energy sources so as to achieve its climate targets. Figure 12 shows the trend of renewable energy subsidies in 2021 billion of euros by financial instrument over the period 2015-2021. Overall, RES (renewable energy sources) subsidies have increased steadily over the period 2015-2020, from €69 billion to €80 billion. The most used forms of energy subsidies are Feed in Tariffs and Feed in Premiums (FiT/FiP), which represented 79% of the total in 2020. FiT/FiP are thought to be policy tools to stimulate the rapid deployment of renewable electricity by giving an additional premium over the market price to producers of RES. Usually, there are caps (with a maximum expected revenue for producers) and floors (with a minimum expected revenue for producers) to stabilize the premium amount of such instruments, which are highly dependent on volatile RES prices (e.g. wind energy sources are characterized by high price volatility given their dependence on the presence of wind in the environment, which is sometimes unpredictable). Alternatively, sliding FiT/FiP can be used to stabilize revenues (when the market price increases the premium decreases, and viceversa). The impact of volatile prices on Fit/FiP can be observed for instance in 2020 and 2021. In 2020, there has been a +7.5% increase compared to 2019, given the fall in wholesale electricity prices after lockdown measures have been implemented across the EU. Meanwhile, in 2021 support for RES has decreased significantly because energy prices have been rising, with wholesale electricity prices exceeding the floor for Premiums, hence decreasing the support by Member States.

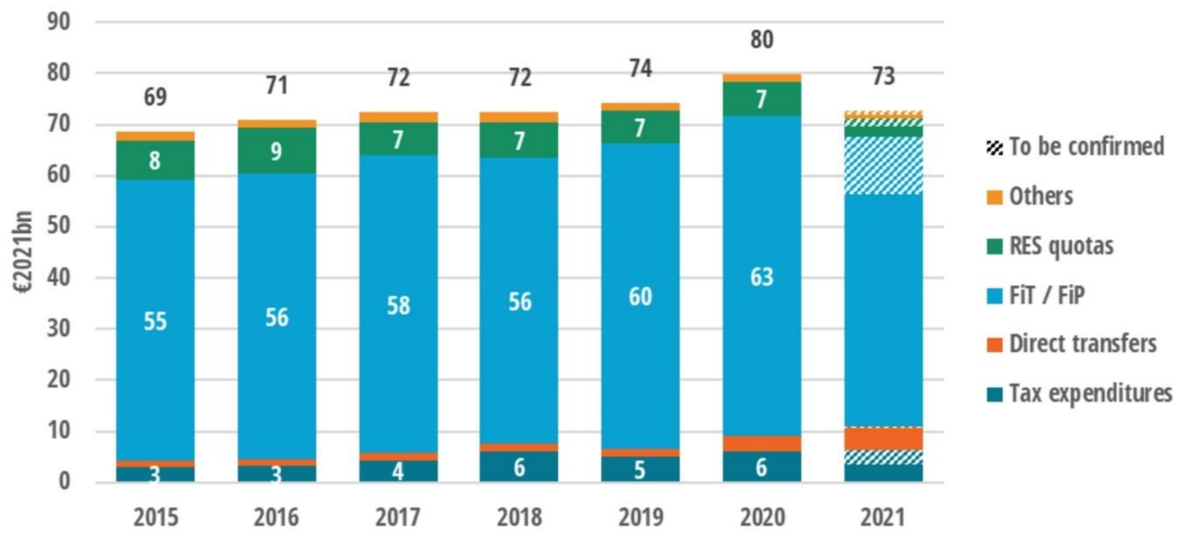

Figure 12. RES subsidies by financial instrument, 2015-2021, in €2021 bn (European Commission, 2022)

Figure 13 shows the allocation of RES subsidies to specific technologies. Solar energy receives most of the support, with an average around €29 billion between 2015-2020. Wind is second with around €18 billion on average over the same period. Although solar accounts for a significantly lower share in energy production than wind (in 2020: 147 TWh from solar and 392 TWh from wind), thus, it receives more support from the authorities in the EU.

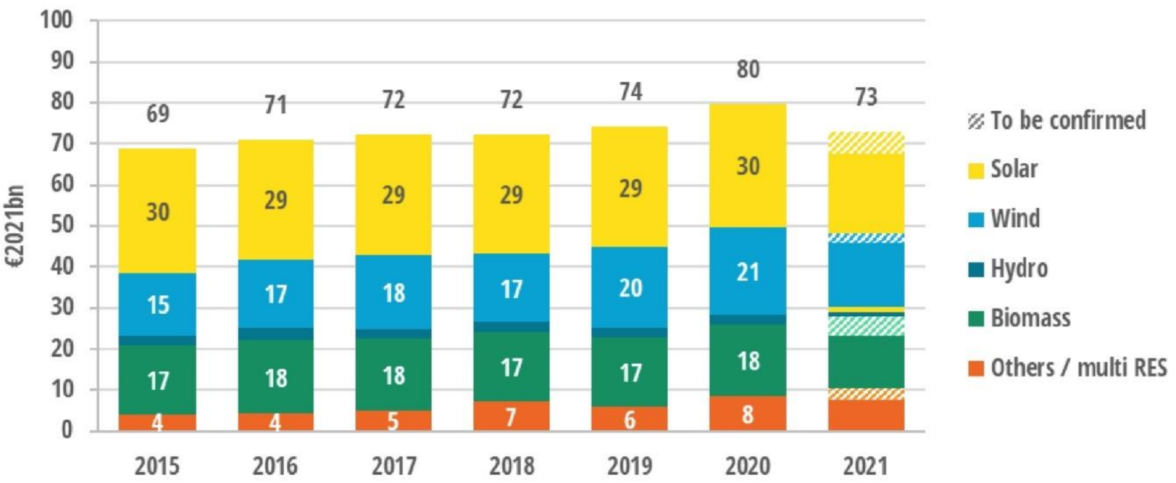

Figure 13. RES subsidies by technology, 2015-2021, in €2021 billion (European Commission, 2022)

Figure 14 depicts the share of GDP (%) of RES subsidies by technology in each Member State in 2020. Germany leads by far, with €33.5 billion (0.94% of GDP), showing its fiscal capacity to support a significant amount of RES subsidies. In relative terms, Greece (around €2 billion, 0.91% of GDP) and Italy (€15 billion, 0.87% of GDP) follow close. France in absolute terms is third (€7.8 billion) but this amounts to only 0.32% of its GDP, a value significantly lower than the EU average (0.57%). Ten countries spend less than half of the EU average: the Netherlands, Romania, Poland, Slovenia, Lithuania, Cyprus, Luxembourg, Hungary, Sweden and Ireland.

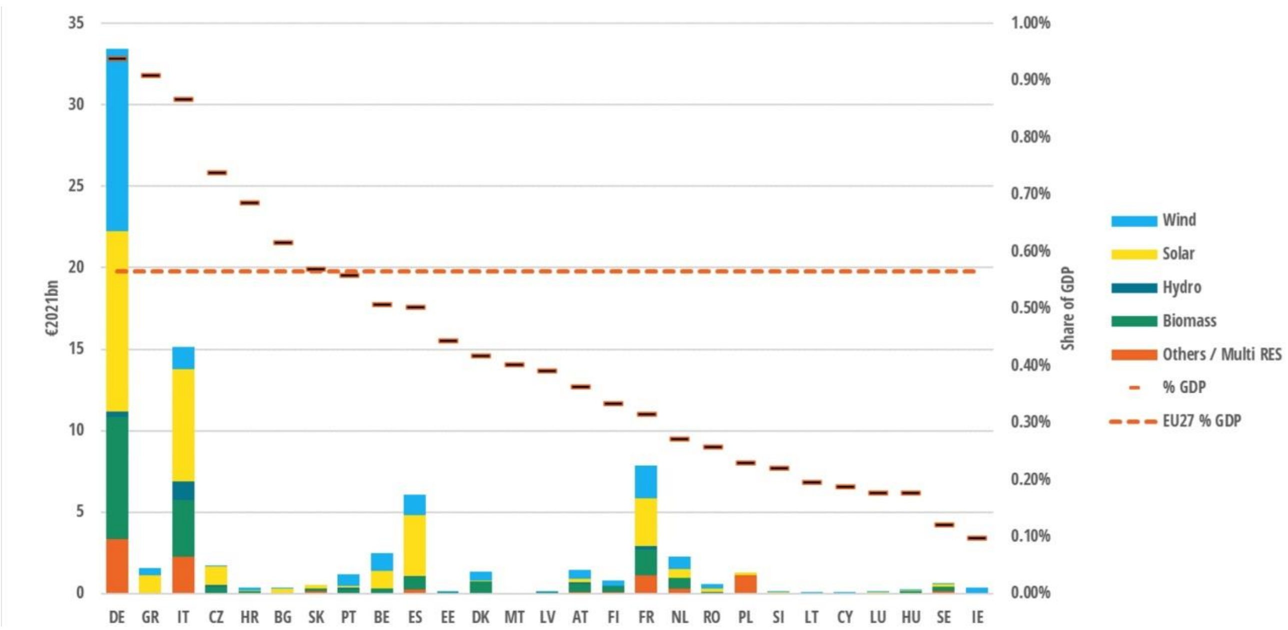

Figure 14. RES subsidies by technology By Member States as a share of GDP (%) in 2020, €2021 billion (European Commission, 2022)

Transport sector: Finally, for the purpose of this study, which is to question the approach the EU is taking in its green industrial policy, it is worth considering the energy subsidies allocated for the transport sector. Since one of the main concerns for the EU regarding the IRA regard the EV subsidies and the related Local Content Requirements for producers, it is useful to address how the transport sector was subsidized in the EU in the past 6 years. Figure 15 shows the trend, also disaggregating the total values for the different means of transport.

The subsidy amount in this sector has been increasing from 2015 to 2019 by +7% per year (in absolute terms, around €1 billion per year on average). The peak has been reached in 2019 with €16 billion. The growth is mainly driven by subsidies for road transport (+11% per year between 2015 and 2019), which accounted for 53% of the total in 2019. The decrease in 2020 is driven by the lockdown measures adopted in most EU Member States to limit the spread of COVID-19. In 2021, transport subsidies bounced back at €15 billion, with an estimated share of 63% of subsidies targeted for road transport.

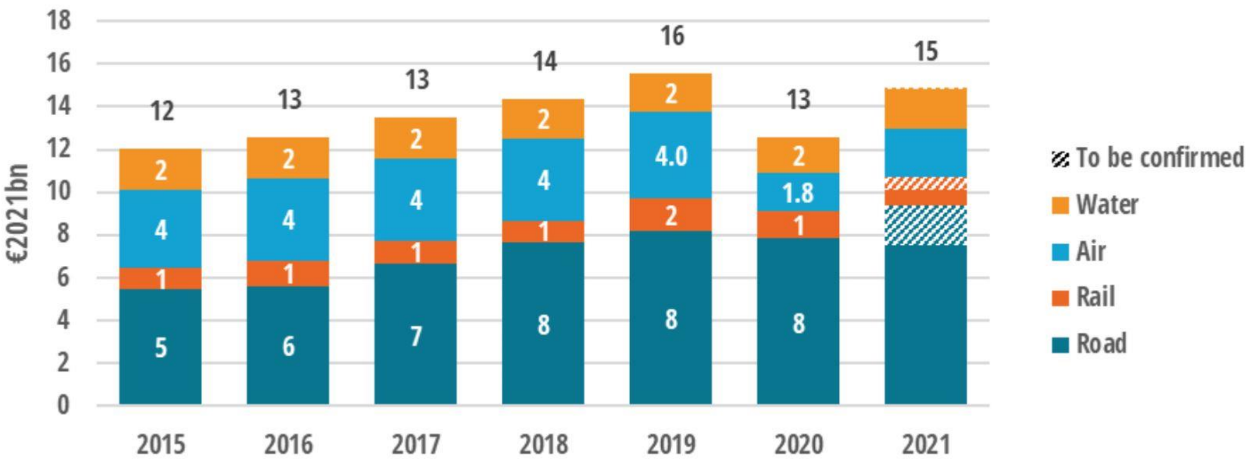

Figure 15. Energy subsidies by transport mode, 2015-2021, in €2021 billion (European Commission, 2022)

Electric mobility: As far as private EVs are concerned, subsidies to recharging infrastructures have increased from €90 million in 2015 to €370 million in 2020. The lack of recharging infrastructures represents a major obstacle to the diffusion of EVs in the private sectors, and the presence of coordination problems among users/producers, justifies the intervention of public authorities. Germany (€255 million, Italy (€90 million) and Sweden (€8 million) were spending the most on such measures. Preliminary data for 2021-2022 show that Germany could soon exceed €1 billion. Other measures for clean or electric vehicles are not categorized as energy subsidies, and they include those specifically directed towards EVs and other supporting measures such as low-emissions thermic vehicles, hybrid electric vehicles, or low emissions vehicles including electric ones[5]. Also, in this category the number of subsidies has been increasing, reaching €1,700 million in 2020, more than €3,500 million in 2021 and more than €5,000 million have already been announced for 2022. Germany leads with €880 million in 2020, followed by the Netherlands with €640 million and Sweden, with €480 million. The financial instruments most used were primarily direct transfers, which amounted to 28 out of the 38 measures identified (usually grants to households for purchasing an EV) (European Commission, 2022).

2.3.3. IRA and EU green subsidies: a comparison

Energy subsidies constitute only a part of the overall amount of public support for green technology, which is fragmented in different regulatory frameworks and policies, both at the EU and at the national level. While Chapter 1 analysed the content of the IRA and how it could impact the EU economy, this section will compare the amount of EU public support programmes in green technologies with the subsidy schemes contained in the IRA.

In the US, the IRA has a low administrative burden because it consists of simple subsidies such as direct payments for units produced or a fixed percentage of the investment cost for mass deployment of green technologies. Meanwhile, in the EU public support is mostly based on research and innovation and it's generally more complex and fragmented. This is due to the great quantity of state aid rules (discussed in section 2.1) that regulate the level playing field in the Single Market (Erraia, 2023) and a vast array of green policies.

Apart from green subsidies, the EU has over the years focused on other market-based policies, such as carbon taxation, which reduce the relative cost of clean energy compared to fossil fuels. An example of this is the cap-and-trade system, named the Emissions Trading System (ETS), which sets a cap on the total amount of emissions allowed in the EU and establishes a limited number of emissions allowances (either with free allocation or through auctions) that can be traded among operators in the sectors in the ETS. This is a quantity-based approach to reduce emissions that sets a quota on the maximum quantity of emissions allowed in the market (ETS covers around 40% of EU GHG emissions) and allows operators to interact in the market in accordance with the received quotas and the actual needs, thereby determining the market price of carbon. The cost of carbon

[5] The authors point out that this category is not exhaustive and does not include all measures in place at MSs level.

emissions cannot but increase the price of electricity, more precisely this latter grew from €30 to €75 per MWh compared to a situation without the system. The increase in the price of electricity, in turn, contributes to make the electricity generated out of renewable resources economically profitable. Recently, to limit the risks that European companies may be induced to locate in (or import intermediates from) countries where ETS-like systems do not exist (i.e. the so called carbon leakage phenomenon), the EU has also introduced the Carbon Adjustment Border Mechanisms, which consists of a fee imposed on imported goods from countries with no carbon pricing mechanisms in place that should reflect their carbon content.

Furthermore, the EU has introduced a variety of instruments to support clean technologies. These include the EU Important Projects of Common European Interest (IPCEIs), cross-border projects that include support for battery and hydrogen manufacturing, the EU Innovation Fund established under the EU emissions trading system (ETS), that supports the demonstration and early deployment of clean technologies and processes in energy-intensive industries, the European Innovation Council's EIC Accelerator, which aims at scaling-up breakthrough technologies, the European Investment Bank (EIB) loans to clean technology projects, and EU guarantees under the InvestEU programme, most of which are administered by the EIB (Kleimann et al, 2023). It is estimated that these support programmes amount to €35 billion[6] for the period 2022-2031, against the CBO's estimated cost of $37 billion (that, however, will probably be exceeded, for additional estimates from the literature see section 1.2.2 in Chapter 1). For renewable energy subsidies discussed above, €800 billion are estimated for 2022-2031 in the EU, against the $208 billion in the IRA.

For EVs, the objects of the most contested subsidized items in the IRA, almost every EU Member State has a subsidy scheme in place. The expenditure for this area amounts to almost €6 billion and around €6,000 ($6,400) per vehicle in 2022, against the $7,500 subsidy per vehicle contained in the IRA. The main difference in such measures is that while EU subsidies are non-discriminatory, the IRA ones work differently on the basis of different local content. In fact, an EV assembled in the US can be eligible under EU member state tax credits, while it is not the other way around. Nonetheless, the European Union MFN import tariff for EVs consumer is higher than the US tariff, being them 10% and 2.5 %, respectively. Bown (2023) calculated that this EU tariff is equivalent to a 7.5% production subsidy. Another important aspect is that in the US EV's EU exporters benefit from a

[6] These estimates do not include national programmes (state aid), except for IPCEIs

25%-point tariff preference relative to Chinese manufacturers. On the other hand, in the EU Chinese exporters face the same tariff of US manufacturers (Bown, 2023).

With regard to battery manufacturing, Erraia et al (2023) have estimated that the level of subsidies for US battery producers exceed by far those available in the EU. Under the US, battery manufacturers can receive subsidies over twice (211%) the initial investment cost. In the EU, under the IPCEIs the battery production received €6 billion in public support. This results in a subsidy equal to 26% of the investment cost. With the TCTF (presented in section 2.1.1) Member States can offer more state aid, which is estimated to correspond to 15% of the investment cost to non-assisted areas up to 35% to a-regions, which are areas in need of additional assistance (Erraia et al, 2023).

Higher amounts of US subsidies are estimated also for hydrogen manufacturing. Under the IRA, hydrogen producers will receive $100 billion in production subsidies in the next decade. For green hydrogen, this will result in a levelized cost per 1 kg of hydrogen of $2.7 ($5.7 without subsidies). In the EU the main program supporting hydrogen is the European Hydrogen Bank, which will support hydrogen producers through a fixed premium per unit of hydrogen produced. Under this scheme, the cost for 1 kg of hydrogen will amount to $3.1 (against $5.3 without the subsidy). For offshore wind, the level of subsidies is similar between the EU and the IRA. For the former, subsidy levels are determined through a competitive auction, while for the latter, subsidies can cover up to 40% of the investment cost of offshore wind projects, but land lease are allocated through auctions, the subsidy level is determined based on the price for the lease (Erraia et al, 2023).

Finally, it should be underlined that there are other important factors contributing to the attractiveness of investments in clean technology. Regulatory frameworks, level of taxation, political uncertainty and production costs are all factors that may induce a producer to move its facility to the US or to the EU. First, for policies and regulations, the EU has always been at the forefront at the global stage trying to lead the green regulatory environment, while the US has often neglected the need to tackle the green transition. Second, the average tax rate is usually lower in the US than in the EU. Third, political uncertainty can increase the required rate of return on investment. In the EU there is more stability and predictability in the level of political support for climate policies, while in the US the Trump administration has often abandoned green policies and has strongly opposed the green subsidies of the IRA, resulting in higher uncertainty for investors. Fourth, production costs are certainly higher in the EU than in the US. While labour costs are comparable between the two electricity prices have been higher in Europe in the last decade, which can significantly affect maximizing profits (Erraia et al, 2023).

THIRD CHAPTER

The economic theory behind industrial policy and market-based solutions for a greener economy

Over the last decade, we have witnessed a return of state interventionism in the economy (as shown in Chapter 2 by the increased state expenditures in the EU). The green transition, COVID-19 and the Russian aggression of Ukraine are the main justifications for such a strong public intervention, which has prompted governments to spend more and more resources to support the economy. In the current context, the IRA is yet again another demonstration of enhanced state interventionism. In addressing the impacts of the IRA on its economy, the EU is confronted with another challenge: following the US in strong protectionist measures such as local content requirements, domestic subsidies and other forms of incentives; or addressing the risk of a further expansion of the EU budget and opting for a more prudent approach in the economy. While recent EU regulations are leaning towards the first approach, all of this has renewed the debate over the role of the state in the economy.

In economic theory, we can find two main schools of thought. On the one hand, some scholars (Mazzucato, 2014; 2015) are actively calling for a mission-oriented policy for the state to actively lead the green transformation. On the other hand, others (Mingardi, 2020; Wennberg and Sandström, 2022) hold that public actors lack the ability and information compared to private actors to successfully intervene in the market and manage the process of innovation. A third school of thought can be identified starting from the work of Rodrik (2004), which tries to bridge the two contrasting views and suggests that the private and the public sectors should engage with each other in strategic collaboration. Other scholars (e.g. Tagliapietra and Veugelers, 2023) agree on this "third" way and call for an industrial policy that is able to both preserve competitiveness and support clean technology development and deployment in the EU economy.

All three of these frameworks address the question of how innovation is created in markets. Particularly for the case of green transformation, research and development are key in providing new technologies to solve great societal challenges. These processes can be addressed with innovation policy, which can be defined as "the interface between research and technological development policy and industrial policy and aims to create a framework conducive to bringing ideas to market" (European Parliament, 2023). If some argue governments should be central in spurring innovation by formulating missions, others call for a general framework setting the right conditions in which firms can operate free of substantial state interventions.

3.1 The history of industrial policy in the EU

Since its creation, the European Union has experienced different waves of both liberalization processes and strong use of industrial policy to steer the economy towards a preferred direction. After World War II, the European Coal and Steel Community (1952) was established to introduce industrial policy in strategic industries to reduce overcapacity, modernise coal production and deprive European countries that for long engaged in war of their heavy industries, which are fundamental for producing armament. Between the 1950s and the 1970s, vertical industrial policies (strong interventionist approach with winners-picking sectoral policies) were introduced to close the income gap and reduce the dependence on the US. In the 1980s, a phase of liberalization with market-oriented industrial policies took place. The goal was solely to establish the right framework for the economy to thrive (so-called horizontal industrial policy). The liberalization process continued in the 1990s and 2000s, in which the EU acted to ensure the regulatory conditions for the Single Market and competition policy, and the 2000 Lisbon Agenda is an example of such an approach (Tagliapietra and Veugelers, 2023).

The 2008 crisis revived industrial policy across the EU to reindustrialize the economy. After that, the challenge of climate change and the growing international tensions further incentivised the EU to intervene in the economy, culminating in adopting the EU Green Deal in 2019. After COVID-19 and the Russian aggression of Ukraine, the EU focused on enhancing its open strategic autonomy, aimed at diversifying international partnerships, establishing industrial alliances for new business partnerships, and monitoring strategic dependencies to assess and reduce the EU's dependency on foreign sources (European Parliament, 2022). This resulted in a series of acts, such as the European Chips Act of 2022 to strengthen the ecosystem of semiconductors in the EU, and the most recent Critical Minerals Act (see section 1.3. in Chapter 1) and the Net Zero Industry Act (see section 2.1.2 in Chapter 2). The increased need to keep up with competition after the approval of the IRA poses another challenge to the EU economy, for which a debate over the means to preserve competition and deliver the green transition is of fundamental importance.

3.2 The Entrepreneurial State

Among scholars, one of the strongest supporters of an active role of the state in the economy is Mariana Mazzucato, professor of Economics of Innovation and Public Value at University College London and former economic advisor to a number of governments and international institutions, including the European Union, the World Economic Forum, WTO and OECD. Her book "The Entrepreneurial State: Debunking Private vs Public Sector Myths" (2013) aims to illustrate the reasons why the state can become a dynamic engine for the economy and its potential for innovation. At the core of her approach lies the idea that the state should have an active role in the economy, not only supporting through counter-cyclical measures when the economy slows down or correcting for negative externalities when the social costs outweigh private costs, but also giving a directionality in the most innovative sectors of the economy, with the state playing a role as a force of innovation and progress and leading the way with courageous and clear vision (Mazzucato, 2013).

The Entrepreneurial State, according to Mazzucato and her acolytes, is thought to be necessary, especially in the transition towards a greener economy, because it can take risks that private actors cannot take. Venture capital[7], private investors and commercial banks often do not adventure in risky investments as they are not bold enough to invest in risky breakthrough technologies. This is the private failure that public measures are meant to address. The State can manage to embark on this path. Governments should keep supporting clean technologies until the advantage of consolidated technologies (e.g. fossil fuels) is eliminated. According to Mazzucato, this process can last long, even a century.

In this framework, the classical cost-benefit analysis that characterizes economic policy is thought to be short-sighted because if a public investment fails, policymakers tend to stop providing resources to the cause. On the contrary, when an investment fails, governments should persevere in their investment as long as returns in the long term can be achieved. If the allocation of resources stops, uncertainty and stagnation can take over and new promising solutions may be abandoned. In addition, Mazzucato rejects the attention to fiscal prudence that is thought to be significant when the state allocates resources to the economy. She takes the example of fiscal prudence in peripheral countries during the euro-zone crisis and claims that it did not deliver: countries lagging behind did

[7] Form of private equity and financing investors provide to startup companies and small businesses that are believed to have long-term growth potential and they usually engage with high-risk investments

not spend enough in areas that lead to economic growth, for instance in R&D. According to Mazzucato, austerity is counterproductive because it does not reduce the debt/GDP ratio, as it limits consumer demand through lower salaries and poorer public services and businesses feel less confident to invest. Structural reforms are not enough, and austerity would only entail more suffering and no benefits. She suggests letting poorer countries in the EU invest in growth measures through higher public spending that should be considered as an investment and hence not added up to the debt count but should be disaggregated from state spending.

To support her thesis calling for a strong entrepreneurial state, Mazzucato takes the example of the DARPA project (Defense Advanced Research Projects Agency) in the US, a research and development agency under the Department of Defence, which served as America's primary tool in the military race and space race against the USSR (Aghion, 2023). Established in 1958, it is a multi-billion program that for 50 years has represented an innovation force that led to fundamental research and laid the foundations for the creation of the Internet, Windows, and GPS. According to Mazzucato, DARPA is not the state that picks winners and losers, but the state developing R&D projects that the private sector, which is risk-averse, is not willing to take. Following the DARPA lead, the ARPA-E (Advanced Research Projects Agency-Energy) has been created to incentivise researchers and private businesses to explore risky projects. The project is thought to link a bottom-up and a top-down approach to innovation by financing guaranteed by both private and public organizations and the collaborative nature between the two. Researchers are free to explore ideas for innovation in the energy sector without the need to produce a commercial value in the short term. Mazzucato argues that projects such as DARPA and ARPA-E help fill the gap of risk-averse private investors not willing to invest in innovative technologies (Mazzucato, 2013).

3.2.2 The Green Entrepreneurial State

The framework of the entrepreneurial state can be applied as well to the transition towards climate neutrality. In "The Green Entrepreneurial State" (2015) Mazzucato elaborates on her theory about the active role of the state in achieving a green economy. The paper aims to explain the "dynamic" effect of the state on innovation and its central role in the green transformation. Governments should engage in substantial investments in the green economy not only to mitigate climate change and provide economic growth, but also to become leaders in the global economy. Since investments in innovation are cumulative, it is likely that countries investing now will lead the race for the years to come. The explanation for this is path dependency, which is the tendency to preserve prior conditions in economic activity even when better alternatives are present. This process would favour those countries that mobilize to act first.

To motivate its rationale, Mazzucato takes three countries as an example of first movers in strong state interventionism to address the green transformation: China, Germany, and the US.

China's "big push" is exemplified by its 5-year plan (2011-2015) to invest $1.5 trillion (5% of its GDP) across multiple industries such as energy saving and clean technologies. China adopts an approach of both demand and supply-side policies. According to Mazzucato, the favourable demand-side policies for the entrepreneurial state should be: a minimum requirement of energy share from RES, targets for reducing CO2 emissions, targets for energy over units of GDP, regulations for buildings and tax on emissions, and energy efficiency. Supply-side policies consist of tax credits, subsidies, loans, grants, and other monetary benefits for specific clean technologies, research contracts, and financing for development and innovation. China is acting on both policy measures. Specifically in the wind industry, SOE Goldwind (a SOE[8]), a wind turbine manufacturer established in 1998, was strongly supported by the state and became the leader in the Chinese domestic market by benefitting from local content requirements. This Chinese "champion" and other wind generators can also benefit from 25-year fixed-price contracts[9]. Since 2005 China has also begun to publicly fund R&D and projects with grants or favourable loan terms. China's "green development" is considered a win-win strategy that, through aggressive demand and supply policies, can complement the attention to both profit and the environment.

Germany is also considered a leader in the entrepreneurial nature of its public authorities towards the green transition. Concerned with the goal of promoting both renewable energy and domestic manufacturing, since the 1990s Germany has massively invested in wind energy which continues today. This has resulted in German manufacturers leading the wind energy market, while at the same time providing annual growth in wind capacity.

The US, on the other hand, is considered an example of state uncertainty and missed opportunities. The US is considered to have failed in supporting more mature technologies and RES. Given that Mazzucato's paper was written in 2015, the IRA would be probably praised by the author for its long-term approach and massive state incentives for domestic clean technologies. A key reason for

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[8] State-owned enterprise

[9] Contracts in which the price of energy is fixed throughout the contract term, reducing price volatility and uncertainty for both suppliers and consumers of energy

the uneven performance of the US is its heavy reliance on venture capital to support the development of green technologies. Venture capital however is considered to be an "impatient capitalist" since investors are not interested in sustaining the risks and costs of technological development over a long-term period and are only concerned with profit. The public sector on the other hand is the only actor able to fund the riskiest and most capital-intensive projects in green technology. To support this thesis, Mazzucato takes the example of Solyndra, a leading manufacturer of solar photovoltaic (PV) systems, which declared bankruptcy in 2011 and received $527 million loan guarantee from the US government to develop solar panels. With the price of silicon (a fundamental component of solar panels) soaring in 2009, the company was attracting both public and private investors. However, when the price of silicon plummeted, venture capital investors, who invested $1.1 billion in the company, fled when it was not economically profitable anymore. Usually taken as an example of government failure and incompetence, Mazzucato argues that the same amount of money lent to Solyndra was later lent to Tesla Motors for the development of its S model, which resulted in a really successful investment. Given the high reward for Tesla, the author suggests that a small percentage of Tesla's profits could return to the state because of the high-risk investment the public authorities had undertaken. This could prevent the innovation policy from only socializing the risks and not the rewards.

In conclusion, Mazzucato argues that the role of governments is key in spurring innovation and technological progress. The main rationale behind it is that the public sector can engage in high-risk investments that the private sector, being risk-averse, is not willing to take. Her thinking goes beyond the commonsensical argument that the state should intervene in the markets only when negative externalities arise to nudge the private sector towards a socially preferable direction. On the contrary, she holds that the "entrepreneurial force" comes from the state rather than from the private sector-led innovation through incentives such as subsidies, tax reductions, carbon pricing and technical standards. To support her arguments, she picks some notable examples of massive long-term government support and state-led innovations in clean technologies from countries such as China, the US and Germany. In her vision, the State should "provide the vision and the dynamic push to make things happen that otherwise would not have" (Mazzucato, 2015: p. 31), and the green transformation requires nurturing risky new industries with long-term commitments to manufacturing and market, which can be only achieved through major government investments.

3.3 A Market-based perspective for innovation policy

If the growing size of interventionist policies we are witnessing today in both the US and the EU can find a theoretical justification in the concept of the Entrepreneurial State, other scholars are critics of such an approach and dismiss the idea that a strong industrial policy is necessary for pushing innovation in the economy. This section will present the main arguments against the concept of the Entrepreneurial State by referring to two books: "Questioning the Entrepreneurial State, Status-Quo, Pitfalls and the Need for Credible Innovation Policy" (Wennberg and Sandström, 2022)[10] and "The Myth of the Entrepreneurial State" (Mingardi, 2020). The core ideas underpinning the rejection of the Entrepreneurial State are that, particularly under Knightian uncertainty[11], the state lacks the information and competence to address a challenge that the private sector usually has. Second, the state lacks a system of accountability for its behaviour. Finally, the state has a crowding-out[12] effect on private actors.

An argument to refute the idea of the Entrepreneurial State comes with the notion of ownership competence, developed in Part II of "Questioning the Entrepreneurial State, Status-Quo, Pitfalls and the Need for Credible Innovation Policy" (Murtinu et al., 2022). The authors define ownership competence as the ability of owners to create economic value depending not only on their incentives but also on their ability. Public actors lack access to information and specialized knowledge held by market participants, which compete against each other in decentralized markets stimulating R&D and innovation, something which the state, with a centrally planned structure, cannot achieve given its ineffectiveness in gathering and processing information necessary to assess profits opportunities. But public authorities also lack the ability to play an ownership role. The owners' idiosyncratic competence drives their ability and efficiency to access resources and recombine them to maximise value creation. Under Knightian uncertainty, it is meaningful to possess ownership competence, as the uncertainty about future outcomes makes it impossible to know in advance how resources should be allocated. If the market process tends to place ownership titles in individuals with higher levels of ownership competence (those using private resources to create value, and whose livelihood depends on creating market value), government intervention

[10] This book is a collection of papers from 30 international scholars
[11] Lack of quantifiable knowledge about possible occurrence. It is an economic concept that acknowledges a degree of ignorance and unpredictability of future events
[12] Economic theory that argues that rising public sector spending drives down or even eliminates private sector spending

and government ownership hampers this process given the different goals between private and public actors.

On the one hand, private actors operating in markets aim to maximize their profits. On the other hand, government officials tend to maximise votes and influence. Hence, government actors are not literal owners, but stewards of resources owned by taxpayers. This process can attract a higher level of rent-seeking activities[13] towards public entities. To show the competence problem of owners picked by the state, the authors refer to the overall failure of state-owned enterprises by citing a famous article in The Economist entitled "State capitalism in the dock" (2014). The article shows the poor performance of SOE in a variety of countries. For instance, state-owned banks in China and India displayed lower evaluations than private banks. Petrobras, an SOE in Brazil, is another example of bad management that led to corruption scandals and stagnant economic growth. Overall, the SOEs among the world's top 500 firms have lost between 33% and 37% of their value in dollars since 2007 in 2014, while global shares have risen 5%.

To explain the lower score of government entities entering markets, Murittu et al. (2022) also refer to the incompetence of politicians and their inability to perform the tasks to which they have been appointed. Faced with information asymmetries when judging the abilities of politicians, voters often cannot understand the capabilities of elected politicians. Politicians manipulate this asymmetry and present themselves as competent in specific areas. This is particularly evident in the case of fiscal policies, in which politicians often call for overly expansionary fiscal policies to solve voter's problems. This process then materializes with strong intervention of politics in firms and markets.

Another point stressed from the ownership competence perspective is that failure is assessed differently between private actors and the state operating in markets. If state entrepreneurs can invest in technologies they like because of their access to taxpayers' resources, private actors risk their money and are accountable to their financiers for bad economic performance. The authors argue that while Mazzucato acknowledges the market failures arising from the risk aversion of investors to engage in long-term high-risk investments, she does not consider the potential failures arising from publicly funded projects. If public investments fail, the consequences will be higher deficits and debt, without a positive impact on aggregate productivity. This would then result in

[13] When an entity seeks to gain wealth without any reciprocal contribution of productivity (Investopedia, 2021)

stagnant productivity in the long term, which is essential for economic growth, reduced sustainability of the debt and fewer resources to face unexpected crises such as COVID-19 and the Russian invasion of Ukraine.

Starting from the concept of failure it can be argued that state entrepreneurship lacks a system of accountability. Since the entrepreneurial state is aimed at fixing and shaping markets, it faces no market competition and hence it cannot be properly evaluated (Larsson, 2022). While entrepreneurs are constrained in their activities by available capabilities and opportunities, the state can ignore both. By having a mission-oriented policy, the state is actively shaping markets, moving the economy towards a new equilibrium and influencing innovation and entrepreneurship with a proactive involvement, not only working on the external context but having its own entrepreneurial decisions. According to Larsson, this process crowds out market-driven entrepreneurship and makes it difficult to define what constitutes failure for the state. Profitability in markets can indicate what is a failure and what is a success. If private entrepreneurs are forced to be realistic when they invest in something that fails, they will run out of investors and outcompeted in markets. On the other hand, with state entrepreneurship there are no such mechanisms: the state is not constrained by market forces and a loss does not result in politicians shifting away from the selected investment. If the state is picking winners in markets, there are no mechanisms to make it stop. The outcome of this is that the entrepreneurial state distorts private entrepreneurship in areas outside the selected targeted schemes by rendering entrepreneurship in areas outside of the state's preferred sectors riskier and less profitable. Hence, by titling the level playing field for business, state entrepreneurship crowds out alternative solutions and means that would otherwise emerge in competitive markets.

Larsson (2022) however claims that he does not have an ideological position against state intervention in the economy. He acknowledges that in case of a clear outcome and measurability, state-led innovation can spur large technological spillovers (such as the landing on the moon). In some circumstances, state investments come with large spillovers if it is properly managed. When accountability is in place and the project is based on a cost-benefit analysis, economists agree that positive externalities can emerge. This is the case for instance with large infrastructural projects, which are often preceded by debates on cost-benefit analysis, accessibility and spillover effects of the project. The problem however consists of favouring a top-down approach in the whole economy by thinking that innovation can be spurred by a radical shift in favour of state's entrepreneurship.

Discussing the green transition, Larsson (2022) argues that if the EU wants to achieve the Green Deal's goal of cutting emissions by 55% by 2030 and reaching climate neutrality by 2050, this would require an accurate evaluation of the direct effects of the policy, its indirect effects, opportunity costs on unrelated sectors, and whether the target can be achieved through acceptable means. This challenge is not considered such as the space race, in which the Apollo project had clear and defined goals and the international competition was high. In the case of the green transition, there is no single acceptable solution that people agree on. It represents an example of Knightian uncertainty, in which there are challenges but there are no defined solutions to solve such challenges. Hence, it would be unlikely that targeted technological solutions picked by the state will help solve the climate challenge. However, as will be argued in Chapter 4, we should not think about the green transition to be deployed by the private sector alone. Given that CO_2 emissions are not accounted in the costs of producers and price paid by consumers, government intervention to align the private cost to the social cost is then necessary. The debate is however over the means and intensity by which the government decide to intervene in fixing such market failure, which in the EU is often contradictory and does not put the socially optimum level of carbon pricing as the first priority.

Other authors, such as Mingardi and Mccloskey (2020) and Grafström (2022) have concentrated their work on confuting the examples of successfully state-led innovation brought by Mazzucato. Whereas Grafström focuses on the performance of the wind power industry in China, Mingardi and Mccloskey concentrate on DARPA and the invention of the internet.

Most investments in the wind power industry in China have been made by the Central State-Owned Enterprises (CSOEs). Grafström (2022) finds that such investments resulted in the construction of numerous wind power plants but without significant added value. The main criticism against the Chinese approach is that first, it built infrastructure for wind power generation without having an efficient grid infrastructure, demonstrating how forced state planning lacks accountability and the political goals of the Chinese party are prioritized with respect to economically profitable investments. Second, the author estimated that even though domestic patents[14] were abundant, Chinese firms have received few international patents (in the EU and the US markets patents are highly incentivised through large monetary benefits). Grafström concludes that this shows how the "win-win strategy" (Mazzucato, 2013) of China in pursuing profitability and sustainability was not

[14] Patent data is often used to compare countries' innovation activities

achieved and how state-planned investments in the Chinese wind industry did not bring significant technological spillovers.

Mingardi and Mccloskey (2020) disagree with Mazzucato's claim that DARPA is an example of a successful state innovation program (see section 3.2 for Mazzucato's interpretation). The authors claim that it was not the state that invented the Internet but rather an ecosystem of inventions and instruments. They argue that for the government to have invented the internet, the state should have had at least an anticipation of the invention. If the state did not have a clear directionality in the DARPA program specifically to invent the Internet, it cannot be considered as planning with directionality. Instead, it should be considered more as an unintended consequence or mere happenstance.

Section 3.3 discussed the main positions against the concept of the Entrepreneurial State. They can be summarized as follows. Critics mainly focus on the lack of knowledge, ability, and competence of public authorities to engage in entrepreneurial activities. If Mazzucato and supporters of the entrepreneurial state have faith in the intentions of public actors, other observers stress the fundamental difference in the goals pursued by public and private actors. If the first are interested in gaining influence and votes, the second are by nature driven by profit. For this reason, the state is not really able to perform entrepreneurial activities and should not be the central core of innovation. Another common argument against the entrepreneurial state is that there are no efficient mechanisms to make public authorities accountable for their failed investments. While private actors are risk-takers and are punished by markets if they fail, the state has no constraints of such form whatsoever. Hence, the best approach to provide the economy with innovation and technological progress, specifically in a situation of Knightian uncertainty, is from the bottom-up, driven by individuals competing one against the other to make their inventions profitable.

3.4 A third way for industrial policy

Moving beyond the dichotomy between top-down industrial policy measures and market-based solutions is the work of Rodrik (2004), which paved the way for a third middle-way approach to address innovation and technological progress. This approach is based on a nuanced use of industrial policy based on the cooperation between the private and the public sector.

According to the influential work by Dani Rodrik, industrial policy should not be considered as about addressing negative and positive externalities with Pigouvian taxes or subsidies, but rather as an “interactive process” between the private and public sectors which can serve as a pool of information for business opportunities and market failures and that generate policy initiatives in response. He argues that is impossible to establish ex ante the outcomes of such a process and the policy instruments to be used. It should be much more important to have a process revealing the areas that need intervention. “Industrial policy is a state of mind more than anything else” (Rodrik, 2004, p.38).

Such a form of industrial policy is thought to complement rather than distort market forces by reinforcing or counteracting the allocative effects that existing markets would otherwise produce. This framework should maximize economic growth while minimizing the risks that will generate waste and rent-seeking activities (Rodrik, 2004).

For the public sector, to prevent corruption and rent-seeking and be able to access the information the private sector has, there are critical institutional elements to possess. These include strong governmental support for industrial policy, coordination between private and public sectors through deliberation councils, and transparency and accountability in the decisions taken for industrial policy. As illustrative programs, Rodrik lists: contests for private-sector entrepreneurs to bid for public resources by bringing pre-investment programs (to reduce uncertainty for new products); developing mechanisms for higher risk finance (the private sector is too prudent) such as development banks; public R&D; subsidizing technical training to address shortages of skilled personnel in new technologies; and finally attract skilled nationals abroad back home (can be a source of self-discovery in the domestic economy).

The Brussel-based think tank Bruegel has recently applied Rodrik’s framework to interpret the contemporary challenges faced by the European Union in the area of industrial policy and fight against climate change. In a policy contribution entitled “Sparking Europe’s New Industrial Revolution: A policy for net zero, growth and resilience” (2023), 18 authors (including Rodrik) explain, from different economic perspectives, the need for the EU to initiate a form of industrial policy that considers both the failure of all-out state interventionism and the need for public authorities to intervene in the economy in some circumstances where the private sector might fail, especially in the transition towards a greener economy. This section will present some of the academic contributions included in Bruegel’s policy contribution (2023).

Aghion (2023) suggests establishing a sectoral-oriented industrial policy that preserves competitiveness between private actors and minimises subsidies to large incumbent firms that limit access to markets for better-performing firms. Industrial policy governance should then concentrate on making it compatible with competition and innovation-led growth.
To support his argument, Aghion refers to DARPA. As Mazzucato, he appreciates DARPA for its combination of top-down and bottom-up approaches. First, the Department of Defence funds the programmes and selects the programme heads (private entrepreneurs) for three to five years. On the bottom-up side, the programme heads can freely manage their programmes. Following the DARPA lead, Aghion proposes to create European DARPAs, aimed at promoting assertive industrial and innovation policies. Such projects should be funded directly from member states' governmental budgets and common EU borrowing mechanisms. This seems to resemble the EU approach in the NextGenerationEU funding (approved in 2020), which consisted of pooling resources (€750 billion) for massive investments for growth in countries most hit by the economic crisis caused by the pandemic. It marked the first time in which the EU used common borrowing mechanisms.

Aghion also argues that the EU should rethink its market-based approach by changing its internal rules. He calls for the update of the Stability and Growth Pact by granting more funds for countries succeeding in structural reforms; he proposes to take an ex-post approach for sectoral state aid in competition policy, as long as it does not result in declining competition or barriers to entry.

Cantner (2023) questions whether industrial policy is appropriate to cope with the issue of technological sovereignty, defined as the ability of a national economy to “provide itself and further develop a technology it deems critical for its welfare, competitiveness and ability to act, and if it can participate in its standardisation and is able to apply and to source this technology from other economic areas without one-sided structural dependency” (Edler et al, 2023, p.2]. His contribution to the debate is notable as the EU (as well as the US) is struggling to secure materials and technologies that are critical for the green transition (such as semiconductors for renewable energy deployment and rare-earth elements to produce EV batteries).

To understand the concept of technological sovereignty at the aggregate level, it is first significant to analyse it at the microeconomic level. The author explains that individuals (operators in the market) achieve technological sovereignty when they generate a technology themselves and make it available to themselves. This can be referred to as autarky. However, in autarky, an individual is not guaranteed the best technology is available to oneself, but only the technology one is able to provide to oneself. Hence, one can acquire better technology in the market. This implies additional costs stemming from developing competencies and skills to use the acquired technology (absorptive abilities). Constraints can arise from the availability of such technology in the international market: the presence of supply chain disruptions, trade restrictions, and excessive dependence on few foreign suppliers are all factors potentially diminishing the availability of the technology. An alternative solution can be choosing to reshore the activity to secure supply, but this option is much more costly, given the costs of know-how and competencies needed to develop a technology elsewhere (Cantner, 2023).

The issue of technological sovereignty becomes relevant to economic policy when at the aggregate level a substantial number of actors or sectors lack key technologies. As the Solow model explains, capital accumulation and technological progress enable higher productivity and, hence higher economic growth in the long term. In a multi-state context, lagging economies can use external knowledge to imitate leading economies and catch up through additional knowledge. Catching up depends on the level of technological gap between economies. The larger the gap, the more knowledge can be learned. But also, the larger the gap, the more difficult it is for an economy to catch up. For this reason, up to a certain threshold, a catching up economy can take advantage of knowledge spillover. After that threshold, the catching up is reduced or even absent.

Different economies have different patterns of development, given the environment of endogenous learning-driven processes of generating new technological knowledge. In international trade, the consequence is an uneven distribution of new knowledge across economies. For this reason, it is important for an economy to gain a comparative advantage[15] over time through R&D. In a dynamic context (a situation in which economies continuously generate new knowledge and technologies), to prevent a large technological gap, a country should specialize in goods with high potential for improvement. Especially in periods of structural transformation driven by new technologies, gaining technological leadership is fundamental in the international context especially for gaining competitiveness and reducing over-dependence on suppliers.

In the current global green transition and international tension, the issue of technological sovereignty becomes relevant. Choosing a trade structure based on goods with a high potential for innovation is therefore significant. To do so, Cantner concludes that a moderate level of industrial

[15] Ability for an economy to produce a good at lower opportunity costs than anyone else

policy (through subsidies and R&D), together with some protectionist measures (barriers to more competitive foreign goods and technologies) until international competitiveness is achieved, is necessary to gain technological sovereignty in selected goods and key technologies. This would explain the current ambition of the EU and US through the IRA to pursue the green transition with the aim to relocate production of key technologies within their territory, even if this means growing public intervention in the economy and some forms of protectionist measures in international trade. Cantner however hopes this does not end up in the extensive use of industrial policy in the whole economy.

Terzi (2023) explains that the first-best policy to address a global externality such as climate change would be carbon pricing. However, given the fact that we live in a suboptimal society, carbon pricing is not sufficient. Other market processes work against decarbonisation, such as path dependency that incentivises the use of fossil fuels, risk-aversion of the private sector to invest in new technologies and the large redistributive implications the optimal level of carbon pricing would have.

Terzi acknowledges that industrial policy will inevitably be designed with a protectionist approach at the national level. Hence, this would entail a new international subsidy race as domestic firms and political actors will try to favour the domestic economy by discriminating against foreigners through trade barriers and local content requirements. Countries that will succeed in the international context will be those with enough financial means and fiscal resources to support domestic businesses. On the other hand, poorer countries will suffer from decreased international competitiveness and will be forced to increase trade barriers to protect domestic production.

Another problem arising is that industrial policy will also distort prices (by intervening in the markets, governments will inevitably distort the price mechanism, and consequently the equilibrium between supply and demand). This will result in higher prices for consumers at home and lower access to internationally cheaper products. Terzi however suggests that these challenges can be overcome if the speed of innovation in green sectors is fast enough to lower cost curves. This would mean seeping up significantly the development and deployment of green technology. In this framework, competition still plays a crucial role. Hence, competition policy should not be loosened, and state aid policy should be restrained.

To avoid tendencies of isolationism in international trade, trade partners should engage in international economic agreements as a natural response to a fractured multilateral trade order.

This idea resembles Nordhaus' theory of establishing an alliance of countries engaging with climate-friendly policies (Nordhaus, 2014), known as the "Climate Club"[16] to make countries that free ride (costs of emissions-reducing policies are paid locally by countries, while the benefit is global). Finally, to support poorer countries in the global south, Terzi suggests enhancing climate finance and climate-linked aid.

3.5 Bridging theory and practice

The literature review provided in this chapter will serve as a starting point for a critical analysis of the current EU direction in industrial policy. By referring to the economic theories listed in this chapter, the rationale of the EU Green Deal Industrial Plan (see Chapter 2 section 2.1.1 for its regulatory framework) is to address the new economic challenges by conceding a stronger role to public authorities. This approach can be defined as giving a "directionality" to the economy, a perspective that is highly supported by the concept of the Entrepreneurial State. Chapter 4 will address the risks the EU can face in adopting such policy initiatives. It will provide a range of examples in which interventionism has not worked, specifically in the implementation of energy taxes and subsidies, resulting in a significant waste of public resources. In Chapter 4 it will be argued that an efficient climate policy should pursue the polluters pay principle, in which carbon pricing is the core policy tool. Finally, Chapter 4 will discuss the economic theories presented in this chapter in light of the alternative framework that will be suggested.

[16] According to Nordhaus, this would entail trade restrictions to those outside the club, so to incentivise them to shift towards climate-friendly policies

FOURTH CHAPTER

A cost-efficient climate policy

This section will present why a market-oriented approach to the green transition is more economically efficient than a top-down approach with a centrally planned framework. It will be argued that although climate change is a negative externality that cannot be solved by market forces alone, the widespread use of policy instruments such as subsidies and inconsistent taxation limit the pace of the green transition. In the public debate, climate policy is usually not addressed by balancing the benefits and costs of reducing carbon emissions. As Nobel laureate William Nordhaus noted in his Nobel Prize Lecture (2019): "*If, for example, attaining the 1.5°C goal would require deep reductions in living standards in poor nations, then the policy would be the equivalent of burning down the village to save it*". This calls for an approach to climate policy that is centred upon a cost-benefit analysis. All emission-reduction policies impose costs on certain categories of society to reduce CO_2 emissions. Hence, an efficient climate policy requires concentrating on tools and instruments that reduce emissions at a lower cost compared to others. It will be argued that the best instrument to address climate policy is applying the "polluters pay principle", in which those that emit the most should carry the costs of the negative externality they create.

As shown by the literature presented in this Chapter (mainly based on Booth and Stagnaro, 2022 and OECD, 2013), the tools that let society apply this principle at the lowest cost are a carbon tax and a carbon emission trading system: they raise the relative price of carbon-intensive products, while implicitly subsidizing low-emission products. They also let individuals decide by themselves, having access to the market, the cheaper way to shift away from carbon-intensive products. On the other hand, other policies such as subsidies or regulations banning certain technologies transfer resources from one category to the other (from taxpayers or consumers to specific producers), resulting in higher costs imposed on society, prevent individuals from finding innovative ways to reduce emissions in carbon-intensive technologies, and incentive overall energy consumption instead of energy consumption reduction measures. It will be finally argued that supporting the losers of such a transition should be a priority for policymakers, as well as pursuing coordination at the international stage because the climate can only be mitigated if there is action at the global level.

4.1 The inconsistency of energy taxes and subsidies in the EU

An insightful report on the effectiveness of policy instruments in the green transition was published by the OECD in 2013. Entitled "*Effective Carbon Prices*", the report compares the effective price put on carbon by policies in different sectors and countries, providing evidence of the actual cost-effectiveness of policies to reduce carbon emissions. By referring to the effective carbon price, the report calculates the net cost of reducing carbon emissions for each unit of abatement that different policy instruments impose on society. The report analyses the electricity sector, road transport, the pulp and paper sector, the cement sector, and the households' use of energy in 15 countries, including the US, France, Spain Germany, and China.

The report finds that, especially in electricity generation, road transport and the household sectors both carbon taxes and emissions trading schemes score significantly lower effective carbon prices than those associated with other policy instruments, such as subsidies. The report concludes that the reason for the lower effective carbon price is the higher cost-effectiveness of these policy instruments. For house insulation, for instance, the CO_2 abatement levels could have been achieved at a lower cost to society using taxes rather than subsidies. Generally, the costs per unit abated for taxes tend to be lower in this sector rather than other subsidy schemes (OECD, 2013, p. 89). For other sectors, such as subsidies for biofuels and RES, the effective carbon price was found very high relative to taxes and emissions trading schemes.

On the other hand, for the cement and pulp and paper sectors, the instruments with the highest effective carbon price were emission trading schemes. The reason for this poorer performance can be found in the reluctancy of countries in applying emissions reducing schemes in these sectors. The largest cost of carbon-related policies in the pulp and paper sectors was found in Germany with a total cost in % of GDP of 0.004, with France following with 0.0006% (OECD, 2023, p.72). Hence, the relative higher effective carbon price of emissions trading schemes compared to other measures is due to the higher ambition of the schemes in reducing carbon emissions, compared to subsidies or feed-in tariffs which were used too little to have an impact on the behaviour of firms in the sector.

For the purpose of this work, the OECD findings are relevant because they suggest that subsidies impose a high burden on society and are sometimes not implemented having carbon emissions abatement as a priority.

Booth and Stagnaro (2022) offer a more recent study on the effectiveness of energy subsidies and taxes in the European Union. The authors argue that energy taxes have been implemented mainly to raise revenues for the government. Generally, energy taxes increase their prices and if taxes are not levied in proportion to the externality arising from the use of a particular fuel, they distort markets and may not even reconcile social and private costs. Their analysis shows that the relationship between environmental damage and energy taxation is indeed weak in most EU countries. The same energy source is often taxed differently depending on how it is used even though this does not affect the level of carbon emissions. Additionally, the same energy source (mainly fossil fuels) is often taxed and subsidized at the same moment, in a rather contradictory combination of actions. If a case for subsidies supporting research and development of clean technologies ca be made, as R&D can produce innovation-related positive externalities, in the EU only a small proportion of subsidies are directed towards R&D and innovation. In 2018, only 2.9% of total energy subsidies were directed towards such activities in the EU. The largest share of subsidies was directed to energy production and consumption of both fossil fuels and renewable energy.

The authors find that the main issues with subsidizing RES are that:

1. Impact on carbon emissions reduction is limited: subsidizing renewables may lead households to consume more energy overall if subsidies to fossil fuels are still in place and households are not encouraged to reduce energy consumption.
2. The use of an intricated framework of different RES subsidies can lead to interest groups investing resources in rent-seeking activities and lobbying.
3. RES subsidies vary dramatically between energy sources. For instance, in 2018 the average EU subsidy for solar power in 2018 was €248 per MWh. This represents almost twice the average level of subsidies for offshore wind, at €138 per MWh, and slightly less than five times that for onshore wind, at €54 per MWh. But if we consider the difference in environmental pollution caused by wind and solar power, Our World in Data (2020) calculates that solar power emits 5 tonnes of GHGs per gigawatt hours (GWh) of electricity produced, while wind power 4 tonne. Hence, the differentiation in in the average subsidy in the EU between the two energy sources do not seem to be motivated by the amount of carbon emissions these two energy sources produce.

An efficient climate policy should reconcile energy taxes, subsidies and the cost that CO_2 emissions impose on society in order to guide resource-allocation decisions. If taxes and subsidies are poorly related to their cost-effectiveness, any further reduction of carbon emissions will come at a greater economic cost.

4.1.2 Energy taxes

To support their argument, Booth and Stagnaro analysed energy taxes and subsidies in both the EU and the UK, taking as a reference the year 2018[17]. To compare the differences in energy source taxation, they present taxes with a common metric, that is tax per tonne of oil equivalent (TOE)[18]. Figure 17 shows that oil is the most taxed energy source, with €334 per TOE in the EU. Natural gas is second with €101 per TOE, coal €84 per TOE in the EU, while nuclear and RES are both taxed €80 per TOE in the EU. It needs to be considered that within the EU, energy sources are taxed differently between member states. For instance, oil is taxed €179 per TOE in Cyprus and €487 per TOE in Italy. As far as gas is concerned, there are almost no taxes in some member states (particularly in Central and Eastern Europe), while for instance in Denmark there are significant taxes.

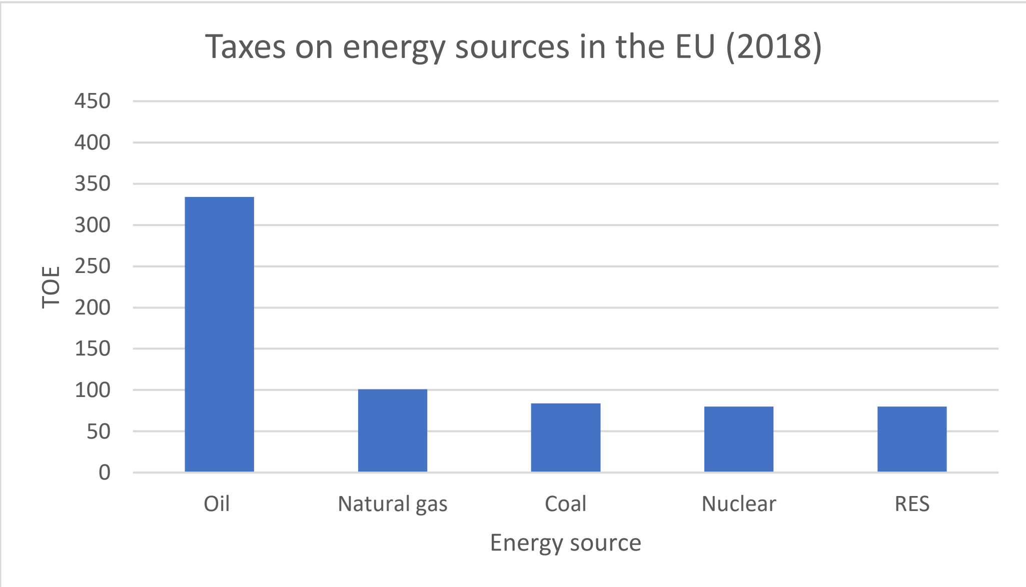

Figure 16: Taxes on energy sources in the EU, 2018. Euro per Tons of oil equivalent (own elaboration based on Booth and Stagnaro, 2022)

If prices after taxes do not reflect well the negative externality that the different sources produce, the effective carbon price is too high with respect to the socially optimum one, and consumers will

[17] Their analysis is based on Eurostat data, and the authors acknowledged that they made some approximation with the taxation level by averaging across uses and users (since energy sources are taxed differently depending on their use). This is because data on the effective tax rates per unit of carbon emissions or per unit of energy source are not available.
[18] Unit of energy defined as the amount of energy released by burning one tonne of crude oil, often used to compare different energy sources

pay a higher price than without the tax. As can be seen in Figure 17, even if coal is the most polluting energy source (Our World in Data, 2020), it is taxed less than oil and natural gas, and this jeopardizes the cost effectiveness of the measure. Coal is taxed slightly more than nuclear, considered one of the most carbon-neutral energy sources. At the same time, RES are taxed only 4€ per TOE, even if they receive a large amount of subsidies, and are considered the best technologies to lead the green transition.

4.1.3 Energy subsidies

Not only taxes are chosen with little reference to the external costs of the diverse energy sources, but also subsidies seem not to follow a reasonable environmental policy. As presented in Figure 7 and Figure 8 in Chapter 2, energy subsidies have been increasing constantly in the EU since 2015. Stagnaro and Booth (2022) estimated the subsidies per TOE by energy source. As shown in Figure 18, RES subsidies average €320 per TOE, oil €47 per TOE, coal €44 per TOE, and natural gas €27 per TOE. Also within RES, there are significant differences in subsidies: €2019 per TOE is awarded to solar power, wind power 743€ per TOE, while hydropower and bio-energies are less than €100 per TOE. As in the case of taxes, moreover, subsidies to energy sources vary significantly between member states, with some subsidizing heavily fossil fuels (coal €263 per TOE in Sweden, while oil €314 per TOE in Estonia), and others directing a high amount of resources at RES (€674 per TOE in Germany, €1000 per TOE in Malta).

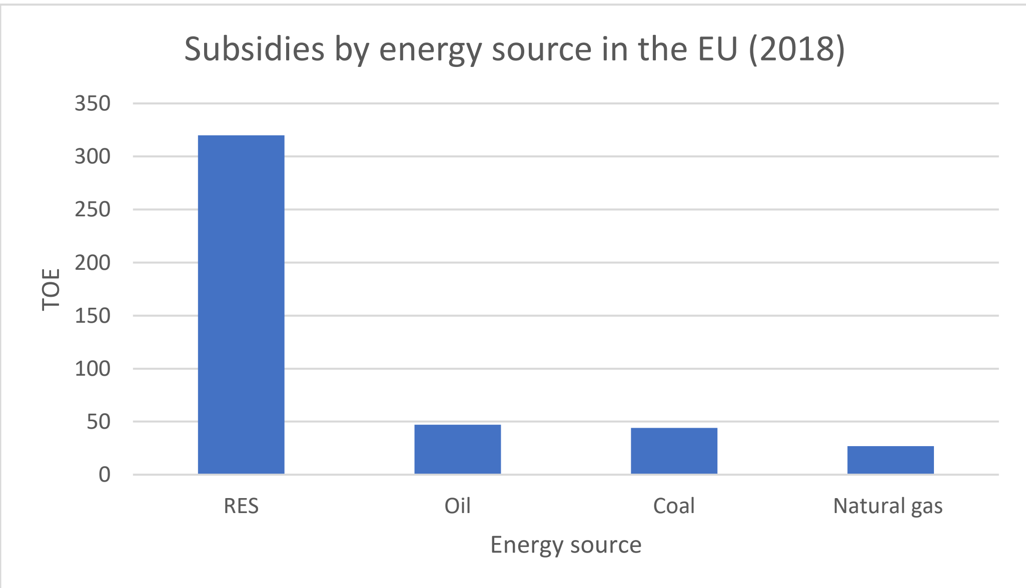

Figure 17: Subsidies by energy source, 2018 (own elaboration based on Booth and Stagnaro, 2022)

Stagnaro and Booth estimated the net amount of taxes and subsidies so as to understand what energy sources are *net* recipients of government support or not.

RES appear to be net recipient of subsidies: €240 per TOE in the EU, although with substantial differences within the category (e.g., solar power receives more than €1900 of TOE, while hydropower about €480 per TOE, and biomass €15 per TOE). On the other hand, natural gas, coal and oil have greater taxes levied on them than they receive in subsidies. It appears that there is no coherent pattern in this case as coal, the most polluting energy source, is taxed the least.

These data show that the EU does not follow an environmentally friendly and economically efficient rationale. Four are the main problems identified:

1. Polluting energy sources (e.g. coal) receive more subsidies than other sources (e.g. natural gas) that have a weaker environmental impact. All energy sources are taxed too little with respect to the negative externalities they produce through carbon emissions.
2. Fossil fuels are both subsidized and taxed at the same moment. This means both taxpayers and final consumers pay a higher price than it would be without a tax or a subsidy.
3. The impact on carbon emissions reduction is limited because subsidizing renewables may lead households to consume more energy overall, even if the energy mix is more weighted towards renewables. Households have fewer incentives to invest in measures that reduce energy consumption. In the current context of FFS still in place, RES subsidies increase energy consumption without significantly contributing to reducing demand for carbon-intensive energy sources.
4. There is a notable difference in energy taxes and subsidies between EU member states. For instance, a tonne of CO_2 emitted by a gasoline-fuelled Italian car costs €430, while a tonne of CO_2 emitted from a coal-fired power plant in Poland is taxed close to zero, and in some cases, it even receives subsidies (Booth and Stagnaro, 2022). There are substantial differences within the RES category too. This might imply that there is no real assessment of the negative externalities of such energy sources, and other criteria guide the national authorities.
5. RES subsidies crowd out innovative efforts to find alternative solutions to reduce GHG emissions. For instance, the adoption of energy efficiency measures may be cheaper for the society than RES subsidies. State intervention in picking a peculiar technology to guide the green transition risks undermining investments and innovations in other cost-efficient

carbon-neutral solutions. Hence, subsidizing specific clean technologies means that the state is indeed picking winners on the basis of criteria that might not be consistent with cost-effectiveness.[19]

From 2018, it seems that there has been little change in the EU in its approach to taxes and subsidies for the green transition. As shown in Figure 9 in section 2.3.2, FFS have increased from 2015 to 2019 (up to €53 billion in 2021 terms), decreasing in 2020 and 2021 mainly due to the economic slowdown caused by the pandemic. Then, when the energy crisis hit Europe in 2023, EU member states decided to increase energy subsidies and support the consumption of energy. They did so predominantly by using price support measures to support households and businesses after the spike in energy prices instead of focusing on incentives for reduced energy consumption and targeted income support measures for lower-income households and businesses. Targeted support is economically more efficient than state interventions on prices. First, it protects the most vulnerable categories of the population who spend a higher share of their income on energy-intensive products (OECD, 2022), whereas price control policies tend to be regressive and help the wealthier segments of the population who consume more in absolute terms. Second, targeted support measures allow for sustainable fiscal costs for a longer period and maintain the price mechanism that permits supply and demand to balance each other, hence incentivising businesses to move away from costly fossil fuels and invest in more sustainable energy sources.

From October 2021 to March 2022, the share of income support measures grew steadily from 20% of the total (income and price support measures combined) in October 2021 to more than 40% in March 2022. However, after the cut in Russian gas supplies, in May 2022 the governments turned to price support measures again, which accounted for 66% of the total, against the 34% for income support measures (OECD, 2022)[20], which has contributed to the increase in the inflation rate in the Eurozone (10.1% in November 2022, Eurostat). Government intervention in prices through such measures is detrimental mainly because by setting a price that is higher (price floor) or lower (price ceiling) than the price that would be in a competitive market, the price mechanism is altered (Robinson, 2015, p.98). Prices incorporate vital information for both consumers and producers on

[19] Most likely, there is no single technology that will likely help governments achieve their climate targets: a variety of technologies can help achieve those targets, including technologies that are not yet developed and will be available in the future. For all these reasons, it can be argued that climate change represents the perfect example of Knightian uncertainty. Translating these elements into political action is not an easy task.

[20] These data refer to the members of the OECD, which include 22 EU member states and the EU Commission

the necessary adjustments for shortages and surpluses. The main consequence of such an approach is that in the longer term, in a supply shortage such as in the energy crisis, prices are pushed even higher because consumers are not incentivised to limit consumption and supply is not able to adjust accordingly[21]. A second significant effect is that allocating resources to subsidized sectors might reduce productivity and prevent firms from investing in new technologies (Guenette, 2020).

An additional issue that emerged from the energy crisis is that EU member states did not invest in structural consumption reduction programmes to ensure that the supply of energy was sustainable in the long term. Germany is the only country in the EU that proposed a plan addressing both demand and supply, and in general supported energy efficiency (Clean Energy Wire, 2022).

The EU has been able to respond relatively efficiently to the energy crisis mainly in terms of diversification of energy supplies and gas storage in 2022, together with a warm winter that helped member states reduce gas consumption. However, the widespread use of price support measures and a lack of lower energy consumption plans have contributed to the increase in the inflation rate over the last 3 years. This shows that economic efficiency was not prioritized in the EU approach.

This unpleasant outcome adds to another unexpected consequence. In 2021, the EU was among the 190 countries at COP26 that renewed their commitments to phase out the use of fossil fuels subsidies and stop the use of fossil fuels. The recent trend has instead gone in the opposite direction. In addition, if we consider the implementation of the National Energy and Climate Plans (explained in Chapter 2 section 2.3.2) to monitor the energy targets in the Green Deal, the EU Commission faced difficulties in gathering information on the member states' phasing out plans for FFS. Frequent changes in policy, lack of clarity and transparency and no clear end-dates for fossil fuels incentives represent further obstacles toward the direction of a clear framework in which the abatement of energy sources' negative externalities is put as a priority in climate policy.

[21] Referred to as suppressed inflation: when price control measures are lifted, the artificially low price for the products targeted by the measures is no longer available, hence prices will increase sharply (Neely, 2022).

4.2 Applying the polluters pay principle

As an alternative framework to subsidies, contradictory tax schemes and picking winners, Stagnaro and Booth propose to price carbon emissions coherently by applying the polluters pay principle, meanwhile supporting the most vulnerable categories of the society most affected by pricing. As the Report of the High-Level Commission on Carbon Prices (2017, p.17) notes, there are several distributional and ethical aspects that need to be considered in the design of an efficient carbon pricing mechanism because imposing higher carbon prices hits societal groups differently. Specifically, the owners and employees of energy-intensive sectors will be particularly hit by the higher prices of carbon emissions. Hence, as explained below, other complementary policies are necessary to ensure a fairer transition towards climate neutrality. In Figure 19 it can be observed how carbon pricing varies between countries (and between member states within the EU and in the EU ETS). The Carbon Price Corridor is based on the report of the High-Level Commission on Carbon Prices adjusted for inflation. The range between $61 per tonne of CO2 and $122 per tonne of CO2 is considered the best carbon price for 2023 in order to keep the global temperature below 2 degrees. As can be seen in the figure, countries apply different carbon prices, even within the EU. This is motivated by different cultures, economic activities, and the overall wealth of countries that make the decision to price carbon differently from each other.

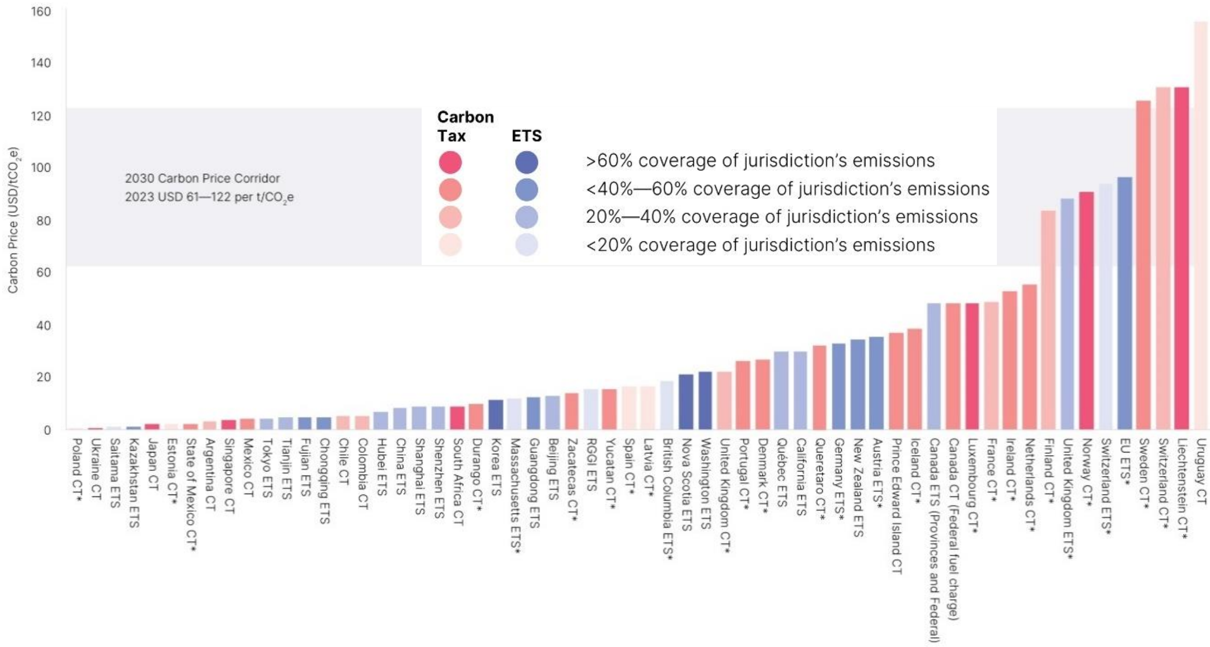

Figure 18: Carbon prices across carbon taxes and ETS, April 2023 (World Bank, 2023)

However, even if there is no international agreement on the best carbon price, at least a growing number of countries are implementing carbon pricing. Figure 20 shows that in 2023, 23% of global carbon emissions were covered by a carbon price, with respect to only 5% in 2005.

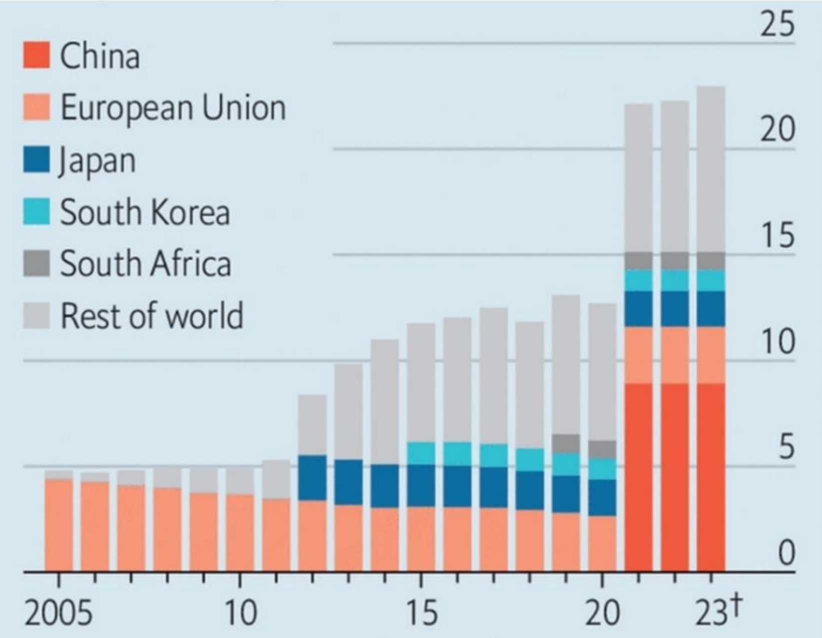

Figure 19: Carbon pricing initiatives as % of GHG emissions covered (The Economist, 2023)

Be it an emission trading scheme, or a carbon tax, there are several potential drawbacks of carbon pricing. While a cap on emissions works correctly if the government knows the necessary emissions reduction target, a carbon tax can reflect the externality and make supply and demand adjust to the optimal level of emissions. Moreover, a tax can be increased or reduced if the desired climate target is not achieved, while a cap cannot (Booth and Stagnaro, 2022). The additional negative aspects of setting up an emission trading scheme are the high price volatility, the presence of lobbying efforts (that can influence the allocation of permits), the unpredictable distributional effects, the administratively difficulty to manage the system. Figure 16 shows the evolution of the EU ETS carbon price from December 2005 to September 2023. In the last few years, the economic recession during the pandemic and the Russian cut in gas supplies after the invasion of Ukraine have contributed to an abrupt fall in the price of carbon. This is evidence of the high volatility and uncertainty still present in the ETS mechanism of carbon pricing.

Figure 20: Price of EU Carbon Permits per tonne of CO_2, 2005-2023 (Trading Economics)

Against the advantages of carbon taxes over the ETS, one has to consider their main downsides:

1. If not accompanied by an income support scheme, a carbon tax is typically regressive (hit harder on poorer and most vulnerable firms, which usually spend a higher share of their income on energy products)
2. It lacks a clear and publicly visible emission reduction target, which can hide the rationale of the carbon tax from the public.
3. Its acceptability in society is limited.
4. High is the complexity in determining the correct tax rate.

Given the inefficiency in the use of subsidies targeting specific technologies and the confused application of taxes on energy sources, however, pricing carbon emissions can at least ensure that people are incentivized to reduce emissions at a lower cost for society.

It would allow individuals to use the information about the cost and benefits of different economic activities so that they can find the lowest-cost approaches to reducing emissions. Booth and Stagnaro (2022) prefer a carbon tax to an emissions trading scheme because it is more transparent and easier to manage. This view is supported by the findings of the Report of the High-Level Commission on Carbon Prices (2017), which suggests that carbon taxes are easier to manage because they do not need a market-based trading system and neither rules to prevent market manipulation. All things considered, both approaches are better and less distortionary than discretionary subsidies to climate-neutral technologies and inefficient fossil fuels taxation. Both are more transparent than alternative instruments where policymakers crowd out any form of competitive selection by picking the preferred technologies with a top-down approach. The main rationale behind such approaches is the polluters pay principle and they are clearly visible, and not chaotic and incoherent such as subsidies.

The priority for policymakers should then eliminate subsidies to both fossil fuels and RES and use a carbon tax to make carbon-intensive energy sources reflect their social cost. This will most likely increase consumer prices but will incentivise innovation to find cheaper and more sustainable technologies, as well as incentivising energy efficiency and lower energy demand in carbon-intensive sectors. Additionally, a form of positive lobbying can arise from carbon pricing. When an industry faces carbon prices, businesses in such an industry will try to make competitors face the same carbon price. Hence, businesses will lobby to ensure a level playing field for all. This can be referred to as the domino effect of carbon pricing (The Economist, 2023).

An essential feature of applying the polluter-pay principle is that pricing carbon, as noted in the section above, is typically a regressive tax. To make up for this effect, other redistributive measures are needed. The higher fiscal capacity coming from the widespread use of a carbon tax and the elimination of energy subsidies would let policymakers dedicate resources to an efficient mechanism to support the most vulnerable categories of society affected by carbon pricing. In doing so, it is often difficult for countries to target the most vulnerable categories of society in need of support. Usually, countries adjust mechanisms for income support measures by relying on changes in the CPI (Consumer Price Index, which measures the average change in price over time of a market basket of consumer goods and services). However, vulnerable categories have different spending priorities with respect to the average consumer. For this reason, the OECD (2022) suggests adjusting income support measures to reference baskets taking into consideration goods and services representing the average standard for low-income households. Such mechanisms should then be accompanied by energy demand reduction programmes and improving energy efficiency.

4.2.1 Climate policy and the new world order

Applying the polluters pay principle cannot be thought of without considering the scale of climate change, which can be considered as a global negative externality. The three biggest economies in the world in 2021 represented only 51.91% of the total annual CO_2 emissions: the EU 7.52%, China

30.90%, and the US 13.49% (Our World in Data). This data suggests that even if the biggest players in the world decided to implement an efficient and rapid climate policy alone, this would not solve the issue. As Nordhaus argues, international agreements such as the Kyoto Protocol or COPs often fail to implement a coordinated policy on carbon emissions because countries' commitment is only voluntary and there is no enforcement mechanism in place. There is an incentive for countries to free ride, meaning that only those committed to implementing climate policies will bear the costs at the local level, while all countries can benefit from others' efforts. Countries are incentivized to promote national interests, thereby delaying the costs of adjustment, and put global concerns aside. This situation triggers the establishment of a non-cooperative equilibrium (Nordhaus, 2019).

Nordhaus' call for the creation of a climate club to overcome the problem of free-riding is a fundamental feature for the creation of an efficient climate policy. He designs a framework in which countries that comply with emissions-reducing policies should stick together and use trade sanctions against those countries that do not comply. As such, non-participants would be penalized and, through the implementation of an ad valorem tariff (tariff proportional to the price) on imports from non-cooperative countries, they would be incentivized to comply with the rules and enter the club. This solution would both protect domestic producers in their local sales, and alter the incentive for the foreign exporters. It is worth noticing that the size of the climate club market is an essential determinant of the strategy: this makes the US, EU and Chinese commitment in the limelight.

The EU is already trying to put into practice a trade mechanism, called the Carbon Border Adjustment Mechanism (a permanent system that should enter into force on 1st January 2026), which is a policy tool aimed at preventing carbon leakage[22] by imposing a carbon tariff on carbon intensive products imported in the EU. In principle, if operationalized, this could be an effective policy instrument to reduce CO_2 emissions in the EU and ensure a level playing field in the Single Market.

However, the design of the CBAM should address problems with its administrative feasibility. For instance, the costs imposed on importers should not exceed the costs that domestic producers face. In addition, exemptions should be considered to prevent that CBAM is imposed on countries that already apply a price on carbon emissions, and a case could be made for least-developed countries

[22] The European Commission defines carbon leakage as "the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints"

that would suffer the most from the mechanism (Stagnaro, 2020). Finally, it would require an accurate reconstruction of the carbon emissions associated with all the steps in the international value chains of EU imports.

Yet, finding the right dose of trade protectionism is not the only problem ahead.

Considering the EU-US relationship on climate policy, it appears clear that both areas are investing in distortionary measures: the protectionist nature of the IRA and the EU Green Deal Industrial Plan (discussed in section 2.1.1 in Chapter 2) suggest that US and EU have chosen to provide state aid policy to protect the domestic economy while investing in clean technologies. Although both the US and the EU are committed to adopt efficient climate policies, the local content requirements provided in the IRA and the CBAM may suggest that trade relations could be jeopardized.

If the EU and the US pursue a strong industrial policy, this will likely spark a subsidy race at the international level, with the results that only richer countries will be able to boost domestic markets and reshore clean production. On the other hand, poorer countries will be the ones most affected by increasing trade barriers. For these reasons, the EU should shift away from a policy based on loosened distortionary state aid and trade restrictions and should rather pursue international coordination and agreements to put a fair price on carbon emissions and exempt least-developed countries that are yet unable to cope with such carbon pricing scheme. In this way, the EU would use trade restrictions only to challenge countries not complying with climate policies and will ensure a cost-efficient green transition by applying the polluters pay principle.

However, other challenges lie ahead. We are witnessing increasing international tensions and a fractured world order. In this context, the EU leadership in climate action should consider that it needs a strategy that strengthens its relationship with allies that share its values such as the US, but also allows the coexistence with countries that intend to change the world order, such as India and China. These latter, remarkably, are respectively in the first and third largest polluters at the global level. This ideal strategy has been named by the European Council on Foreign Relations as “strategic interdependence” (Aydıntaşbas et al, 2023). This strategy would acknowledge the complexity of the new multipolar world order, which is no longer dominated by only two superpowers as in the Cold War. This would stress the idea that avoiding excessive dependencies on specific countries can pose a substantial threat to the EU’s stability, as the energy crisis following the war in Ukraine has demonstrated. However, to convince a high number of countries to embark on climate policy and create trade agreements that include climate targets, the EU should be willing to co-exist with regimes and other players that do not respect the rule-based order that Western democracies pursue.

4.3 Back to economic theory: the Entrepreneurial State or a market-based approach?

This section analyses the three economic theories presented in Chapter 3 on the role of the government in shaping the green transition by referring to the framework presented in this Chapter.

First, climate change is a global negative externality that cannot be solved by market forces alone. As discussed in this chapter, it is necessary to put a price on the negative externality of CO_2 emissions. If the state should have a role, it should concentrate on applying a carbon tax or an emissions trading scheme that, even if it is highly complicated, reflects at best the social cost that carbon emissions impose on society. In this sense, the government should have a primary role in shaping markets.

However, the recent trends in energy subsidies and taxation in the EU show that there is an inconsistent framework in their implementation. Fossil fuels subsidies are both subsidized and taxed at the same moment, while energy subsidies are often concentrated only on a few technologies and not on other low-emitting energy sources. This can indicate that the public authorities are subject to lobbying and rent-seeking activities by interest groups that try to direct resources to their specific sector. In this sense, Mazzucato's call for the widespread use of directionality by the state in green sectors falls short of evidence. Another aspect that is missed by Mazzucato is that it does not balance the benefits and costs that the green transition entails. Certain categories, especially the poorest, will bear higher costs of the transition towards a greener economy. Hence, it is of fundamental importance to pursue a climate policy that takes cost-effectiveness into consideration. The Entrepreneurial State implies that governments should not be concerned with the amount of resources they direct towards the economy. This however does not consider that public revenues stem from taxpayers' money and they do not represent an unlimited pool of resources.

In addition, if there can be a case for subsidies to R&D which can spur innovation in clean technologies and are highly supported in the Entrepreneurial State, in 2018 they accounted only for 3% of the total. The highest percentage was instead directed towards energy consumption and production.

A final point to be discussed is that the Entrepreneurial State does not consider the problem of the size of economies. In a big economy such as the US, the state can have access to vast amounts of resources and know-how that smaller economies simply do not possess. Discussing the Entrepreneurial State does not consider the political and economic reality of a variety of different states with different sizes and resources. This comes to the fore when discussing the importance of cost-effectiveness in climate policy, where bigger countries might be able to heavily subsidize, while smaller ones need to scrutinize with closer attention to their public resources.

The implementation of the polluters pay principle finds its best theoretical explanation under a market-based approach to the economy. As discussed above, current policies are more costly than they could be with the implementation of cost-effective policy instruments. A market-based approach to climate policy lets individuals with decentralised information find cheaper ways to reduce carbon emissions if it is accompanied by public authorities implementing a rational carbon pricing mechanism.

For instance, the EU ban on the sale of petrol and diesel cars from 2035 can crowd out alternative solutions. Banning technologies assumes that the government possess the knowledge to replace the carbon-intensive ones that it decides to phase out. However, it might happen that a government ban a technology that turns out to be extremely expensive to replace with a carbon-neutral alternative. Furthermore, phasing out petrol cars almost guarantees that businesses cannot profit from making them more carbon efficient in the future or low-carbon fuels from developing. This would represent a constraint on innovation and limit the opportunity for the market to come up with cheaper ways to reduce CO_2 emissions.

One argument that can be contested in the market-based approach is that the government should have a role in putting a price on carbon emissions. Public authorities have a primary role in quantifying the costs of emissions that society pays for, such as environmental damage and health care costs, and transform them into a carbon price through the implementation of carbon taxes and/or emissions trading schemes. It is a demanding task, but it represents the best way to implement an efficient climate policy.

Second, governments are necessary to obtain the core information for applying redistributive measures to help those categories of society that will suffer the most from the widespread use of carbon pricing. As explained above, a governmental database to target such categories is necessary.

A valuable contribution to the discussion is offered by the "third way" of industrial policy provided by the work of Bruegel (2023) and Rodrik (2004). A case for moderate use of trade measures for achieving technological sovereignty (see section 3.4 in Chapter 3) in the EU can be made in a transition towards a greener economy: securing domestic production of key technological goods is beneficial for both national security concerns and speeding up innovation in cleaner technologies (Cantner,2023). However, there is an important caveat: technology sovereignty policy entails a race between economic and societal actors to ensure that their sector is protected by international competition. Again, rent-seeking activities and lobbying can tilt a rational use of such a measure and trigger protectionist approaches. Given the information asymmetry between specific technological sectors and the government, it is likely that the information advantage of specific sectors will favour rent-seeking activities. Hence, the state should invest in mechanisms to reduce information asymmetries by establishing new bodies (Edler et al, 2023). The international context and the need for rapid deployment of climate policy seem to make this challenge difficult to overcome.

Finally, the authors supporting the "third way" for industrial policy acknowledge the need to address the issue on a global stage. Terzi's contribution (2023) presented in section 3.4 in Chapter 3 is based on the development of international climate agreements both between the EU and the US and at the same time with least developed nations to reinforce climate aid and make up for the costs they would pay in the presence of industrial policies in most advanced economies. Terzi's argument is valuable because it focuses on the fundamental aspect of climate policy, which is the need to address it on the international stage. However, he also calls for the necessary use of industrial policy, even though he acknowledges the risks associated with it. On the contrary, this chapter has proposed an alternative framework in which carbon pricing is the core policy measure that governments should pursue, rather than a central role assumed by the state in leading the green transition by picking specific technologies.

CONCLUSION

The purpose of this work was to understand the economic theory at the core of the revived industrial policy of both the EU and the US. COVID-19, Russian aggression on Ukraine and the subsequent energy crisis, international tensions with China, and climate change are events that triggered new interventionism in the economy. In this new framework, the US Inflation Reduction Act pours billions of dollars into clean technology through tax credits, direct expenditures and other forms of public investments. Given the protectionist nature of the IRA, the EU responded by presenting a series of regulatory frameworks aimed at increasing state aid measures to protect domestic businesses from relocating to the US, strengthening the EU's open strategic autonomy, and boosting the deployment of clean technologies. This framework has renewed the debate over the role of the state in the economy.

This work has tried to demonstrate that the most efficient way to tackle the green transition is to use a market-based approach and implement policy tools such as a carbon tax or an emissions trading scheme, which would ensure a cost-effective transition towards a greener economy. Governments however have a pivotal role in shaping climate policy. They are necessary to impose a fair price on carbon and to target support for the most vulnerable categories of society that are most likely to suffer from carbon pricing.

In this alternative framework to the widespread use of state aid, governments play a crucial role also in shaping the international dimension of climate policy. A coordinated effort is needed on the global stage to reduce CO_2 emissions. For this reason, Nordhaus' call for the creation of a climate club is to be taken under serious consideration. The EU, being historically the leader in the green transition, should enhance its effort to make other countries, both allies and non-allies, pursue climate-reduction policies.

There is some optimistic feedback coming from the EU, such as the commitment to implement the Carbon Adjustment Mechanism to balance the carbon prices paid by domestic producers and importers. Additionally, the EU has recently created the Emissions Trading System 2, which covers fuel combustion in buildings, road transport and other sectors not covered by the existing ETS. The EU should build on these mechanisms but at the same time, it needs to eliminate subsidies to carbon-intensive energy sources and avoid picking winners in the green transition.

The figures on subsidies and the recent regulatory framework presented under the Green Deal Industrial Plan seem however to go in the opposite direction. State aid is on the rise and the temporary framework used to address the energy crisis is now extended. In this sense, further research should concentrate on the future of the EU if common borrowing, initiated with the NextGenerationEU, becomes a common praxis in the European Union. As the European Fiscal Board 2022 reports, after the rebound in 2021, the structural primary deficit worsened in the euro area (European Fiscal Board, 2022), indicating that public investment expenditure increased considerably.

If the direction is moving towards common borrowing and increasing state aid measures, to avoid a fragmentation of the Single Market, in which only the richer states might be able to pour enough money into the domestic market, common fiscal rules need to be adopted. An Insightful reasoning in this sense has been offered by Mario Draghi in The Economist (2023), who suggested creating an EU fiscal union to let countries receiving funds use them more successfully. Lax state aid rules would only allow countries with enough fiscal space to invest resources, making poorer countries lag behind. A focus on this new direction would be needed to understand the fiscal implications that enhanced state expenditure and loosened state aid rules can have on EU member states.

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