THE ROAD TO

NetZero

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URSULA VON DER LEYEN CALLS FOR GLOBAL COLLABORATION TO FIGHT SHARED CHALLENGES

CHRISTOFER SCHROEDER AND LIVIO STRACCA ARGUE THAT CARBON TAXES ARE UNDERMINED BY 'LEAKAGE'

CONOR MCCAFFREY AND NICLAS POITIERS ARGUE FOR THE EU TO GET MORE INVOLVED IN SKILL POLICIES

SUSTAINABLE DEVELOPMENT

Foreword

Welcome to the Spring edition of The Road to Net Zero, a *World Commerce Review* supplement. This publication has been prepared in response to readership demand for an overview of the steps being taken in the transition to a cleaner and greener sustainable world.

All aspects of climate action are examined, with the most respected authors providing the reader with the most comprehensive information available. Our brief is to provide all the data necessary for the readership to make their own informed decisions. All editorials are independent, and content is unaffected by advertising or other commercial considerations. Authors are not endorsing any commercial or other content within the publication. ■

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Carbon leakage: an additional argument for international cooperation

Climate change is a collective action problem that requires substantial international cooperation. Christofer Schroeder and Livio Stracca present new evidence that carbon taxes are undermined by 'leakage'

Carbon dioxide (CO_2) emissions are a key driver of climate change and a major threat to lives and livelihoods. As the environment is a global good, emissions reductions benefit the planet as a whole, regardless of where the reductions occur. Governments, therefore, have an incentive to free-ride on the environmental policies of others, foregoing the costs while reaping the benefits in terms of mitigating climate change.

Although this collective dimension is well recognised (eg. Snower 2022), governments around the world have largely introduced unilateral policies aimed at reducing emissions or slowing their growth.

Among the menu of unilateral policy options available, carbon taxes are generally regarded as particularly efficient (Metcalf 2019, Nordhaus 1977) and potentially less regressive (Levinson 2018). Indeed, carbon taxes have been found to exert a significant negative impact on domestic emissions (Andersson 2019, Bustamante and Zucchi 2023, Metcalf 2019), though evidence of their macroeconomic impact is less clear (Känzig and Konradt 2023, Metcalf and Stock 2020).

Carbon leakage

A common concern with carbon taxes is the potential for 'carbon leakage' – shifts in the production of emissions away from regions in which they are taxed. This undermines the effectiveness of such policies, even abstracting from the fact that their introduction suffers from a free-rider problem. Indeed, initiatives such as the EU's Carbon Border Adjustment Mechanism (CBAM), which will come into force in 2026, aim precisely at preventing this problem.

While carbon leakage is an established theoretical channel (see Copeland *et al* 2022 for a detailed discussion), the empirical evidence is mixed. Böning *et al* (2023) find that the EU's Emissions Trading System (ETS) has led to carbon leakage, while Aichele and Felbermayr (2015) provide evidence of carbon leakage from the Kyoto Protocol.

Indeed, aggregate data show that emissions in many advanced economies have been declining since the early 2000s while rising in many developing economies (Plumer 2017). The extent to which these patterns are explained by carbon leakage, however, remains unclear.

In this column, we summarise new empirical evidence of carbon leakage, drawing on our recent research estimating the impact of carbon taxes on emissions, using annual country data from the Global Carbon Project

Nationally determined policies will have a meaningful impact on reducing global emissions only if they are accompanied by mechanisms that eliminate carbon leakage

(Schroeder and Stracca 2023). Our findings suggest that carbon taxes do indeed lead to carbon leakage, particularly for countries that are more open to trade.

Importantly, our study distinguishes between two different measures of emissions at the national level: territorial emissions (or the emissions emitted within a country's borders) and consumption emissions (or the emissions emitted anywhere in the world to satisfy a country's domestic demand)[1].

The difference between the two measures of emissions are net imported emissions. Within this framework, carbon leakage can be observed when a carbon tax leads to a reduction in territorial emissions that is offset by an increase in net imported emissions. Together, these leave consumption emissions less impacted or unchanged.

Our estimates show that carbon taxation has a negative, cumulative impact on territorial emissions over time, which is good, but no impact on consumption emissions, which may imply that their overall effect is limited if implemented in isolation (note that in our paper we do not directly measure the effects of taxes on emissions in other countries).

The results plotted in panel A show that carbon taxes significantly reduce territorial emissions starting around three years after implementation. Consumption emissions, on the other hand, are estimated to fall by less than territorial emissions; these estimates are not statistically significant, as shown in panel B. Together, these results offer evidence of carbon leakage from carbon taxes.

The role of international trade

Carbon leakage across international borders implies that trade acts as a conduit for emissions. That is, countries more open to trade may be more susceptible to carbon leakage than countries less open to trade. Indeed, we find evidence of this outcome.

The results in Figure 2 show that the patterns in Figure 1 are driven by countries that are more open to trade. In particular, carbon taxes significantly reduce territorial emissions over time, regardless of a country's openness to trade, as shown in panel A. The impacts on consumption emissions differ, however, as shown in panel B.

Countries that are more open to trade see no significant impact of carbon taxation on consumption emissions, while countries that are less open to trade see a significant reduction. These results suggest that openness to trade is a key country characteristic enabling carbon leakage.

Our findings have important implications for the design of policies aimed at mitigating emissions, which are not limited to carbon taxes but can also involve green subsidies and other instruments. Nationally determined policies will have a meaningful impact on reducing global emissions only if they are accompanied by mechanisms that eliminate carbon leakage.

'Climate clubs' or CBAMs, for instance, can help reduce the incentive to offshore the production of emissions, despite their administrative challenges (Dominioni and Esty 2022). Our findings are in line with a broad literature emphasising the importance of international cooperation and coordination in implementing the policies needed for reducing emissions to meet the goals set out in the Paris Agreement (Ferrari *et al* 2023). ■

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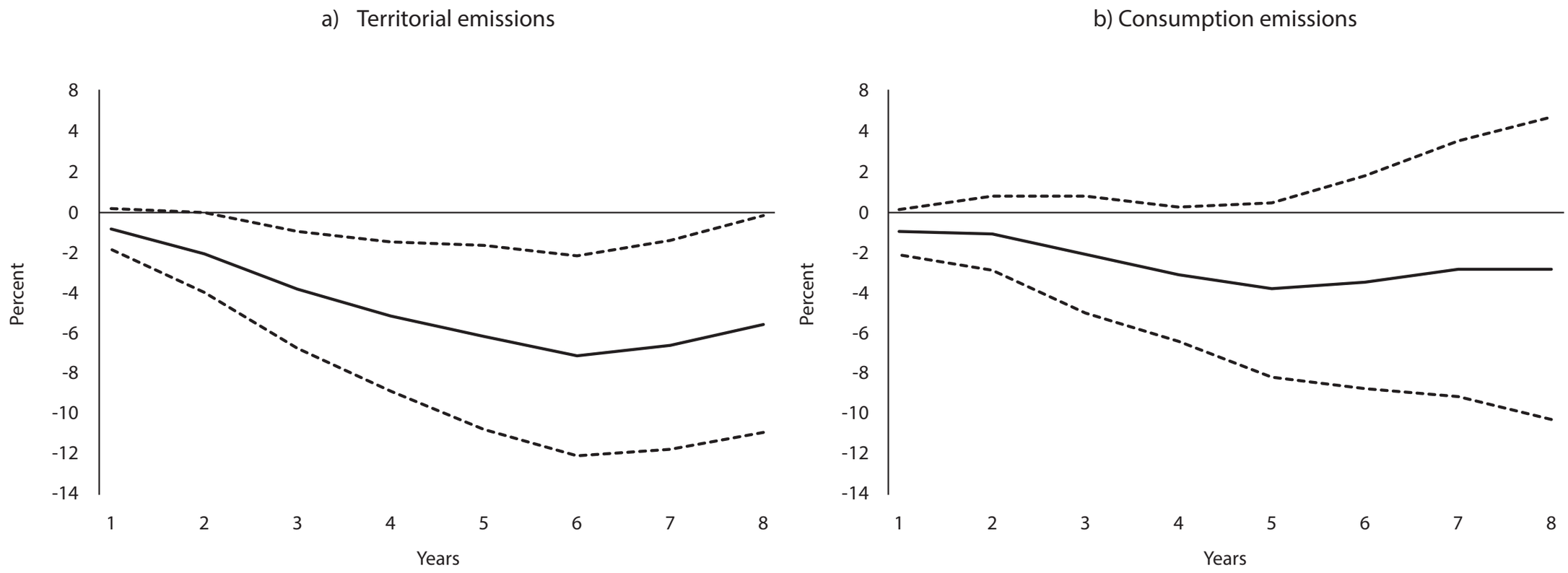
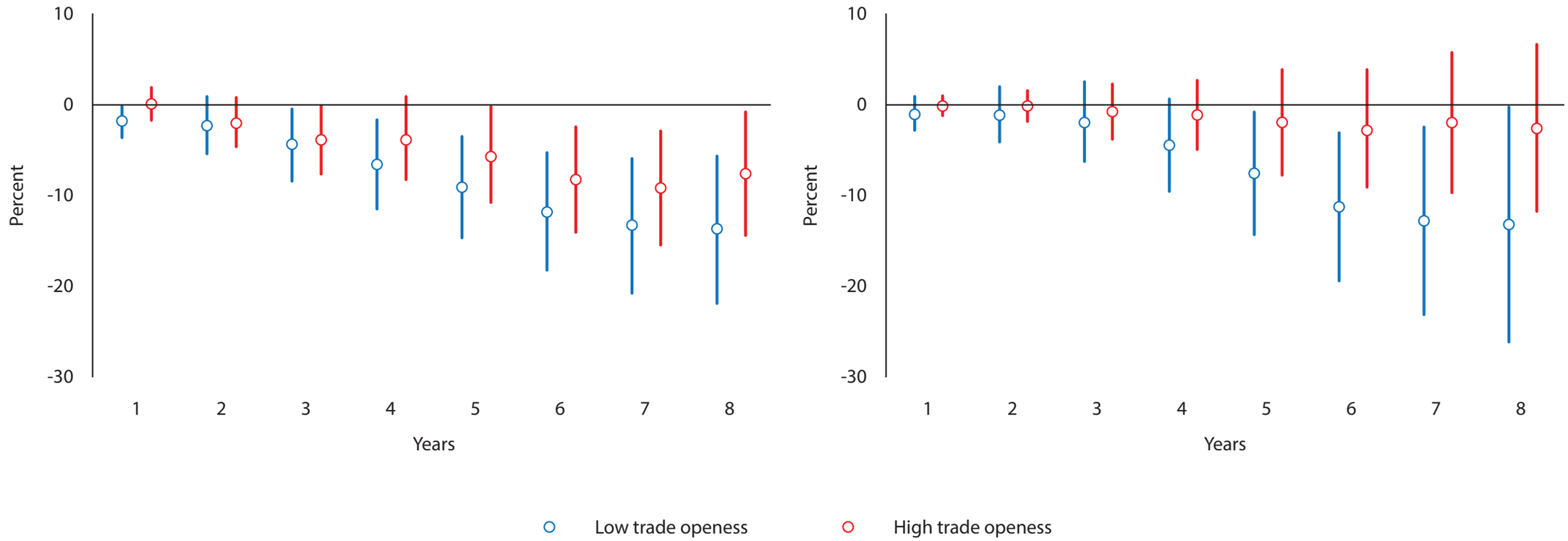
Figure 1. Dynamic effects of carbon taxation on emissions



Notes: This figure plots impulse response functions capturing the dynamic cumulative effects of carbon tax implementation on territorial (panel a) and consumption (panel b) emissions based on local projections of annual data. The dashed lines represent 90% confidence intervals surrounding the point estimates of the dynamic impacts plotted by the solid lines.

Figure 2. Dynamic effects of carbon taxation on emissions by openness to trade



Notes: This figure plots impulse response functions capturing the dynamic cumulative effects of carbon tax implementation on territorial (panel a) and consumption (panel b) emissions by countries' level of trade openness. The blue circles plot point estimates of the effect for countries with low openness to trade. The red squares plot point estimates of the effect for countries with high openness to trade. High openness to trade countries are defined as those with above median openness to trade in a particular year. Both series of estimates are surrounded by 90% confidence intervals represented by the solid lines of the same colour.

Endnote

1. We draw on data on territorial and consumption emissions from the Global Carbon Project (GCP). See https://www.globalcarbonproject.org and Andrew and Peters (2021) for detailed accounts of the data. In practice, the GCP estimates consumption emissions by adjusting territorial emissions with estimates of net emissions transfers via international trade. Net emissions transfers are estimated via environmentally extended input-output analysis (EEIOA).

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Authors' note: This column should not be reported as representing the views of the ECB. The views expressed are those of the authors and do not necessarily reflect those of the ECB. We thank Massimo Ferrari Minesso, Irene Heemskerk, Mario Morelli, and Agnieszka Trzcinska for useful comments. This article was originally published on VoxEU.org.

A call for global collaboration

Ursula von der Leyen's message at the WEF is that countries and businesses need to closely collaborate in facing the challenges of today and tomorrow

The World Economic Forum's *Global Risk Report* makes for a stunning and sobering read. For the global business community, the top concern for the next two years is not conflict or climate. It is disinformation and misinformation, followed closely by polarisation within our societies. These risks are serious because they limit our ability to tackle the big global challenges we are facing: changes in our climate – and our geopolitical climate; shifts in our demography and in our technology; spiralling regional conflicts and intensified geopolitical competition and their impacts on supply chains.

The sobering reality is that we are once again competing more intensely across countries than we have in several decades. And this makes the theme of this year's Davos meeting even more relevant. 'Rebuilding trust' – this is not a time for conflicts or polarisation.

This is the time to build trust. This is the time to drive global collaboration more than ever before. This requires immediate and structural responses to match the size of the global challenges. I believe it can be done. And I believe that Europe can and must take the lead in shaping that global response.

The starting point for that is to look deeper at the *Global Risk Report* to map out a way forward. Many of the solutions lie not only in countries working together but crucially on business and governments – business and democracies – working together.

It has never been more important for the public and private sector to create new connective tissue. Because none of these challenges respect borders. They each require collaboration to manage risks and forge a path forward.

While governments hold many of the levers to deal with the great challenges of our time, businesses have the innovation, the technology and the talents to deliver the solutions we need, to fight threats like climate change or industrial-scale disinformation.

Europe is uniquely placed to show how this can work. Because our democracies and our businesses have interests that align: creating prosperity, wealth and security for people, creating a stable environment to unlock innovation and investment, and creating equal opportunity and freedom.

This is more important than ever as we start 2024 – the biggest electoral year in history. Democracies across the world will head to the polls, and half of the global population will be affected; this includes over 450 million people

Overreliance on one company, one country, one trade route comes with risks. That is why the European Green Deal puts such strong emphasis not just on reducing emissions but also on a strong, competitive European presence in the new clean energy economy

in the European Union. A Union of 27 democracies where all of us have the right to speak our mind, to be ourselves, even if we are different from the majority.

In a democracy it is the people, with their choices and behaviours, who pick winners and losers in the economic arena. Companies are free to compete. Changemakers are free to innovate. Merit determines economic success. And our rules are built to ensure this: to protect intellectual property, the safety of industrial data, or the savings of people and companies. And Europe stands up for global trade based on fair and open markets.

Of course, like in all democracies, our freedom comes with risks. There will always be those who try to exploit our openness, both from inside and outside. There will always be attempts to push us off track, for example with disinformation and misinformation.

And nowhere has there been more of that than on the issue of Ukraine. So let me provide you with some real information. Russia is failing on strategic goals. It is first and foremost a military failure. We have not forgotten that when Russia invaded Ukraine, many feared that Kyiv would fall in just a few days, and the rest of the country within weeks. This did not happen.

Instead, Russia has lost roughly half of its military capabilities. Ukraine has driven Russia out of half of the territories it had captured. Ukraine has pushed back Russia's Black Sea Fleet and reopened a maritime corridor to deliver the grain to the world. And Ukraine has retained its freedom and independence.

Russia's failure is also economic. Sanctions have decoupled its economy from modern technology and innovation. Russia is now dependent on China. And finally, Russia's failure is also diplomatic. Finland has joined NATO. Sweden will follow soon. And Ukraine is closer than ever on its path to the European Union.

All of this tells us that Ukraine can prevail in this war. But we must continue to empower their resistance. Ukrainians need predictable financing throughout 2024 and beyond. They need a sustained supply of weapons to defend Ukraine and regain its rightful territory. They need capabilities to deter future attacks by Russia. And they also need hope.

They need to know that, with their struggle, they will earn a better future for their children. And Ukraine's better future is called Europe. It was with immense joy that last month we decided to launch the accession negotiations for Ukraine's EU membership. This will be Ukraine's historic achievement. And it will be Europe responding to the call of history.

We all know that Russia's invasion has also had an impact on the cost of living and the cost of doing business here in Europe. I know how much that has affected everyone. But I started by saying that the risks we face require collaboration between countries and business and that our joint capacity to respond was far stronger than we might believe.

And nowhere is this best exemplified than when it comes to energy and sustainability. Two years ago, before Russia's aggression against Ukraine, one in five units of energy consumed in the European Union in 2021 was imported from Russia. This high dependence on Russia was widely recognised as a risk, especially after Russia's occupation of Crimea. And then came Russia's invasion of Ukraine.

Russia had already increased Europe's vulnerability by deliberately not filling gas storages to their usual levels. And in the face of Ukrainian heroism and European solidarity, Putin decided that the time had come to threaten Europe directly by cutting gas supplies and using energy as his weapon.

We all carry the bruises from Putin's decisions. We faced difficult choices and uncertainties, especially during the winters. But we made the right choices. Now, only two years later, Europe has taken its energy destiny back into its own hands.

Last year, one in twenty units of energy consumed in the European Union came from Russia. Sure, the crisis checked momentum in the European economy but fears of economic collapse proved unfounded. And now energy prices have come down and stayed low even during the recent cold snap at the start of January. Gas storages are still well supplied.

Europe has made real progress in improving the resilience of its energy system. How was this possible? Because we acted in collaboration. Because we had well-functioning and open markets and good friends around the world that stepped in and stepped up alternative supplies.

Because we had a Single Market that allowed us to redirect flows of energy to where it was needed. But most of all, because we doubled down on clean energy transitions, investing in the clean, efficient and renewable technologies of the future.

European industries and companies have been central to this. Latest numbers from the International Energy Agency show that growth in renewable energy capacity hit another record in the European Union in 2023. And the European Union improved the efficiency of its energy use – the best energy is the one that is not used – by almost 5%.

In this way, we turned Putin's challenge into a major new opportunity. Last year, for the first time, the European Union produced more electricity from wind and sun than from gas. And this year, for the first time, the European

Union is set to get more overall energy from wind and solar photovoltaic than it does from Russia. That is good news.

But amid the reasons for optimism, let us not forget a key lesson from the crisis. Overreliance on one company, one country, one trade route comes with risks. That is why the European Green Deal puts such strong emphasis not just on reducing emissions but also on a strong, competitive European presence in the new clean energy economy. This includes Europe's leadership in clean energy technology, development and innovation.

Let me go back to the number one concern of the *Global Risk Report*: disinformation and misinformation. Tackling this has been our focus since the very beginning of my mandate. With our Digital Services Act, we defined the responsibilities of large internet platforms on the content they promote and propagate. A responsibility to children and vulnerable groups targeted by hate speech but also a responsibility to our societies as a whole. Because the boundary between online and offline is getting thinner and thinner. And the values we cherish offline should also be protected online. This is even more important in this new era of generative AI.

Now the World Economic Forum *Global Risk Report* puts artificial intelligence as one of the top potential risks for the next decade. First of all, let us not forget that AI is also a very significant opportunity, if used in a responsible way. I am a tech-optimist. And as a medical doctor by training, I know that AI is already revolutionising healthcare. That is good.

AI can boost productivity at unprecedented speed. First movers will be rewarded, and the global race is already on, without any question. Our future competitiveness depends on AI adoption in our daily business. And Europe must up its game and show the way to responsible use of AI. That is artificial intelligence that enhances human capabilities, improves productivity and serves society.

We should invest where we have a competitive edge. For instance, Europe has got talent. There are nearly 200,000 software engineers in Europe with AI experience. That is a greater concentration than in the United States and China. And our continent also has a huge competitive edge when it comes to industrial data. We can train artificial intelligence on data of unrivalled quality, and we want to invest in this.

This is why we will provide European start-ups and SMEs with access to our world-class supercomputers, so that they can develop, train and test their large AI models. This is similar to what Microsoft is doing for ChatGPT, by running it on its own supercomputers.

We will also put common European data spaces at the service of start-ups. And we will make available massive amounts of data in all EU languages, because AI should work also for non-English speakers. This is the new frontier of competitiveness. And Europe is well positioned to become the leader of industrial AI – the use of AI to transform critical infrastructures to become intelligent and sustainable.

When we took office four years ago, we felt the need to set clear guard rails at European level, to guide the development and deployment of artificial intelligence. This is the thinking behind Europe's Artificial Intelligence Act, actually the first of its kind anywhere in the world and another example of how democracies and businesses can help strengthen each other.

The Artificial Intelligence Act builds trust by looking at high-risk cases, like real-time biometric identification. And by building that trust, it enables companies to innovate in all other fields to make the most of this new and revolutionary technology.

Our world is in an era of conflict and confrontation, of fragmentation and fear. For the first time in generations, the world is not at a single inflection point. It is at multiple inflection points, with risks overlapping and compounding each other. And there is no doubt that we face the greatest risk to the global order in the post-war era.

But in my mind, there is also no doubt that we can move forward with optimism and resolve. Yes, the risks we face are real and present. But in order to face risks we have to take risks – together. This is what Europe has always done. The European Union is at its best when we are bold, as we have seen only in the last few years on the European Green Deal, NextGenerationEU, supporting Ukraine or facing up to the pandemic.

The next years will require us to think in the same way. And I believe the common power of our democracies and our business and industry will be at the heart of this. Our companies thrive on freedom – to innovate, to invest and to compete. But freedom in business relies on the freedom of our political systems.

This is why I believe strengthening our democracy and protecting it from the risks and interference it faces is our common and enduring duty. We need to build trust more than ever and Europe is prepared to play a key role. ■

Ursula von der Leyen is President of the European Commission

This article is based on a speech delivered at the World Economic Forum in Davos, Switzerland, 16 January 2024.

Climate policies carry political costs, but those costs can be mitigated

Davide Furceri, Michael Ganslmeier and Jonathan Ostry argue that climate policies must be calibrated carefully if they are to be accepted by the public and thus not hurt politicians' electoral chances

The global agreement to move away from coal, oil and natural gas, reached at the December 2023 COP28 climate summit in Dubai, exceeded the expectations of some, but was seen by others as a compromise that fell short of phasing out fossil fuels entirely. Nevertheless, it is a small step towards the ultimate goal of reducing reliance on fossil fuels in reality. Progress will now depend on policies adopted by countries and on the decisions of households and firms in response to new incentive structures.

Perhaps the greatest roadblock to a greener future is the hesitancy of politicians to implement such policies and structures, which should ideally alter incentives away from fossil fuels quickly and fundamentally.

Politicians hesitate to act on the grounds of economic efficiency alone, even though median voters in many countries have become greener over time and support for ambitious climate change policies remains strong among the electorate (Van der Duin *et al* 2023).

But such support is far from unconditional and depends on the changes to people's lives climate policies will require[1]. For politicians, the concern is that insufficient attention paid to the economic and social impact of environmental policies will hurt them in the run-up to elections.

Politicians' fears have a rational basis in terms of possible blame for the collateral effects of green policies that may create economic hardship. Such losses may be immediate, visible and concentrated, while the benefits of climate policy may be diffuse and postponed, and perhaps even invisible to voters (since they amount to the prevention of environmental damage).

Distributional consequences associated with the phasing out of combustion engine vehicles and traditional domestic heating systems, however, are immediately visible to voters. Opposition to such effects is understandable.

The status quo bias in policymaking is not new. It plagues areas including contending with unsustainable fiscal deficits or implementing productivity-enhancing reforms (structural reforms). War-of-attrition models (for example, Alesina and Drazen, 1989) have been used to study policy outcomes in situations when there are multiple veto players, and welfare-enhancing reforms with the potential to make everyone better off are delayed until one of the veto players concedes, once it becomes apparent that the cost of continuing to fight exceeds the cost of the concession (the loss – or distributional penalty – from the reform itself).

Policy design can be tweaked to make CCPs more acceptable to voters

The sentiment that there is a political penalty to be paid from structural reform (Ostry *et al* 2019, 2021) was expressed in the 1990s by Jean Claude Juncker before he became President of the European Commission: *"We all know what to do; we just don't know how to get re-elected once we've done it."*

Niccolò Machiavelli expressed a similar idea half a millennium earlier when he warned that reformers would have as enemies *"all those who have done well under the old conditions"* and only *"lukewarm defenders"* in those who may do well in the new situation.

What will it cost?

In Furceri *et al* (2023) we estimated the average effect of climate change policies (CCPs) on popular support for the government implementing them. We used the OECD's Environmental Policy Stringency (EPS) indicators (Botta and Kozluk, 2014) as proxies for CCPs, and the International Country Risk Guide[2] Index of Popular Support to proxy the level of government support. Our assessment covered 30 developed and emerging economies between 2001 and 2015 (see Furceri *et al* 2023, for technical details).

The popular support measure is based on opinion polls and scaled between 0 (high risk of losing office) and 4 (low risk). The OECD's EPS measure is the most comprehensive source for environmental policy measures across countries (28 OECD and six BRICS countries) and time (1990 to 2015)[3]. All policy indicators are scaled from 0 (not stringent at all) to 6 (very stringent).

In addition to its wide geographical and temporal coverage, the dataset includes both market-based and non-market-based measures, such as indices of taxation of emissions, trading schemes and feed-in tariffs (market-based), and indices of emission limits and research and development subsidies (non-market-based). The availability of these sub-indices allowed us to test whether some instruments are politically costlier than others.

We found that, overall, increasing environmental policy stringency has significantly negative and sizeable effects on popular support for the government. A government moving from the first to the third quartile of the EPS distribution will experience on average a 10 percent decline in popular support (Figure 1)[4].

This impact is equivalent to a decline in vote share of about 11 percent during election years – a sizable impact, especially when electoral outcomes are close. These results are robust to alterative sets of controls and the magnitude of the coefficients does not change with model specification.

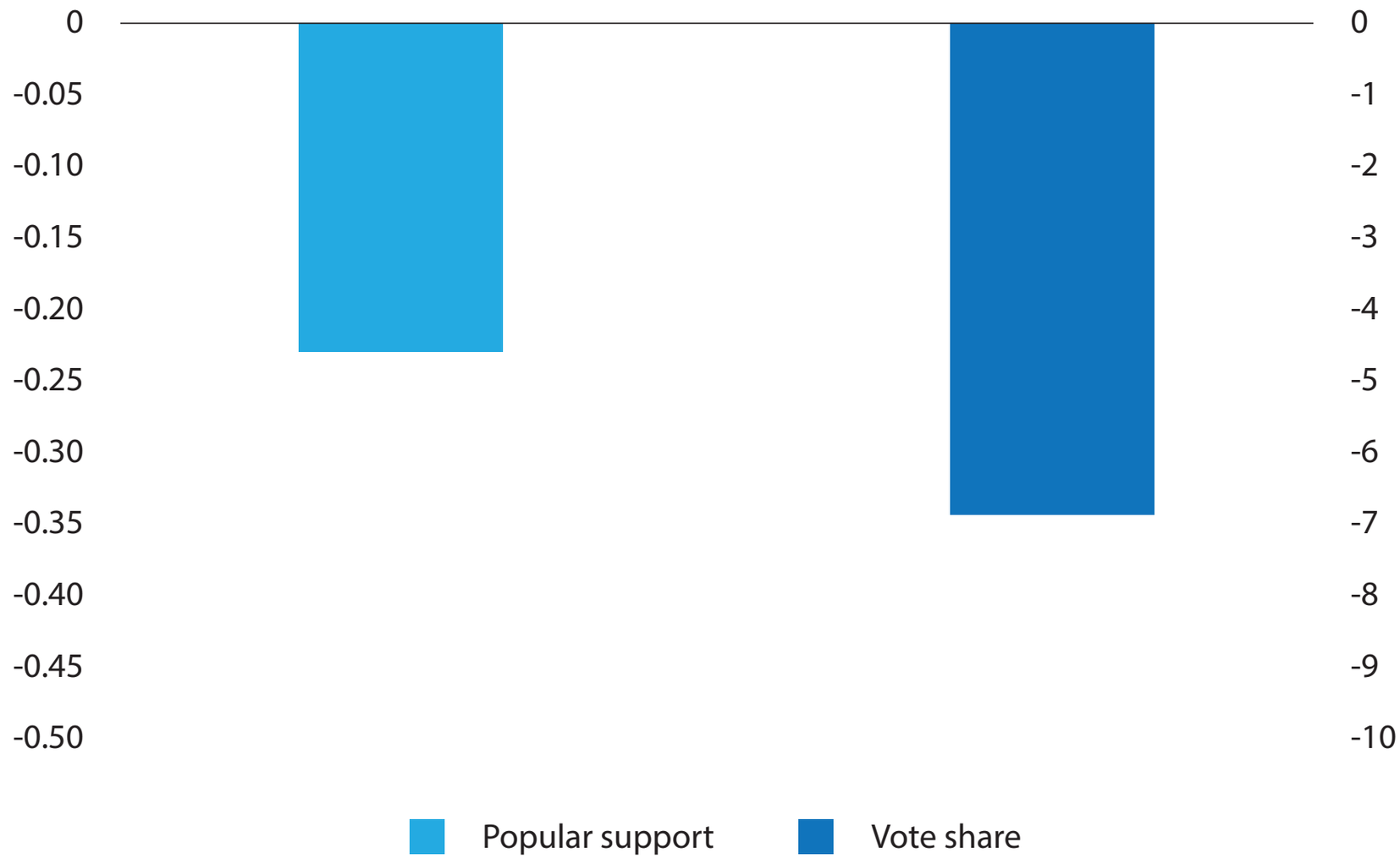
We also used an instrumental variable (IV) approach to estimate the causal effect of CCPs on popular support for the government[5]. Our instrument interacts a time-varying global term capturing cross-national pressure for climate change policies (the occurrence and impact of global extreme weather events) and a country-specific term capturing the vulnerability of a country to climate change (such as the length of its coastline as a gauge of vulnerability to rising sea levels). The IV estimates suggest a much larger political cost of CCPs than the estimates described above[6].

Unpacking the cost

More detailed examination shows, however, that careful policy design offers pathways to mitigate the political costs, in three respects. First, the adverse effect on popular support is markedly different depending on the type of instrument used.

Market-based measures, such as emissions taxes, lead to significant drops in popular support (Figure 2). But non-market-based measures such as emission limits do not entail significant political costs.

Figure 1. Impact of stricter environmental policy on popular support (left axis) and vote share (right axis)



Note: The left bar shows the effect on popular support of an increase in EPS, while the right bar shows the impact on vote share for the incumbent in election years from a change in EPS.
Source: Furceri et al (2023).

Though many economists see Pigouvian taxation as the first-best corrective tool for carbon emissions, opting for second-best nonmarket-based measures can be an effective alternative when market-based measures are not politically viable.

Second, timing and country characteristics matter. Political costs are higher when CCPs are adopted in times of high global fuel prices, but are statistically insignificant at times of low fuel prices (Figure 3)[7]. These findings suggest that political costs depend on the visibility of the reform and on the existing price level of affected products (eg. fuel).

CCPs also create a greater political backlash when adopted in economies that depend heavily on dirty energy sources. Economic diversification is thus an important overarching consideration.

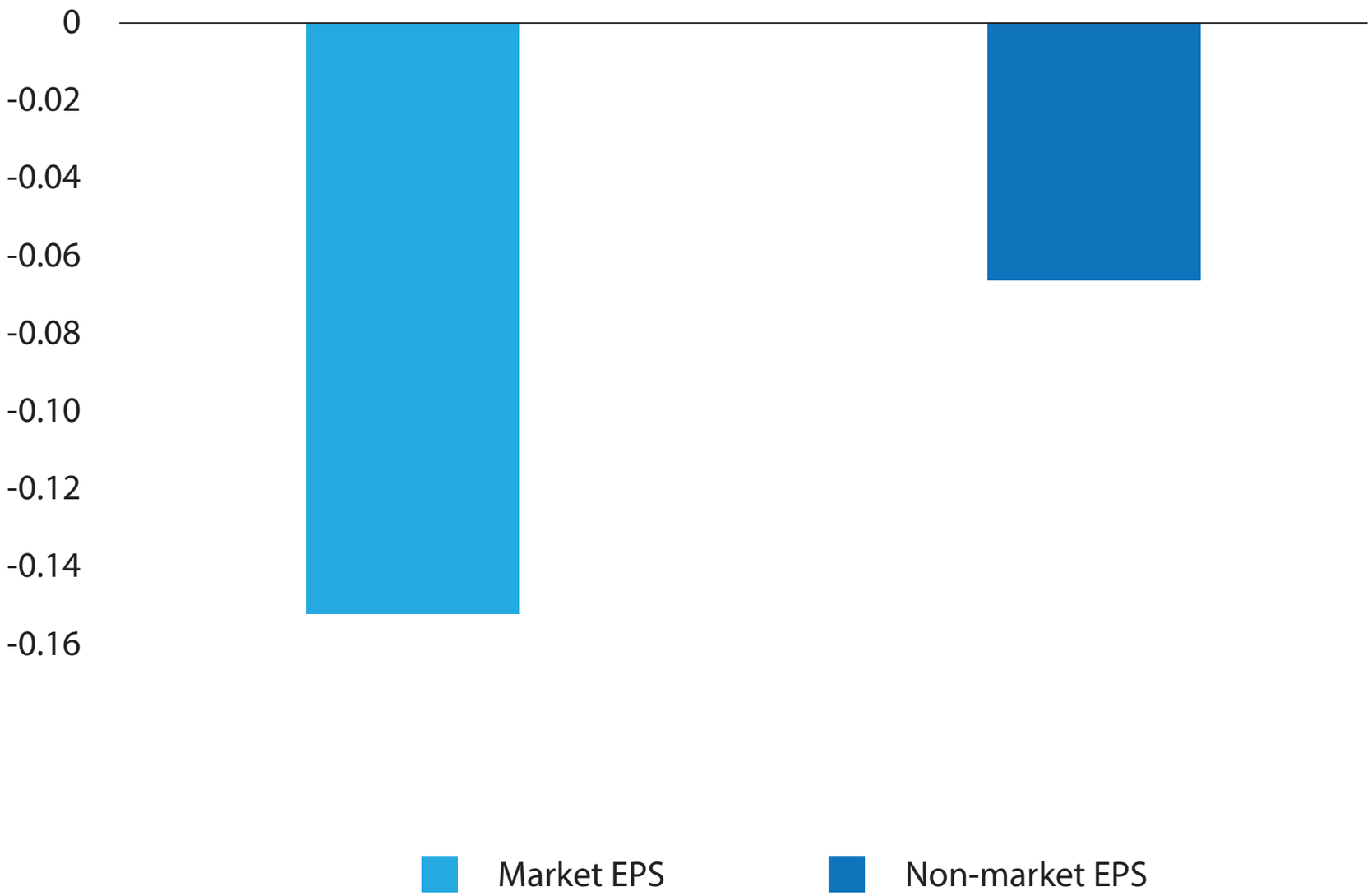
Third, political costs are higher when inequality is relatively high and when social benefits – in the form of direct transfers to households, unemployment benefits and active labour market policies to help job reallocation – are relatively low[8].

Remarkably, if inequality is low and benefits are high, the political cost of CCPs are statistically not different from zero (Figure 3). Climate-related policymaking is thus ultimately a social question, and sufficient social-insurance mechanisms are vital to enable the adoption of CCPs in a politically feasible fashion.

Policy design can help deliver a pathway out of political hesitancy

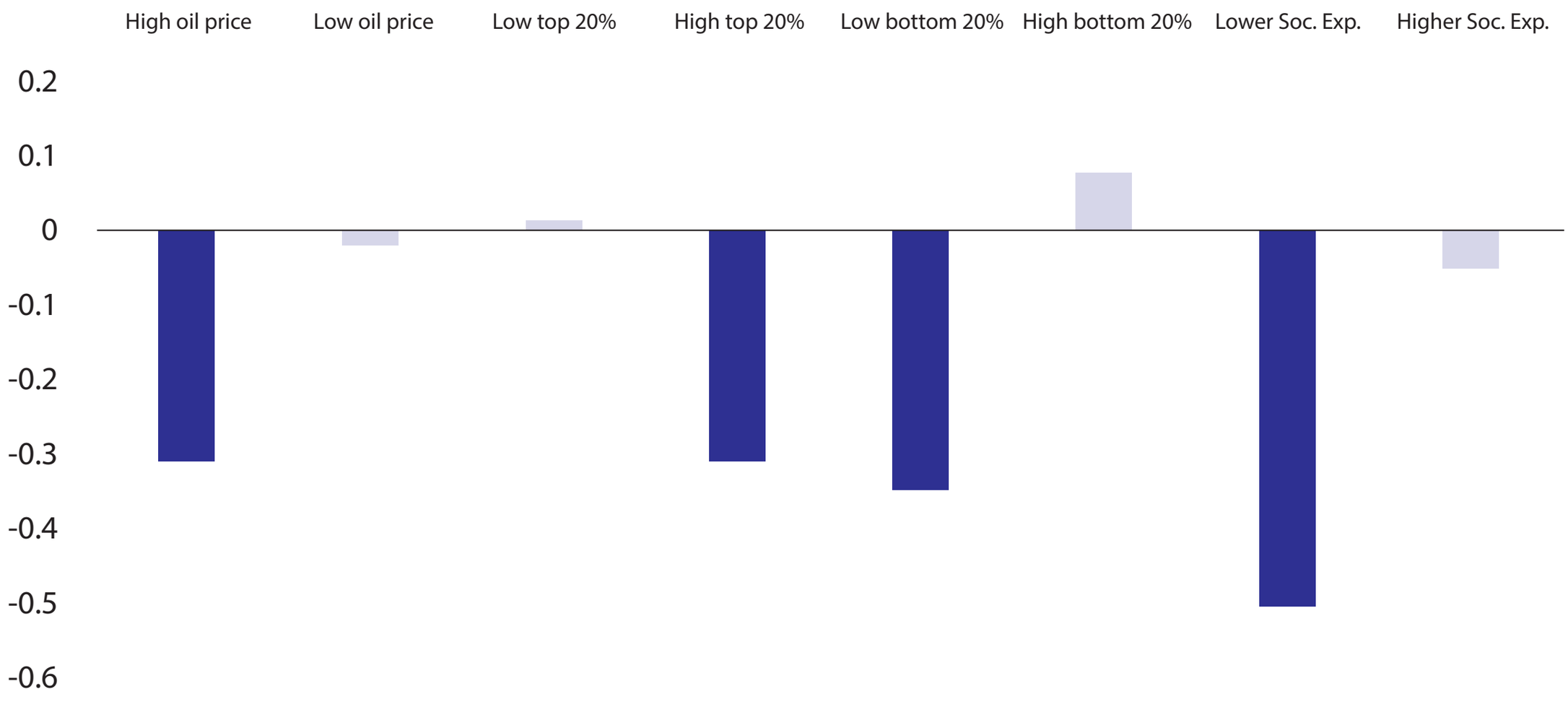
Successful implementation of climate-change policies requires political and popular support. Policy design is critical, in terms of instrument choice and the social policies that accompany a tightening of CCPs.

Figure 2. Effect of market- and non-market-based instruments on popular support



Note: Bars denote effect of a change in climate change policies on popular support for the government. Dark (light) blue indicates that the effects are (not) statistically significant at the 10 percent level.
Source: Furceri et al (2023).

Figure 3. The impacts of changes in CCPs on popular support: role of global energy prices. inequality, and social insurance mechanisms



Note: Dark (light) shading indicates (in)significance of the effect at the 10 percent level. Top and bottom income shares in the figure refer to shares of pre-tax national income.
Source: Furceri et al (2023).

Market-based instruments (taxes) seem far more politically toxic than non-market-based instruments (emission limits and regulations). Generous social welfare policies and active labour market policies are essential to mitigate the political costs from environmental policies.

Research has shown that some environmental policies are unpopular among some voters, but there is little evidence on how adoption of CCPs affects the popularity of the government overall.

Our research sheds some light on how environmental legislation translates into political costs for incumbents, and how policy design can be tweaked to make CCPs more acceptable to voters. ■

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Endnotes

1. See for example Jonathan Ostry, 'Politics, as well as economics, matter when making climate policy', Financial Times, 27 August 2023.

2. See https://www.prsgroup.com/explore-our-products/icrg/.

3. As our data ends in 2015, it was not possible to test within our sample whether the COP21 meeting in 2015, where the Paris Agreement was adopted, raising the ambition of government policies on climate change and increasing public awareness of the science around climate change, had an impact on the relationship between environmental policies and popular support.

4. The EPS varies from 0 to 6. A movement from the first to the third quartile of the EPS distribution corresponds to a movement of about 1.5 points.

5. The IV approach makes use of four alternative instruments, with each being the interaction between a global time-varying term and a constant country term. In all cases, the first-stage estimates suggested that the instrument is strong and statistically significant. To test the validity of the instruments, we checked whether the instruments have a direct effect on popular support by including them (stepwise) as additional controls in the baseline model: the instruments are invariably insignificant. We also directly tested the association of the baseline residuals with the instruments and found the relationship to be indistinguishable from zero. These findings support the validity of the instruments.

6. The direction of the bias in OLS is unclear ex ante. On the one hand, governments might require political capital to implement unpopular reforms. This mechanism implies a positive effect of the dependent variable on our policy variable and biases the OLS estimate towards zero. On the other hand, a government might implement CCPs because its unpopularity implies it has little to lose from reforming. This would imply a negative effect of popular support on CCPs and thus the possibility that the OLS estimate could overestimate the true effect. It turns out that the magnitude of the IV coefficient is (more than) three times larger than the OLS estimate, which suggests that OLS estimates are biased towards zero. This is informative given that the direction of bias is ambiguous ex-ante. See Furceri et al (2023) for details.

7. These results are obtained in a model in which the change in EPS is interacted with a smooth transition function of the level of world energy prices. It is also the case that political costs are higher within one year of an election and are statistically insignificant at other times over the electoral calendar: Furceri et al (2023).
8. These results were obtained in a richer model in which the change in CCPs is interacted with the level of inequality or the generosity of social benefits using smooth transition functions of each. The inequality measures consist of: the GINI (net and gross); top and bottom income shares (1 percent, 10 percent and 20 percent). The social insurance measures (sourced from the OECD), sometimes referred to as 'fiscal sweeteners', consist of: total public social expenditure as a percent of GDP; public social expenditure for active labour market policies as percent of GDP; public social expenditure for unemployment benefits as percent of GDP; social benefits to households in cash; and social benefits to households in kind.

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Accelerating strategic investment in the EU beyond 2026

The EU has to manage the climate and digital transitions and achieve greater economic resilience. Maria Demertzis, David Pinkus and Nina Ruer discuss the potential EU approach to funding strategic objectives

Executive summary

The European Union's ability to meet its long-term objectives – primarily managing the climate and digital transitions and achieving greater economic resilience – will depend crucially on how much it invests and what it invests in.

For the two transitions, the EU member states collectively face a total annual investment gap of at least €481 billion up to 2030. Closing this gap, which is necessary if the EU is to achieve its strategic objectives, will rely on the efficient use of public resources and on mobilising private investment.

We discuss a potential long-term EU approach to the financing of strategic objectives. We define the notion of strategic investment in the context of the EU, set conditions for such investment to be (co-) financed at EU-level, and make recommendations about strategic investment in the EU beyond 2026.

We argue that EU (co-)finance would be justified if there is demonstrable EU value added, for example in the form of crossborder efficiency gains. The term 'strategic' would help prioritise how the EU pursues its economic and security interests.

Examples that would qualify as European strategic investments include energy and connectivity infrastructure with crossborder impact, and facilities that boost innovation and promote economic security and resilience at the EU level.

We examine various past and present EU strategic project financing programmes. We also survey national programmes to identify best practices in public investment management. We make the following main policy recommendations:

1. There is a lack of continuity in the way that the EU has pursued investments in that programmes have been finite and sporadic, with different sources of funding and overlapping objectives. We propose the creation of a dedicated and permanent fund for European Strategic Investments (ESIs), that can come in the first instance from a partly repurposed European budget (the Multiannual Financial Framework).

2. We argue that the European Investment Bank (EIB) would be the natural manager of such a fund. The fund itself should employ all the financial instruments at its disposal to finance projects. Projects should be evaluated in terms of how well they provide European added value and contribute to the EU's strategic objectives.

3. Beyond current financing means, the EU still needs to make progress on establishing new own resources, or revenues for the EU budget, to repay debt issued under the NextGenerationEU post-pandemic recovery instrument. At a later stage, a consequence of having established new own resources will be that the EU will then have additional dedicated financing streams that it could use for ESIs. This would ensure continuity in pursuing strategic objectives.

1 Introduction

The European Union's ability to meet its long-term objectives, from managing the twin transitions (climate and digital) to greater economic resilience, and from security to promoting multilateralism, will depend crucially on how much it invests and in what.

The huge investment that has been identified as a prerequisite to move forward on some of these objectives will require the participation of the private sector and public authorities alike.

In this study, we explore the EU's role, beyond that of member states, in financing directly some of the strategically relevant projects.

A major objective for the EU economy is to remain competitive globally, without resorting to protectionist measures that go against the multilateral system.

A necessary ingredient to remaining competitive in a world of big players is to increase and maintain scale. Deepening and expanding the EU single market for goods and services are ways of promoting scale. European economies still operate with a considerable home bias that favours domestic firms over those that may reside even just over the border.

A bigger and deeper single market for goods and services is necessary for developing big firms that can compete globally, and for creating conditions for innovation and ensuring dynamism in the labour force.

Finance should play an important role in deepening the single market but when it comes to financial inter-mediation, there are no unified markets for banks and capital across the EU. Despite the creation of a banking

union, banks still operate predominantly within national borders. Making progress with completing the banking union would help move in the direction of a unified market that would increase the financing capacity in each country.

But bank finance also has its limits as it is not conducive to risk-taking (Demertzis *et al* 2021). To deal with these risks, the EU must develop deeper and more unified capital markets to finance riskier projects.

The EU can play an important role in making sure that the necessary investments in energy and transport systems are done by all countries, while also safeguarding a fair transition

In the meantime, the lack of such risk finance means that the public sector must absorb some of the risk associated with delivering on longer-term and less-certain investments. Some of these investments may be strategic in nature. As not all countries have the same fiscal capacity, they may opt to pursue some of these European strategic objectives at different speeds.

This can be problematic. Pursuing, say, climate goals at different speeds may compromise the ability of all countries to achieve important milestones. This is why we see an important role for the EU to ensure that all countries advance at a minimum acceptable speed, at least for some of the most important European public goods, such as climate or connectivity.

With European elections in 2024, this is a natural point for the EU to reflect on its long-term strategy, including on how to invest beyond 2026, the year when the new European budget will have to be agreed and the NextGenerationEU initiative (NGEU) comes to an end.

We define the notion of strategic investment in the context of the EU, set out conditions for such investment to be co-financed by the EU and make recommendations about what these should be in the EU beyond 2026. We present first the EU's main long-term objectives, in the context of the challenges it faces. All member states and the EU as an entity will have to plan how to accelerate investment to meet these objectives.

We discuss the rationale for EU-level financing of some of these objectives, alongside private sector and member state financing. EU involvement would necessarily require there to be value added, for example in the form of crossborder efficiency gains, in pursuing some of these long-term objectives.

This is necessary on economic grounds and is also crucial for democratic legitimacy and acceptability. Having identified projects that offer such efficiency gains, the EU needs to prioritise those that are strategic – in other words, pivotal to the EU's economic interests and economic security.

We look at the EU's previous efforts to finance long-term projects using funds from the European budget (Multiannual Financial Framework, MFF) and the newly established NGEU. We observe a lack of continuity in the instruments used to pursue these objectives as programmes span at most seven years and typically between three and five.

Also, multiple institutions oversee different programmes that sometimes have over-lapping objectives. Additionally, we look at how countries have used public investments to advance their own objectives, as a way of identifying best practices in terms of maximising the impact of public resources.

We make two main contributions in this study. First, we define strategic investment in the context of the EU and set out conditions identifying when to finance projects with EU resources. Strategic investment, in the form of gross fixed capital formation, is investment consistent with the EU's long-term objectives and priorities.

We discuss when there is a good case for the EU to finance some of these strategic objectives directly, beyond what EU countries and the private sector do. When EU 'additionality' is established, it means that projects will be underprovided if left to countries or the private sector alone. Crossborder efficiency gains would be one example of a justification for EU financing.

Second, we formulate recommendations on how to think about European strategic investments, grouped into three categories:

1. Reform current funds and tools. The EU's previous attempts to finance projects of strategic relevance have been characterised by a series of time-limited programmes. Such funds are finite in that they last only a few years, they come from different sources of funding, and they often overlap. We propose creating a dedicated fund for European Strategic Investments (ESIs).

The priorities in terms of achieving long-term objectives need to be evaluated periodically. Such continuity will require dedicated funds that can come in the first instance from a partly repurposed European budget (the MFF).

2. Put the European Investment Bank in charge. A dedicated fund will also require a dedicated manager. We argue that the EIB is the natural manager for such a fund. Financial support should be distributed on a project-by-project basis once the European added value has been established.

The EIB has the resources and skills to evaluate complex and technical projects and can build tools for transparent monitoring of projects.

3. Work towards new funding tools. The EU still needs to make progress with finding new 'own resources' to finance the debt it has issued under NGEU. At a later stage, a consequence of establishing new sources of income for the EU budget will be that the EU will have dedicated financing streams for ESIs as a way of ensuring continuity.

As ESIs are relevant to all EU citizens of current and future generations, they are a prime candidate to be financed by common EU resources and through long-term debt.

2 The EU's long-term objectives and the role of public investment

In this section, we identify the long-term objectives the EU has set for itself. Then we summarise some of the budgetary needs that have been identified in the literature and discuss the benefits of public investment, as described by the literature.

2.1 The EU's long-term objectives

As is the case for any investment, strategic investment needs to be consistent with a set of long-term objectives. This is necessary to ensure consistency in the way investments are selected and implemented.

European strategic investments should therefore be consistent with the long-term objectives set at EU level. Based on European Commission publications, we group high-level EU objectives into the following five groups.

1. Open strategic autonomy and competitiveness

The European Commission Joint Research Centre's 2023 strategic foresight report (Matti *et al* 2023, p. 30) states that *"Open strategic autonomy refers to the EU's objective of strengthening independence in critical areas, supporting the EU's capacity to act, while being open to global trade and cooperation."*

Open strategic autonomy became an important topic initially after the first supply chain interruptions during the pandemic, and later with the increased geopolitical tensions globally following the Russian invasion of Ukraine.

The objective of competitiveness refers to strengthening Europe's global competitiveness. The EU needs to identify the conditions that will allow its industries to promote sustainable growth internally and to compete in global markets.

It is particularly important to ensure that new legislative proposals and high-level projects, such as the Twin Transition (see below), do not harm the region's competitiveness. Fostering EU leadership in technology and cybersecurity have also been highlighted as crucial to ensure European competitiveness on the global stage.

2. Twin transition

EU policymakers employ the concept of the 'twin transition' when talking about transforming EU economies into more environmentally sustainable and more digitalised systems. The objectives of the landmark European Green Deal were set out in the European Commission's priorities for 2019-2024[1].

They are: (i) no net emissions of greenhouse gases by 2050, (ii) economic growth decoupled from resource use, and (iii) not leaving any citizens behind in the transformation.

The digital transition aims to prepare businesses and citizens for the increasing importance of digital technologies. Building the necessary infrastructure to take advantage of new technologies is part of the 'European Digital Decade', as is enabling citizens to participate in transforming labour markets through re-skilling. Ensuring proper and safe development and use of artificial intelligence is also part of this objective.

3. Resilience and economic and territorial cohesion

The 2020 Strategic Foresight Report (European Commission, 2020a, p. 3) defined resilience as *"the ability not only to withstand and cope with challenges but also to undergo transitions in a sustainable, fair, and democratic manner."*

This objective aims to prepare Europe for future economic, social and health shocks. Recently the concept has been captured by the notion of de-risking, which refers to the reduction of extreme dependencies on

critical goods and promotes EU economic security. Fostering the resilience and strength of health systems in the EU is also part of this objective.

Economic and territorial cohesion refers to strengthening the internal cohesion of the EU, including efforts to address imbalances between countries and regions. The goal is to achieve a level playing field inside the EU for all economic players and to preserve the integrity of the single market. In the process, it is important to provide equal opportunities to all citizens across all regions.

4. Security and European values
The European Council listed *"protecting citizens and freedoms"* as part of its 2019-2024 agenda (European Council, 2019). The relevance of this theme has only increased with the Russian invasion of Ukraine. This objective includes securing the EU borders and ensuring the security of supply chains. Defending and promoting European values, such as ensuring and strengthening democracy and protecting the rule of law, is a key EU objective.

5. Open markets and rules-based multilateralism
Europe's relationship with the rest of the world is defined by adherence to rules-based multilateralism and open markets. Supporting and cooperating with other regions and economies to achieve common goals, such as the twin transitions, is also part of this objective.

The Global Gateway facility – with an objective of investing internationally in high-quality and sustainable infrastructure to foster development and growth in partner countries – is an example of such a policy[2].

2.2 European budgetary needs

The European Commission has identified a series of budgetary needs to be met for the EU to meet its long-term objectives. These span several areas. A non-exhaustive list includes:

1. Climate and energy transition. Pisani-Ferry *et al* (2023) reported that for the EU to achieve a 55 percent emissions reduction by 2030, compared to 1990, it will need annual additional investment (compared to investment levels from 2011 to 2020) amounting to about 2 percent of GDP (€356.4 billion).

This represents investment in energy and transport systems. Pisani-Ferry *et al* (2023) also estimated that when it comes to the green transition, annual public investment is expected to be within 0.5 percent to 1 percent of GDP in the future (see also Darvas and Wolff, 2022). A substantial part of the gap will need to be filled by the private sector.

Lenaerts *et al* (2021) reported similar numbers that go beyond 2030 and studied how to reach climate neutrality by 2050. More specifically, achieving the benchmarks set forth in the 'Fit for 55' package – a body of EU laws facilitating the reduction of net EU greenhouse gas emissions by at least 55 percent by 2030 compared to 1990 – would demand annual investment of approximately €487 billion for the energy sector and €754 billion for the transportation sector from 2021 to 2030.

Additionally, REPowerEU, a programme put together after the Russian invasion of Ukraine to increase the EU's energy resilience by decoupling from Russian fossil fuels, entails total investment of €210 billion between now and 2027 (European Commission, 2022a).

2. The digital transition. Bridging the investment gap within the EU for the digital transition will entail a minimum annual expenditure of €125 billion between 2020 and 2030 (European Commission, 2020b).

According to Papazoglou *et al* (2023), the principal EU funding instruments – the Recovery and Resilience Facility (RRF), the Connecting Europe Facility 2 (CEF2) Digital, the Digital Europe Programme, Cohesion Policy and Horizon Europe – will contribute a total of over €165 billion up to 2027 to support the Digital Decade targets, to be achieved by 2030[3].

More than 70 percent of these funds will come from the RRF. Ockenfels *et al* (2023) estimated an overall investment gap of at least €174 billion to meet just two of the twelve Digital Decade targets (specifically the fixed Gigabit coverage and providing 'full 5G service'). Again, they argue that the private sector will have to play a major role to fill this gap.

3. Defence and security. The financial implications of the new geopolitical landscape are also substantial. Defence spending by EU countries reached €214 billion and €240 billion, in 2021 and 2022 respectively (European Defence Agency, 2023). This marks the eighth year of consecutive growth in defence spending. Several EU countries still fall short of their NATO obligation of military spending of 2 percent of GDP.

4. Reconstruction of Ukraine. The reconstruction efforts in Ukraine will necessitate a collective contribution of €384 billion from all partners over the next decade (World Bank, 2023). This amount will increase in line with the duration of the war, and it is also expected that the private sector will bear a part of that.

In 2021, the Council of the EU approved the establishment of the European Peace Facility (EPF), with a current financial ceiling exceeding €12 billion. The EPF aims to prevent conflicts, promote peace and enhance international security.

In October 2022, the EU Military Assistance Mission in support of Ukraine (EUMAM)was formed with the purpose of providing individual, collective and specialised training to Ukraine's Armed Forces, and to coordinate and synchronise the activities of member states delivering this training.

5. Health Union. Similarly, an EU4Health programme with a budget of €5.3 billion was put together in 2021 for the period 2021-2027 to advance the EU's health policies, towards a European Health Union, intended to ensure collective preparation for, and response to, health crises[4].

Amounts stated above include both investment and spending needs, as it is often not possible to separate the two. From 2021 to 2027, EU spending power is just over €1800 billion, of which €1050 comes from the MFF and €750 billion from NGEU. This amounts to an average of €257 billion in annual spending power.

This average annual total spending power falls significantly short of the €356.4 billion in additional annual investment needed for the green transition alone, as estimated by Pisany-Ferry *et al* (2023). Even if the EU were to spend its entire budgetary resources only on the green transition, it would fall very short of what is needed.

And that is only one of the EU's objectives. This is why many voices have called for private investment to be mobilised to help achieve the EU's objectives.

EU policymakers recognise the importance of maximising crowding-in of private capital for strategic projects. This was a central aim of two EU investment programmes: the investment plan for Europe (the so-called 'Juncker Plan') and InvestEU (see section 4.2 for details of these programmes).

These two initiatives were established in 2015 and 2021, respectively, to increase overall investment levels in the EU. EU initiatives need to be careful to maximise the impact of the limited resources, including by avoiding the crowding-out of private-sector investment. Instead, private investment should be facilitated by EU actions.

These include participating in the financing of projects, by picking up the risk tranches that the private sector is reluctant to take on, reducing red tape and unifying regulatory frameworks for infrastructure. The scarcity of resources also underlines the importance of well-designed allocation mechanisms and the prioritisation of objectives.

EU countries have a crucial role to play by deploying public funds to help finance investments of strategic relevance for the EU. But not all countries have the same ability to play a role in this regard. Darvas *et al* (2023a) reported that the European Commission projects that 18 of 27 EU countries will have either a debt level above 60 percent of GDP or a budget deficit above 3 percent of GDP in 2024, which under the old fiscal framework[5] would trigger the EU excessive deficit procedure (EDP).

The EDP was suspended in 2020 because of the COVID-19 pandemic but its reinstatement is planned in 2024. A reform of the EU fiscal framework agreed at the end of 2023 requires from EU countries very ambitious fiscal adjustment of more than 2 percent of GDP over the medium term, in addition to what had already been planned for 2023-24 (Darvas *et al* 2023b).

In addition, there is also the issue of the speed at which countries are asked to reduce debt, which will constrain some countries even further in the medium term (after countries have brought their deficit below the level of 3 percent of GDP.

Budgetary limitations and the need to reduce high levels of debt will directly affect the ability of countries to undertake strategic investments at national level. Part of the rationale for pursuing certain ESIs at EU level is based on the need for all member states to advance at a common minimum speed to ensure that EU long-term objectives are not threatened by lack of progress in individual countries.

Tighter fiscal rules might lead countries to cut back on investment support, increasing the importance of a well-defined framework for EU strategic investments.

Given the importance of the issue of how to finance the EU's objectives, the discussion goes beyond the two main current tools, the MFF and NGEU, and touches on the wider issue of EU fiscal capacity.

One possibility is to pool resources at EU level, in other words to establish a stream of additional 'own resources' that can be used to fund, among other things, strategic investments. For the moment the discussion on own resources is motivated by the need to repay NGEU borrowing, which involved the largest EU bond issuance in its history.

As a one-off instrument however, own resources are also finite. We argue that if permanent new income streams were to be established, then ESIs would be the next natural candidate item to be funded through vehicles other than the MFF.

European Commission (2021) proposed three new sources of revenue for the EU budget: 1) the EU emissions trading system, 2) the Carbon Border Adjustment Mechanism (CBAM), and 3) taking an allocation from member state taxes on the largest multinational companies.

The European Parliament supports these three sources of revenue and has asked the Commission to also explore several other potential sources as a basis for own resources, including corporate taxation (derived from a aggregation of the corporate tax base in the EU, as put forwards in the Business in Europe: Framework for Income Taxation (or BEFIT proposal), a tax on cryptocurrencies, a tax related to the digital economy, a financial transactions tax (FTT) and an EU 'fair border tax' (European Parliament, 2023a).

In a February 2023 resolution, the European Parliament (2023b) urged the Commission and member states to make progress on adopting an FTT to help the EU boost its industrial competitiveness and other policy priorities.

To that we would add the point that temporary issuance of debt for the RRF meant that the EU did not benefit from its full potential (Claeys *et al* 2021). Even though the European Commission followed the diversification practices of big issuers, the markets still priced a premium on this debt over and above what fundamentals justify.

This was a consequence of: i) the issued volume being small and therefore not fulfilling the purpose of issuing a significant new safe asset, and ii) the issuance being presented as a one-off event, thus making it less attractive to investors. A permanent stream of own resources would lead to more favourable issued debt by the EU than now.

Last, the intergenerational nature of ESIs makes a case for financing them with intertemporal means, such as long-term debt issued by the EU. Naturally, other instruments than debt issuance should also be considered (Helm, 2023).

2.3 The macroeconomic impact of public investment

The role of public investment in promoting economic growth has been studied extensively in the literature. The consensus is that public investments have a positive multiplier effect on the economy, but the magnitude of this

multiplier effect varies depending on the economic situation, the composition of investments and the economy's absorption capacity.

Public investment is seen as a potential driver of long-term growth by catalysing private sector investment and by enhancing productivity by modernising infrastructure, stimulating innovation and promoting education.

Moreover, public investment can play a crucial role in stabilising the economy by mitigating the negative effects of economic contractions. The EU Recovery and Resilience Facility (RRF) offers a good example, having the objective of supporting investments in the twin transition during a severe recession when public resources were very limited.

By helping to sustain the course on meeting long-term targets, the RRF has relieved national budgets and allowed countries to deal with the serious contraction during the pandemic.

Based on the literature, we summarise next the effects of public investment on the macroeconomy.

2.3.1 Impact on economic growth

Public investment in infrastructure and education has played a central role in growth and poverty reduction strategies designed by many developing countries in recent decades (United Nations, 2020). This role is only likely to increase in importance in a post-COVID-19 world as countries seek to restore pre-pandemic growth rates and repair the scarring effects that lockdowns and closures have inflicted on human capital (Agarwal, 2022; Larch *et al* 2022).

There is a substantial body of work that seeks to quantify the macroeconomic effects of such investment efforts and its financing (Atolia *et al* 2021; Gurara *et al* 2019; Zanna *et al* 2019).

An increase in public investment can affect economic growth in two ways. First, an increase in public investment has positive effects on aggregate demand. Second, efficient public investment can contribute to the economy's productive capacity by increasing the stock of public capital.

However, it is important to consider the costs and benefits of additional public capital carefully, taking into account the financing alternatives and their effects on output and public finances. Considerable uncertainty surrounds the size of short-term fiscal multipliers.

They are, for example, larger during recessions, but found to be smaller in the presence of weak public finances, particularly when debt sustainability is at risk. In addition, multipliers depend on how the expenditure is financed, through debt, increases in revenues or cuts to other expenditure categories.

Empirical estimates of the effect of public capital on output tend to be positive but variable (Romp and De Haan, 2007). Studies by Barro (1988) and Aschauer (1989b) found that increases in public capital, such as infrastructure investment, have a positive impact on long-term economic growth by contributing to the economy's productive capacity.

Meta-analyses reveal an average long-term elasticity ranging from 0.12 (Bom and Ligthart, 2014) to 0.16 (Nuñez-Serrano and Velazquez, 2017) for public capital. Thus, for every 1 percent increase in public capital, long-term output tends to increase by somewhere between 0.12 percent to 0.16 percent, which is far below Aschauer's (1989b) estimate of 0.39 percent.

Abiad *et al* (2016) found positive and significant effects of public investment on output for advanced economies, both in the short-term and long term. For low-income developing countries, Furceri and Li (2017) found a

positive effect of public investment on output in the short and medium terms. Ramey (2021) underlined the macroeconomic perspective on government investment, offering robust evidence in favour of the enduring advantages of infrastructure expenditure.

2.3.2 Impact on productivity, job creation and inequality

One of the primary channels through which public investment affects economic growth is by enhancing productivity. Infrastructure investment, such as roads, bridges and telecommunications networks, reduce transportation costs and improve the overall efficiency of the economy (Munnell, 1990).

Public investment also plays a vital role in job creation. Investment in infrastructure projects generates employment opportunities in construction, engineering and related industries. Cingano *et al* (2022) evaluated a public investment subsidy programme in Italy. Under this scheme, funds were allocated through calls targeting different sectors, primarily in industry. The main objective of this policy was job creation.

The authors found that the policy induced the desired behavioural response in terms of job creation: firms benefitting from the programme increased investment by 39 percent and employment by 17 percent over a six-year period, compared to similar firms not eligible for the subsidy.

Infrastructure investment can have an impact on income inequality beyond its effect on aggregate income. Infrastructure can improve the access of the poor to services and productive opportunities. It can also improve access to human capital.

Infrastructure can also support the integration of poor and marginalised communities into the wider society and economy (Calderón and Servén, 2014). Empirical evidence indicates that infrastructure development and access

is negatively correlated with various measures of inequality, although with some measurement limitations (for an overview see Calderón and Servén, 2014). While the evidence on infrastructure and inequality is limited, the impact on inequality should be taken into account when planning infrastructure projects.

2.3.3 Differences between countries and investment types

The effectiveness of public investment is shown to depend on a country's level of development, institutional quality and governance. Governance of the public investment process affects the macroeconomic effects of public investment in different ways (Miyamoto *et al* 2020).

Countries with stronger governance achieve a stronger output impact of public investment. Stronger infrastructure governance[6] helps public investment yield a higher growth dividend by improving investment efficiency and productivity, and it stimulates private-sector investment.

By contrast, weak infrastructure governance is shown to crowd out private investment, lead to higher debt-to-GDP ratios and cause significant waste of public money, all of which have a negative impact on output, even after sizeable public investments.

Moreover, the type of investment matters. While infrastructure, education and healthcare investments are all recognised as having positive effects on output, the effect varies in magnitude (Ramey, 2021; Atolia *et al* 2021).

Holmgren and Merkel (2017) performed a meta-analysis of the relationship between infrastructure investment and economic growth. They found significant variance in the effect of infrastructure investment on production.

Specifically, the estimated effects of a one percent increase in infrastructure investment range from a 0.06 percent decrease to a 0.52 percent increase in output. The effects appear to vary depending on the type of infrastructure in which the investment is made, and the type of industry.

A more recent line of research indicates that investment multipliers are more pronounced for green investments. According to Batini *et al* (2022), spending on clean energy, such as solar, wind or nuclear, exerts a GDP impact approximately two to seven times greater (depending on the technology and timeframe analysed) than spending on non-environmentally friendly energy sources, including oil, gas and coal.

Afonso and Rodrigues (2023) studied the impact of public investment in construction and R&D in 40 countries, notably on economic growth and on crowding-out effects on private investment. They compared the effects of these investments in emerging and advanced economies by controlling for the level of economic development.

They found that: i) innovations in public investment have more positive effects on GDP growth and private investment in emerging economies; ii) the positive impulse of public investment on the private sector is pronounced and significant in emerging economies; iii) government construction investment has a more positive effect on economic growth in emerging economies; iv) innovations in public construction crowd out private investment spending in advanced countries; v) emerging economies benefit from public R&D investment.

Two recent, timely papers (Kantor and Whalley, 2023; Gross and Sampat, 2023) showed that public R&D may have large effects locally and also at the aggregate level. Both papers examined episodes of applied public R&D 'moonshots': the US government's massive R&D effort during the Second World War and the US Apollo mission in the 1960s that culminated in the moon landing. In both cases the level of public investment was massive.

Bloom *et al* (2019) discussed several of the main innovation policy levers and described the available evidence on their effectiveness: tax policies to favour research and development, government research grants, policies aimed at increasing the supply of human capital focused on innovation, intellectual property policies and pro-competitive policies.

They brought together this evidence into a single-page 'toolkit', in which they ranked policies in terms of the quality and implications of the available evidence and the policies' overall impact from a social cost-benefit perspective. The authors found that, in the short term, R&D tax credits and direct public funding prove most impactful.

However, increasing the supply of human capital yields greater effectiveness in the long run. Additionally, while competition and open trade policies may offer somewhat modest benefits for innovation, they are cost-effective.

In conclusion, there is general agreement that public investment can play a positive role in economic growth and the achievement of policy objectives. However, the effective implementation of these investments and their alignment with economic and policy priorities are pivotal to their success.

3 Defining European strategic investments

The term 'strategic investment' is used often but very seldom defined. In his award-winning book Chip War, Chris Miller (2022) quoted a Reagan Administration economist who, in response to the multiple Silicon Valley requests for support for the semiconductor industry, invoking its strategic relevance, stated: *"Potato chips, computer chips, what's the difference? ... They are all chips. A hundred dollars of one or a hundred dollars of the other is still a hundred."*

The quote illustrates the lack of a common definition of the notion of 'strategic'. Is strategic something that you cannot do without, or is it something that aims to achieve long-term objectives, or possibly both, or something else entirely?

According to the Cambridge Dictionary, the term strategic refers to investments made by a company with the intention of enhancing its long-term success. This might involve investing in a new business that offers access to new markets or developing innovative products.

Milgrom and Roberts (1992) defined strategic investments as investments that benefit the entire organisation, not just the specific unit making the investment decision. These investments are crucial for businesses as they can lead to competitive advantages through cost reduction and product differentiation, ultimately creating value (Porter, 1980; Makadok, 2003). These definitions from the business context have only limited application to a policy context.

A common theme in these definitions is the emphasis on long-term impact. Strategic investments are typically seen as financial commitments made with a focus on creating long-term value, rather than seeking short-term returns. In essence, they involve allocating financial resources to projects, assets or initiatives aimed at achieving specific long-term objectives and strengthening an organisation's competitive edge.

Closer to the policy context is the concept of strategic investment funds. Divakaran *et al* (2022) defined such funds as having six attributes: i) they are initiated and (partially) capitalised by governments or quasi-sovereign institutions, ii) they invest primarily in unlisted assets and aim to achieve financial returns as well as pursue policy objectives, iii) they aim to mobilise co-investment from private investors, iv) they provide long-term, patient capital (mostly, but not exclusively, equity), v) they operate as professional fund managers seeking financial returns for their investors, and vi) they are investment funds established as separate legal structures.

Looking at the EU's past efforts labelled as strategic investments, this definition is only a partial fit. In particular, achieving financial returns has not been a major objective of some of the main strategic investment initiatives in the EU.

3.1 European strategic investments: a working definition

Bringing together insights from the literature, and international and EU experiences with strategic investment, we define 'European strategic investments' (ESIs) as follows:

> *Investments, defined as gross fixed capital formation, carried out at the national or EU level are ESIs if they are consistent with the EU's long-term objectives and priorities*[7].

The term 'strategic' must provide a rationale for prioritising investments and therefore the order in which long-term objectives are pursued. European strategic investments can be financed by the private sector, by EU countries or with EU financing. Therefore we supplement our definition with:

> *The decision to (co-)finance some of these ESIs at the EU level additionally requires that those investments are European public goods (EPGs). This means that there is added value to be had by pursuing investment at the EU level instead of solely at member state level.*

Not all European public goods are investments as some might refer to consumption, for example, common procurement of vaccines. Equally, not all investments that are EPGs are necessarily strategic, in other words, of the highest priority.

In this paper, we only focus on ESIs that merit EU financing according to the thinking just described. However, the objective is to encourage the participation of both the private sector and member state governments. The remainder of this section discusses the concepts of EPGs and 'strategic' in more detail.

3.1.1 What are European public goods (EPGs)?

A starting point for the provision of any public good is the presence of a market failure that prevents the private sector from taking up a specific economic activity. In the presence of externalities, a good or service either will not be provided or will be underprovided by the markets.

For EPGs, there is also a failure at the national level, in that a good or service will not be provided or will be underprovided if EU countries are left to provide for it individually.

The concept of EPGs encompasses the concept of additionality that is cited in the regulations that underpin many EU investment instruments. Additionality means that EU financing does not displace financing from any other source.

In other words, the additionality principle states that the project would not be realised, or not to the same extent, without EU financial support. Importantly, efficiency gains such as shorter delivery times or lower cost can also satisfy the additionality principle.

Fuest and Pisani-Ferry (2019) justified the provision of a public good at the EU level when the benefits of doing that exceed the benefits of providing it at member state level. Such added value could come from economies of scale, crossborder spillovers and similarity in country preferences and interests.

Efficiency gains at the EU level would come either through crossborder spillovers or through cost-savings arising from economies of scale if a good is financed at the EU level rather than separately by each country. Buti *et al* (2023) argued that providing EPGs could strengthen cohesion across countries and, therefore, also benefit the EU as a political entity.

Since the COVID-19 pandemic crisis and then the energy crisis following the Russian invasion of Ukraine, the discussion on market failures has broadened to include not only the under-provision of a good or a service, but also the issue of underinvestment in resilience (Grossman *et al* 2023).

The idea here is that firms themselves might be individually sufficiently diversified in how they organise their supply chains, for example, but sectors might not. This could make a sector vulnerable and could, if economically systemic, pose a significant risk to a whole country's 'business continuity'.

Public intervention is then justified as a way of internalising this systemic vulnerability. The rationale suggests that if efficiency gains are achievable at the EU level, say because of crossborder spillovers, conducting this public intervention at the EU level is most fitting.

An example of such a vulnerability that unravelled was relying entirely on imports for the provision of face masks at the start of the pandemic, a good that was critical for safeguarding public health.

The question then is, what public goods can achieve efficiency gains if provided at the EU level? Buti *et al* (2023) identified six areas where EPGs exist: digital transition, green transition and energy, social transition, raw materials, security and defence, and public health.

These public goods could include both investment (for example in infrastructure) and consumption (as the joint purchase of face masks), or could require joint action at EU level (for example procurement). In our definition of European strategic investments that are eligible for EU financing, we thus only include EPGs that refer to investments.

3.1.2 When is an investment strategic?

A common theme that underpins all definitions of strategic investment is the need to respond to long-term objectives. However, long-term investment has been challenged in the past 15 years with the world economy hit by extreme shocks that originated in very different geographies and parts of the economy.

Extreme events now occur seemingly more often, and it is no longer safe to assume that similarly severe shocks will not continue to occur. A financial crisis, followed by a pandemic and more recently the Russian invasion of Ukraine that has forced the EU to reconfigure its energy relationships, all in the space of 15 years, has meant that investments have had to be delayed or re-prioritised to deal with urgent issues.

In response to these three extreme shocks, the EU has had to redefine its priorities. The financial crises required the EU to invest in strengthening its institutional power to monitor and safeguard its banking sector.

The pandemic required protecting the economic value of households and firms, prioritising the financing of critical goods such as vaccines and reassessing the length of international supply chains. The energy crisis has forced the EU to change its energy mix and rethink how it can secure its energy supply.

Arguably, some of the investments made in fossil fuels in the EU to ensure energy security (such as in liquid national gas terminals or the re-opening of coal mines) can be understood as an example of reprioritising the objective of energy security above climate objectives, at least in the short run. No one could doubt that such investments were of strategic relevance to the EU's interests.

Nevertheless, adhering to long-term objectives remains crucial in the process of identifying strategic investments. The challenge for policymakers in identifying and pursuing ESIs is to navigate the high levels of uncertainty present while remaining consistent with a long-term vision.

3.2 Examples of European strategic investments

A non-exhaustive list of projects that are ESIs potentially qualifying for EU financial support under our definition would include[8]:

Energy infrastructure and projects boosting energy efficiency, especially crossborder projects. These include power plants, power grids and energy-storage facilities. There is a strong case for EU action since reaching the EU's climate goals depends strongly on the European energy mix and the infrastructure to transfer energy across the Union. The actions of a single country will benefit or harm the global climate, and therefore have direct implications for other EU countries.

Projects with a direct crossborder element, such as crossborder grids or grid interconnectors, could particularly benefit from EU action. While not necessarily constituting infrastructure, projects to boost energy efficiency, such as the refurbishment of buildings, would also qualify as being of EU value added.

ICT infrastructure, especially crossborder projects. This category includes infrastructure needed to connect European citizens within and across borders. Examples would be the 5G rollout or the development of optical fibre networks. Fast internet connections are becoming increasingly important for European competitiveness. Ensuring the continuity of services across borders would benefit the EU as a whole and justify EU action.

Transport infrastructure, especially crossborder projects. This category includes projects that physically connect European citizens and goods, as well as connections with the rest of the world, for example, roads, railways and ports. EU support is justified particularly for crossborder projects or facilities on important

European transport axes. Projects that aim to make transport more sustainable, such as electric-vehicle infrastructure or sustainable urban transport infrastructure, should also be considered.

Facilities enhancing economic security and resilience. Within this category are essential facilities that, if absent, would pose a threat to the EU's economic security and autonomy. An example of such critical industries would be critical raw materials or semiconductors.

When it comes to economic security, the EU needs to consider strategic investments as part of the broader aim of diversifying its sources of supply. The objective is not to eliminate dependencies but to safeguard business continuity through a mix of international trade and domestic production.

Facilities and projects boosting innovation. Research and development infrastructure and projects with an expected significant impact on innovation in the EU would also qualify for EU financial support under the ESI programme. Innovation will be crucial to the EU's global competitiveness and economic growth.

This category includes physical facilities and programmes supporting the EU's objective to be a global leader in innovation, such as research hubs and R&D projects in strategic sectors. This group could also include social infrastructure projects important for citizens' welfare, such as research hospitals and medical research facilities.

4 EU programmes to finance long-term objectives

This section focuses on the EU's approach to long-term investment. We develop a taxonomy of the EU's public investment instruments and initiatives and examine the outcomes in terms of private capital mobilisation.

4.1 Taxonomy of EU public investment instruments and initiatives

We have identified 24 public investment initiatives implemented by the EU that are relevant to our study.

We discuss the six largest and most important initiatives in more detail: the Recovery and Resilience Facility (RRF), REPowerEU, the European Regional Development Fund (ERDF) and the Cohesion Fund (summarised in a single item because they share the same EU regulation), Horizon Europe, the European Fund for Strategic Investments (EFSI), and InvestEU.

We focus on these programmes because of their size and relevance to the concept of strategic investment in the EU.

We describe here briefly the purpose of each of these programmes and include a detailed taxonomy of all EU initiatives in Appendices 2 and 3[9].

1. The RRF, created in 2020, provides €723.8 billion in grants and loans to support reforms and investments in EU countries. It is the centrepiece of NGEU, a temporary recovery instrument to support the economic recovery from the COVID-19 pandemic and to build a greener, more digital and more resilient future for the EU. NGEU is worth €806.9 billion as of 2023 and is scheduled to operate from 2020 to 2026[10].

2. The related REPowerEU initiative was put together to help deal with the energy crisis following the Russian invasion of Ukraine in 2022. It aims to facilitate an affordable phase-out of Russian gas by 2027 and was funded by the €225 billion at the time still available in the loan component of the RRF that had not been claimed by member states.

To support REPowerEU, the financial envelope was increased with €20 billion in new grants. These grants will be financed through the frontloaded sale of emissions trading system (ETS) allowances and the resources of the Innovation Fund[11], to be partly replenished through the Market Stability Reserve[12].

Additionally, EU countries have the option to voluntarily transfer €5.4 billion of funds from the Brexit Adjustment Reserve[13] to the RRF to finance REPowerEU measures. This comes on top of the existing transfer possibilities of 5 percent from the cohesion policy funds[14] (up to €17.9 billion).

3. The ERDF and Cohesion Fund, with a total budget of €274 billion between 2021-2027, are dedicated to reinforcing economic, social and territorial cohesion within the EU.

4. Horizon Europe, with a total budget of €95.5 billion, is the EU's primary funding programme for research and innovation. It will be implemented in the period between 2021-2027.

5. The EFSI is the main vehicle of the investment plan for Europe (also known as the 'Juncker Plan'), created in 2015 to boost competitiveness and growth by helping unlock European Investment Bank financing for economically viable projects that would normally have been considered too risky for EIB participation. It pledged €33.5 billion and aimed to raise €500 billion by 2020 (a goal that was achieved; see section 4.2).

6. Finally, InvestEU the successor to the Juncker Plan, was created in 2021. Just like its predecessor it aims to enhance EU competitiveness, innovation, sustainability and social cohesion. It has pledged €26.2 billion and aims to raise €372 billion in investments.

The EU regulations underlying each of these instruments define the projects eligible for investment in terms of objectives rather than sectors. These objectives are typically very broad and therefore often overlap between programmes.

Projects enhancing the competitiveness, socio-economic convergence and cohesion of the Union, particularly in the realms of innovation and digitisation, are covered by all six instruments. The same is true for projects fostering sustainability, inclusiveness in the Union's economic growth and social resilience, including education, social infrastructure and training programmes.

All initiatives also aim at increasing access to finance for small and medium and mid-cap companies. Finally, meeting the sustainability and climate EU objectives figure prominently in each initiative.

Importantly, the regulations underlying all these recent initiatives, with a specific exemption concerning immediate energy security aims in REPowerEU and Horizon Europe, include a 'do no significant harm' clause, meaning that projects financed under these programmes cannot go against EU environmental objectives.

Programmes are managed and governed by different entities, but any given project can qualify for several of these programmes. Programmes are also targeted at different entities. For example, InvestEU funding is targeted at projects, while funding from the Cohesion Fund is disbursed to regions. Streamlining the number of initiatives could yield efficiency gains for strategic investment at the EU level.

Two main takeaways emerge from Table 1. The first is that there are two sources of funding for these programmes: the EU budget (MFF, either through direct funding or providing a guarantee) or funds raised through borrowing in the context of NGEU. Long-standing investment programmes that have been present in the EU budget for several

Table 1. Shortened taxonomy of the main investment initiatives at EU level

Name	Time	Budget	Source of funding	Instruments	Capital mobilisation targets (€ billions)
RRF	2021-2026	723.8 (which includes most of REPowerEU)	• Dedicated bonds (NGEU)	• Loans • Grants	-
REPowerEU	2022-2026	300 (mainly from RRF with only 20 billion being new grants	• RRF • ETS allowances • Brexit Adjustment Reserve • Cohesion Funds	• Loans • Grants	-
ERDF/Cohesion Fund	2021-2027	274	• EU Budget	• Grants	-
Horizon Europe	2021-2027	95.5	• EU Budget • NGEU	• Mainly grants	-
EFSI	2015-2020	33.5	• EU Budget guarantee • EIB resources	• Credit enhancement (intermediate loans, subordinated loans, gaurantees) • Loans • Equity • Venture debt	500
InvestEU Fund	2021-2027	26.2	• EU Budget guarantee	• Credit enhancement (intermediate loans, subordinated loans, guarantees) • Loans • Equity • Venture debt	372

Note: RepowerEU funds are for the most part from the unclaimed funds in the RRF and are therefore not new money.
Source: Bruegel.

political cycles, such as Horizon or predecessors of the ERDF or Cohesion Fund, are mainly funded with resources from the EU budget.

The RRF (and REPowerEU) are funded through an issuance of EU debt in capital markets. NGEU, created during the pandemic, was remarkable for two reasons: first, it increased EU spending capacity by 75 percent; second, it was financed by the issuance of debt. The EU had issued small levels of debt in the past to finance loans.

It was the first time, however, that it issued such high levels of debt and that it issued debt to fund grants to member states. It is worth noting that a big part of the loan component of the RRF was not taken up by many countries at the start of the RRF, even if for some countries the interest rate charged under the RRF was lower than the market rate.

Subsequently, the existence of this underutilised pot allowed the money to be repurposed to deal with energy security under REPowerEU. EFSI and the InvestEU Fund are funded through a more recent financial structure — a guarantee from the EU budget.

The idea of a guarantee backed by the EU budget was born against the background of limited EU resources to spur investment when EFSI was designed (Claeys, 2015). Using the guarantee to absorb potential losses could attract private investors to projects that are considered too risky without the guarantee.

EFSI is one of the few programmes for which ex-post evaluation is possible since it started in 2015. Its target of mobilising over €500 billion based on €33.5 billion of resources would result in a target multiplier of over 15[15]. According to EIB analysis, this target was achieved (Wilkinson *et al* 2022). Therefore, the guarantee seems to have fulfilled its purpose.

However, as noted by Claeys (2015), the programme would only have been truly successful if it unlocked financing for projects that would not have been financed otherwise. Claeys and Leandro (2016) cast some doubt on this issue for the projects financed by EFSI in its first year. The EIB acknowledged that it cannot verify that all financed projects would not have been financed without its support (Wilkinson *et al* 2022).

Only EFSI and the InvestEU Fund set explicit targets for mobilising private investment. Additionally, the Horizon Europe regulation mentions maximising the mobilisation of private capital where possible. Finally, the RRF regulation mentions mobilisation of private capital, but rather as an additional benefit than an objective in itself.

When EFSI was announced, it was uncertain whether the EU budget guarantee would truly change the tendency of the EIB to invest in relatively low-risk assets (Claeys, 2015). According to the EIB, EFSI altered the riskiness of its portfolio with EFSI projects being on average riskier than other projects financed by the EIB.

However, as of 2022, the cumulative number of guarantee calls was modest, at approximately €184 million. This relatively low amount could suggest that a guarantee from the EU is enough to unlock financing for most projects executed under EFSI, without significantly increasing the burden on the EU budget.

On the other hand, the low default rate of projects could simply suggest that the projects were not very risky to begin with, and that the EU budget guarantee has not led the EIB to invest in significantly riskier projects.

In this regard, it should be noted that the EIB has a fiduciary duty towards the EU budget with regards to operations under the budget guarantee, and therefore a low default rate should be seen as positive.

The second takeaway from Table 1 is that programmes differ regarding the financial instruments used to finance projects of interest. The programmes funded by the EU budget or bond issuance (RRF, REPowerEU, Horizon Europe, ERDF and the Cohesion Fund) mainly use loans and grants.

The programmes funded by an EU guarantee and managed by the EIB use loans, equity, venture debt and credit-enhancement instruments. EFSI and InvestEU reflect a broader spectrum of capital market instruments. Credit-enhancement products in particular can be suitable for financing infrastructure projects (OECD, 2021).

These products transfer risk from investors to the EIB (backed by the EU budget) and can reduce the cost of financing while attracting additional investors[16]. Diversifying the range of financial instruments available to projects and companies is important for optimising resources and adapting the financing structure to project needs.

Some of the lessons learned from EFSI were embedded in the design of its successor, InvestEU. For example, under the EFSI regulation, the only implementing partner for financing projects was the EIB. A side-effect of this was that only relatively large projects were eligible for EFSI financing. Under InvestEU, the range of implementing partners was extended to local institutions.

The RRF required member states to prepare Recovery and Resilience Plans (RRPs) that detail national programmes of reforms and investments over the RRF period (up to 2026). Of the plan's total allocation, 37 percent and 20 percent should be allocated to the climate and digital objectives, respectively.

RRPs have been assessed by the European Commission and endorsed by the Council. The assessments comprise development of two documents, a Council Implementing Decision (CID), and a staff working document (SWD).

Milestones and targets are associated with each reform/investment (and detailed in the CID). The Commission disburses the funds after achievement of the pre-agreed milestones and targets at each payment request. Disbursement of funds is thus conditional on reaching milestones and targets.

The RRF experience will yield valuable lessons on the viability of making funding available to member states for strategic investments in combination with implementing structural reforms.

At the outset, however, while the grant component of the RRF was taken up by all countries, only a limited number of countries took up the loan component in the beginning[17] (Demertzis, 2022). This meant there were funds available that could be redirected to REPowerEU. Taking into account the latest requests at time of writing, take-up of the total loan component of the RRF (€385.8 billion) now amounts to €292.6 (or 76 percent). Some of the latest loan requests are still subject to formal approval[18].

Member state performance in the context of the RRF remains to be evaluated. The RRF is a performance-based programme, in the sense that the disbursement of funds is conditional on countries achieving milestones and targets. But Darvas *et al* (2023a) argued that Article (2) of the regulation defines 'milestones and targets' as *"measures of progress towards the achievement of a reform or an investment."* The expression *"measures of progress towards"* thus indicates a process, not necessarily the achievement of results. This has also been observed by the European Court of Auditors (2023).

Therefore, a clearer definition of 'performance-based' is needed and should be based on outputs and results. There is also discussion on whether the milestones and targets set are sufficiently ambitious. As mentioned by Corti *et al* (2023), Italy will successfully fulfil its milestones and targets but will likely not achieve some of the objectives of the measures included in its RRP, including reducing regional and local inequalities in the provision of employment and

childcare services. This could indicate that milestones and targets defined under RRF are too easy to achieve and not necessarily what the programme aims for.

Last, Claeys *et al* (2021) claimed that the temporary nature of NGEU borrowing, and its relatively small scale compared to borrowing by national governments, increased the cost of debt. Permanent EU borrowing would be more widely accepted by financial investors and could have the added benefit of creating a true European safe asset.

In addition to providing financing for projects, EU investment initiatives have also created auxiliary services to facilitate investments. For example, the European Investment Advisory Hub, established in 2015 alongside EFSI, aimed to enhance investment after the economic crisis. The Hub provides advisory services to project promoters to support investment in the real economy.

The Hub's objective is described (in Regulation 2015/2017) as building on existing EIB and Commission advisory services in order *"to provide advisory support for the identification, preparation and development of investment projects and act as a single technical advisory hub for project financing within the EU."*

However, a report from the European Court of Auditors (2020) highlighted concerns. The Hub was deemed a 'demand-driven' tool without sufficient prior assessment of its advisory needs, potential demand or required resources. While it satisfactorily offered tailored advisory services, it lacked a clear strategy for targeting support where it could maximise value. Some beneficiaries questioned the uniqueness of Hub support compared to other advisory sources.

Moreover, only over 1 percent of EFSI-supported financial operations benefited from Hub assignments. Additionally, the Hub lacked proper procedures to follow up on investments resulting from its assignments, hindering performance evaluation.

By the end of 2018, the Hub had completed too few assignments to contribute significantly to boosting investment. These findings were considered in the design of its successor, the InvestEU Advisory Hub.

This Hub has replaced thirteen[19] centrally managed advisory programmes and is the central entry point for advisory and technical assistance requests. InvestEU Advisory Hub partners provide project advice, capacity building and market development support to promoters and intermediaries. The Advisory Hub is aligned with the objectives of the InvestEU programme.

4.2 Leveraging private capital

One of the goals of past ESI initiatives was leveraging private capital. The two largest initiatives, the EFSI and InvestEU, have aimed explicitly at maximising the mobilisation of private capital. EU policymakers acknowledge that the investment volume needed to achieve long-term political objectives will need to be largely supplied by the private sector (European Commission, 2023a). Therefore, future efforts for ESI should also focus on maximising private-sector participation in investment projects where possible.

From a macroeconomic perspective, several studies document the positive effect of public investment on attracting private investment (Aschauer, 1989a; Abiad *et al* 2016; Pereira, 2001; Brasili *et al* 2023). Abiad *et al* (2016) showed that the effect is greater in times of economic slack and when public investment efficiency is high.

Brasili *et al* (2023) showed a positive effect of local government investment on private investment, while evidence from Brueckner *et al* (2022) suggested that local governments are more efficient in crowding-in private investment than national governments. Focusing on public R&D support programmes, Azoulay *et al* (2019) and Moretti *et al* (2019) showed that public R&D spending crowds-in private R&D investment.

Turning to the experience of past and present EU strategic investment initiatives, such public efforts can mobilise private investment in four ways. First, a public sector entity can finance or secure the riskiest tranche of capital of an investment project that private investors are unwilling to take on, leaving them the less risky part.

Second, public investment, notably in SMEs and mid-caps, can result in increased corporate investment. Third, having a large public institution with a good track record as part of the investor mix can enhance the credibility of a project.

Fourth, public investment in important enablers such as infrastructure or financial support for R&D activities can mobilise private capital and improve the use and allocation of resources (European Investment Bank, 2022c).

Recent EU programmes offer insights related to the first point. EFSI achieved its goal of mobilising over €500 billion of investment, according to EIB estimates, using only €26 billion in EU budget guarantees and €7.5 billion of EIB own resources, resulting in a multiplier of over 15 (Wilkinson *et al* 2022).

Overall, the strategic investment programmes managed by the EIB have been successful in mobilising private investment using guarantees, loans, equity and quasi-equity instruments. However, it should be noted that most of the assessment of EFSI is based on analyses by the EIB itself. The EIB's assessment of EFSI's activities yield some insight on how the multiplier of 15.75 was achieved.

Some, though not all, project promoters that benefitted from EFSI support under its Infrastructure and Innovation Window (IIW) highlighted in particular that the EIB's involvement in their project attracted other investors. However, promoters indicated that in some instances, EFSI financing might have crowded-out financing from other investors (Wilkinson *et al* 2022).

A survey of EFSI partners also indicated that EFSI operations led to improved availability and conditions of financing for SMEs and mid-caps, notably through increased lending activity to such firms at better conditions (lower collateral, fees, interest rates) by partnering lending institutions.

One in ten of respondents, however, reported that they could have obtained financing/guarantees at similar conditions from other sources without EFSI support. The EIB describes this level of redundancy as acceptable (Wilkinson *et al* 2022).

On the second point (increased corporate investment), given the relevance of SMEs in the European economy, the role of public investment in helping them increase their investments is particularly important. EIB analyses show that their loans translated to better financing conditions for SMEs and mid-caps, ultimately resulting in increased employment, investment and stronger growth of supported firms.

EIB (2022a) argued that their venture loans, which typically provide liquidity between rounds of raising equity in fast-growing firms, have helped lower financing costs and have crowded-in additional debt. The EIB estimates that alleviating financing constraints for EU firms could unlock €120 billion of corporate investment annually. Similarly, better infrastructure can lower the cost of doing business for firms and increase output.

On the third point, in addition to directly affecting the financing conditions for a project or company, EIB analyses indicate that EIB investment also has a reputational effect that can attract private investors.

Finally, public investment in infrastructure or research activities can generate additional private investment and improve productivity and the allocation of capital. European Investment Bank (2022c) projected that EFSI investment operations will have long-term positive effects on the EU economy, predominantly because of such structural effects.

The EIB makes use of financial instruments other than traditional equity and loans that can unlock private sector capital. Such instruments include intermediated loans, low-interest loans, credit enhancement, guarantees and venture debt. An important question is which financial instrument is most effective at crowding-in private investment.

Credit-enhancement products in particular have the clear potential to provide a high multiplier, ie. mobilising considerable investment by using a comparatively small amount of public resources. European capital markets are not as developed as in the United States.

Consequently, European companies have greater difficulty accessing risk capital than US counterparts. Furthermore, financing conditions for European firms might be deteriorating. The EIB Investment Survey (European Investment Bank, 2023b) indicated that the share of EU firms dissatisfied with the cost of finance in the EU increased from 5 percent in 2022 to more than 14 percent in 2023.

These factors increase the potential impact of public guarantees. In the future, research comparing different instruments in terms of cost and accessibility would be valuable in designing strategic investment programmes.

On the equity side, large infrastructure projects sometimes require an equity or quasi-equity buffer to make the project interesting for private investors. The public sector can play an important role in de-risking large-scale projects to attract private investors, including institutional investors such as pension funds and insurance companies.

The EFSI and InvestEU experiences show that equity and quasi-equity provided by the EIB has a positive effect for SMEs and mid-caps. Future ESI initiatives should explore the potential of such instruments to provide effective de-risking to projects.

5 Public investment management

5.1 Framework and examples

Improving the management of public investment is crucial in boosting the efficacy of public capital expenditure. Recent estimates indicate that roughly 30 percent of resources are lost in the process of managing public investment (Baum *et al* 2020).

Governments exhibit a relatively high level of inefficiency in deploying public investment, and Rajaram *et al* (2014) emphasised the range of reasons behind this phenomenon. The complexity of public investment projects, involving prolonged processes and presenting challenges in planning, coordination, financing, procurement and contract implementation, often results in cost overruns and delayed completion, surpassing even meticulously planned estimates. Baum *et al* (2020) estimated that inefficiencies could be halved through the enhancement of public investment practices.

Efficient public investment management across levels of government – regional, national and EU-level – is crucial for designing the future of ESIs. Insights from the public investment management can inform the ESI governance framework.

Based on this literature, we have identified four pillars for a well-functioning public investment system: i) planning, ii) budgeting, iii) implementation and monitoring, and iv) ex-post evaluation.

Underlying these four pillars are the '12 Principles for Action' for effective public investment management across levels of government, published by the OECD in 2014 (OECD, 2014; OECD, 2019).

In 2015, the International Monetary Fund proposed its own framework to assess the quality of public investment management practices – Public Investment Management Assessment (PIMA; IMF, 2015).

The PIMA Framework focus is on the concrete planning of investments (with attention paid to coordination between the different policy levels), on allocating investment to the right project (based on transparent criteria and a long-term vision) and on implementing the selected projects within the set timeframe and within the planned budget.

Finally, Manescu (2022) provided fresh insights into public investment practices within the EU. The key elements highlighted for an ideal public investment system across various stages, as highlighted by Manescu (2022) include: planning, appraisal and selection, budgeting, monitoring and implementation, ex-post reviews and assets registers.

We highlight four pillars to enhance a public investment system, within which we classified the 12 Principles of the OECD:

5.1.1 Planning

Governments should formulate robust investment plans based on a comprehensive, long-term strategy. These plans should include deliverables, accurate cost estimates, an assessment of existing capital assets and identified needs.

Table 2. Fours pillars of public investment management

Pillar 1: Planning	Pillar 2: Budgeting	Pillar 3: Implementation and monitoring	Pillar 4: *Ex-post* review
Principle 1: Develop an integrated investment stategy tailored to local factors	Principle 6: Mobilise private investors and financing institutions to diversify sources of funding and strengthen sub-national capacities	Principle 5: Engage with stakeholders throughout the investment cycle	Principle 7: Strengthen the proficiency of public officials and institutions engaged in public investment, particularly at the sub-national level
Principle 2: Adopt effective instruments for coordination across national and sub-national levels of government	Principle 7: Develop a fiscal framework aligned with investment objectives pursued	Principle 11: Promote transparency and strategic use of public procurement	Principle 8: Focus on results and promote learning from experience across levels of government
Principle 3: Coordinate horizontally among sub-national governments to invest at the relevant scale	Principle 10: Enforce sound and transparent financial management at all levels of government	Principle 12: Ensure quality and consistency in regulatory systems across levels of government	
Principle 4: Assess the long-term impacts and risks of potential projects upfront			

Note: Principles from OECD.
Source: Bruegel.

The objectives are to: i) design and implement investment strategies tailored to the specific locations they intend to benefit; ii) foster synergy and minimise conflicts between different sectoral strategies; and iii) encourage the production of data at the appropriate sub-national level to guide investment strategies and provide evidence for decision-making.

While most EU countries have some form of strategic investment planning, the extent can vary. Some examples of clear, multi-year investment plans can be found in the Netherlands (MIRT), Ireland (Project Ireland 2040) and Latvia (NDP27)[20].

Coordination between different entities involved in a public investment effort is an essential aspect of success. Neglecting this can lead to misallocation of resources. In the Netherlands, a good example is the Association of Dutch Municipalities (*Vereniging van Nederlandse Gemeenten*, VNG), which unites all municipalities, and the Association of Provinces (*Interprovinciaal Overleg*, IPO) which coordinates between sub-national administrative layers.

In the UK, a Cities Policy Unit was created in 2011 with public, private, central and local stakeholders to help coordinate urban policy. The goal of the Cities Policy Unit is to work with cities and government to help cities create new ideas and turn the ideas into successful plans.

In Italy, the Interministerial committee for economic planning and sustainable development (CIPESS) is an example of efforts to minimise conflicts between different sub-national governments. CIPESS is responsible for the coordination and horizontal integration of national policies, and for aligning Italy's economic policy with EU policies.

Finally, France has the *Contrats de plan État-région* (CPER), operational since 1982, which are important tools in regional policy in terms of planning, governance and coordination.

5.1.2 Budgeting

The second pillar refers to the importance of establishing a well-designed, stable and transparent medium-term budgetary framework that will ensure reliable budgeting for public investment. The goal is to promote consistency between annual budget decisions and the multi-annual lifespan of investment projects.

Additionally, involving private parties and financing institutions in investments can strengthen government capacity and bring expertise to projects, improving ex-ante assessment and achieving economies of scale and cost-effectiveness. Public-private partnerships (PPPs), enabled through innovative financing instruments, are ways of leveraging private capital that provides necessary scale and scope for investments.

The UK also utilises the Medium-Term Fiscal Framework (MTFF) to align budget preparation and public investment plans with fiscal policy. In France, key entities involved in public investment management include Bpifrance and *Caisse des Dépôts et Consignations* (CDC). Both institutions are tasked with investing in projects with policy goals and collaborating with the private sector.

5.1.3 Implementation and monitoring

Monitoring serves at least two related purposes: i) it can facilitate efficient capital allocation and, ii) it can identify potential problems early on and solicit remedial action. Good practices include the publication of monitoring reports, including reappraisal and termination options in project agreements, and defining and enforcing milestones.

Implementation is facilitated by ensuring consistent regulatory frameworks across the different levels of government involved. Furthermore, public entities should engage with a project's stakeholders regularly throughout the investment cycle.

In France, the *Secrétariat général pour l'investissement* (SGPI) is responsible for ensuring the coherence and monitoring of the state's investment policy through the implementation of the France 2030 plan. It is involved in the decision-making processes related to contracts between the state and investment management entities, and coordinates the preparation of project specifications and monitors their alignment with government objectives.

Moreover, it is responsible for the overall evaluation of investments, both before and after implementation. In the Netherlands, the Delta Programme represents a collaborative initiative involving the Ministry of Infrastructure and Environment, provinces, municipal councils and regional water authorities, working closely with social organisations and businesses.

Established in 2010, its primary objectives are to safeguard the Netherlands from flooding and secure a sustainable freshwater supply for the next century. Active stakeholder engagement in the programme has resulted in tailored strategies and the commitment of various entities at both regional and national levels.

Furthermore, the Rijkswaterstaat has a major role in managing the three major infrastructure networks: the road network, the waterway network and the water system.

In the UK, to engage public, private and civil society stakeholders throughout the investment cycle, the government uses Local Strategic Partnerships (LSPs), which are non-statutory bodies that bring together different parts of the public, private, voluntary and community sectors working at local level. LSPs have no legal powers or resources of their own.

5.1.4 Ex-post reviews

Clearly defining the desired outcomes of public investments is of utmost importance. To achieve this, evaluation and monitoring criteria should be established during the initial phases of policy design. This is essential for allocating necessary resources and generating relevant data.

Consequently, regular status and completion reports, and thorough ex-post reviews, become imperative to learn from past experiences. Additionally, fostering active information exchange and ongoing mutual learning among stakeholders engaged in public investment further enhances the effectiveness of the process.

In the EU, ex-post reviews are common but sometimes restricted to a subset of projects. For example, in Ireland, the Public Spending Code requires all large capital projects and a proportion of other capital projects to undergo ex-post review, while in France a similar requirement is in place for the investments in the France 2030 plan.

Furthermore, in many EU countries public administrations often lack the required knowledge and skills needed for effective public investment management, resulting in significant barriers to investment. The European Investment Bank (2023a) identified, for example, the lack of available skills such as environmental planning and engineering expertise as significant factors hampering investment projects.

Enhancing the capacity for public investment in public institutions across all levels of government is important to create an enabling environment.

In Italy, the Basilicata region invested heavily in monitoring and evaluation to support decision-makers. The region has created a Public Investment Evaluation Unit (NVVIP), which is responsible for monitoring and evaluation, including through impact assessments, all public investments in the region, and for checking the consistency of strategic projects with respect to the regional development plan and the annual financial plan.

In Ireland, the Irish Commercial Skills Academy (CSA) was setup in 2019 to offer training on best-practice approaches for effective delivery throughout the lifecycle of a project. Its aim is to enhance the skillsets of key spending departments and public sector bodies.

5.2 Public investment management and European strategic investment

The OECD principles serve as the fundamental basis for any public investment management system. However, when applied to ESIs, certain nuances emerge.

For instance, Principle 2 necessitates effective coordination not only between levels of government within EU countries, but also between the EU and its member states. One plausible solution could be the establishment of dedicated agencies within each country that would be responsible for screening projects from that country and liaising with the EU institution responsible for project selection.

Infrastructure financing is highly complex and requires a specific set of skills and experience, not only to assess the viability and financing of a project, but also its long-term impact. In line with OECD Principle 4 (on assessment), it is important to include experts in the teams responsible for project appraisal and selection in member states and at EU level.

A guiding principle should be value for money to maximise efficiency and the impact of EU funds, as well as to avoid duplication. Similarly, specific teams should be set up for project monitoring, and for maximising the use of technology for efficient monitoring.

The EU has a mixed track record in infrastructure planning. Effective planning is crucial to mitigate the risk of misallocating EU funds to poorly planned or poorly executed infrastructure projects – so called 'white elephants'. Misallocating societal resources is a financial burden for public institutions, and undermines public welfare.

Large infrastructure projects often experience cost overruns coupled with shortcomings in expected benefits[21], highlighting the importance of sound planning practices. The EU can play an important role in ensuring efficient allocation of funds for investment by planning and designing projects well.

While many infrastructure projects that benefit from EU funds, for example under EFSI and InvestEU, have been successful, EU resources have also been allocated to projects that were not well planned or executed.

For example, the European Court of Auditors (ECA, 2014) detailed flaws in EU infrastructure planning[22], notably in relation to airports. EU financing was used to build airports that were too big or too close to each other. The Court noted that EU financing operations were insufficiently supervised by the European Commission, leading to over-capacity and poor value for money.

The UK experience can also be instructive. The DfT (2015) value for money framework indicates the department's approach to assessing value for money and requires a clear value-for-money case for any proposal involving public resources.

Such a principle should also be applied to ESIs. It is important to not repeat the same mistakes in the future, and rather work towards replicating successful practices.

The EU should carry out a systematic review to establish a set of best practices based on successful projects. It should also recognise and assess the projects that have failed to deliver on their promises and aim to learn from those mistakes. Better control over the process can be aided by reducing the number of institutions responsible for disbursing funds for ESIs and by investing in capacity building.

A challenge particular to the EU is the extensive fragmentation of planning and of existing network infrastructure. Infrastructure is mostly planned at member state level. Connecting network infrastructures originally built by different entities can be challenging within a single country (Helm, 2023), and this challenge is only amplified when striving to connect networks across national borders within the EU.

The EU's ability to support such projects is not limited to financing either. A more coordinated approach to infrastructure planning and harmonisation of regulatory frameworks between EU countries could yield significant benefits (Dermine *et al* 2023). The EU is uniquely positioned to take on this responsibility.

6 Takeaways from the EU's experience

We summarise a few takeaways from the EU's experience in pursuing long-term objectives.

Europe faces large investment gaps. We have identified significant investment gaps to meet the two major transitions that will ensure that the EU remains competitive globally. Several studies have argued that the public sector will have a major role to play in in financing these gaps, alongside the private sector.

We also argue that those objectives that are of strategic relevance and refer to European public goods should be financed at EU level.

Lack of continuity. The EU has created several investment programmes (section 4). Some important current instruments – InvestEU and the RRF – have limited lifespans (expiring in 2027 and 2026 respectively) and are not expected to be repeated when they expire.

The finite nature of these programmes is not conducive to an investment framework that pursues long-term objectives. This 'stop-and-go' culture is not in line with the long-term nature of strategic investments and is detrimental to planning for the public and private sectors alike.

Rather than a sequence of programmes, therefore, the EU needs a long-term financing framework for strategic investments beyond the current planning horizon of approximately five years.

Need for simplification and capacity building. Current and past programmes have overlapping objectives that create information frictions. There is therefore a need to streamline the objectives of each programme to avoid complexity and help match programmes to investors. Experience with the RRF and at member state level has shown the importance of coordination across levels of government regarding planning of strategic investment.

Capacity building at all levels of government is also crucial to ensure a steady flow of high-quality projects and efficient implementation. EIB analyses show that local authorities often lack the capacity for implementation of investment programmes.

Coordination. Some of the country-level examples show that there is value in coordinating public investment management between different levels of government, both in terms of identifying good projects and monitoring progress. Carrying this over to the EU level is crucial, as the EU adds an extra layer of governance and therefore increases the level of complexity.

Do no significant harm. The 'do no significant harm' principle, as set out in EU regulations, refers only to environmental objectives. No project pursued should contradict environmental targets. We go a step further and

suggest that strategic investment co-financed by the EU's ESI programmes should not be inconsistent with any long-term objectives, including environmental goals.

While events may require objectives to be reprioritised, investments should not contradict single or multiple long-term objectives. There is a great need therefore to balance carefully the multiple objectives over time.

Evaluation based on outcomes. The RRF has shown the importance of robust and well-defined performance indicators. However, evaluation should be based on outputs and results. Milestones and targets should be observable metrics of results and not only of progress made. For instance, in the case of a power plant, a result indicator could be a predetermined level of energy production to be achieved by a specified year.

Lack of standardisation. There is a lack of standardisation in reporting and planning public investment projects in the EU. The EU should create and promote the use of templates for similar investment projects. A single reporting procedure would reduce the administrative burden and enable investment by reducing red tape.

Financing instruments to tackle big risks and incentivise reform. We believe two issues are important when setting up investment-finance programmes:

1. Absorbing risk. As a result of the EU not having deep capital markets, sufficient 'risky' capital is not available. Both the climate and digital transitions require accepting high levels of risk, which banks, the traditional funders of investment in Europe, cannot take. Public authorities have a major role to play to fill in this gap.

By providing carefully designed public credit-enhancement instruments backed by, for example, public budget guarantees, the public sector will be insuring against the riskiest part of any given investment,

thereby releasing private funds to cover the rest. Equity and quasi-equity instruments should also be used for efficient de-risking to attract private investors.

2. Incentivise reforms. The combination of a grant and loan programme, as implemented under the RRF, has interesting features worth replicating. The loan component increased the total envelope of funds available. This would allow a few countries to borrow below market prices. The link to reforms provided the right incentives to accelerate a number of structural measures.

Sources of EU funding. European funding so far has come from two sources: 1) the Multiannual Financial Framework (MFF), or long-EU term budget that covers a seven-year period (€1074 billion at 2018 prices for 2021-2028); 2) through debt issuance at EU level (€750 billion at 2018 prices for 2021-2026). When it comes to funding, there are three issues to resolve.

i. Lack of sufficient own resources. As part of repaying the borrowing for common debt issued under the NGEU programme, the EU is at time of writing discussing how it can increase its 'own resources'. Making progress on this issue can also be important for ensuring dedicated resources for strategic investment at EU level.

ii. The question of fiscal capacity. The issue of fiscal resources is crucial. Many EU countries have high debt levels and, with the return to the EU fiscal rules expected at the start of 2024, we expect that not all countries will be able to undertake investments at the same speed and level.

The fiscal space is very different in different countries and countries will also be impacted differently by EU fiscal rule constraints from January 2024. The EU has an important role to play in supporting countries in strategic investment.

The RRF is a prime example that allowed countries to continue to invest in the green and digital transition while releasing funds to deal with the pandemic crisis.

The urgency of advancing with some of the long-term goals dictates that there should be coordination between countries on how to make progress in ways that do not jeopardise achievement of the goals. This coordination need is at the heart of the rationale of pursuing certain ESIs at the EU level.

iii. EU debt issuance has not benefitted from scale or quality. The experience of RRF debt issuance has shown that the EU has not benefitted as much as it could have done (Claeys *et al* 2021). If the EU establishes a stream of 'new' own resources, then it can credibly issue long-term debt and therefore benefit from its scale and the market demand for high-quality debt. ESIs are the prime candidate to be financed by common and intertemporal means, such as EU-issued debt.

7 Conclusions and policy recommendations for ESIs beyond 2026

In this paper, we have defined European strategic investments and discussed how such investments can be supported with EU resources. Investments that are of strategic relevance to the EU are those that are in line with the priorities set and are consistent with the EU's long-term objectives.

Countries, private firms and the EU itself must finance the twin transitions, among other things, that EU societies will undergo over the next decades. The EU's involvement in directly financing some of these strategic investments is desirable when there is European value added, such as efficiency gains and crossborder coordination, and when the additionality criterion is satisfied.

The green transition is among the most important strategic objectives that the EU must pursue. Pisani-Ferry *et al* (2023) pointed to the huge annual investment needs to achieve a 55 percent emissions reduction by 2030 compared to 1990. The EU's role in helping countries achieve that is crucial.

Pisani-Ferry *et al* (2023) advocated for an EU green investment plan to match the NextGenerationEU resources after NGEU ends in 2026. As a prime example of a European (and indeed global) public good, unless all countries advance at a minimum common speed, the EU will not meet its climate objectives.

The EU can play an important role in making sure that the necessary investments in energy and transport systems suggested by Pisani-Ferry *et al* (2023) are done by all countries, while also safeguarding a fair transition.

Based also on the EU's experience with strategic investments so far, we make a number of recommendations, grouped into three categories: 1) how to repurpose existing funds and tools to tackle ESIs, 2) the role of the EIB in this process, and 3) issues beyond the EU funds currently available.

First, we discuss how to redirect or reform current tools to finance European strategic investments.

1. Create a dedicated long-term financing programme for ESIs. The pursuit of long-term objectives requires stable and predictable financing resources. A possible source of funding could be the EU budget or guarantees backed by the EU budget, building on the experiences with EFSI and InvestEU.

   The programme should at the very least be a stable component of the MFF, to facilitate planning for implementing partners, public or private. This fund should be accompanied by a permanent advisory facility following the lessons learned from the InvestEU Hub and its predecessors.

A clear definition of European strategic investments should be established that defines a set of projects potentially eligible for financing from ESI resources.

2. Streamline and centralise. Based on prior experience, there are gains to be had by streamlining existing programmes for financing infrastructure, R&D and SMEs in the EU. We recommend centralising the management and funding of these programmes, where possible.

This will give a better overview of financing opportunities for implementing partners, reduce redundancies (such as project evaluation by several different EU institutions) and simplify the financing process. One central institution in each member state should liaise with the EU on ESI projects.

Such a structure would have the added benefit of a single contact point for private-sector entities (particularly infrastructure promoters and SMEs) interested in applying for ESI financing. ESI initiatives should also collaborate with local implementing partners, where possible and useful.

3. Link financing to reform. ESI programmes should encourage reform by providing the right incentives. The RRF experience has shown the potential for enabling change if a grant provided is made conditional on reform. ESI financing from the EU to its member states should be made conditional on implementing policies enabling strategic investment and, more generally, addressing obstacles to investment.

Examples include the reduction of red tape in permitting procedures related to large infrastructure projects, or increasing the capacity of public authorities to assess strategic projects. Capital for strategic investments can be a strong incentive for EU countries to undertake such reforms. Importantly, any such reforms should be democratically legitimate in the member state concerned.

4. Second, we believe that the EIB can play a crucial role in identifying, selecting, financing and monitoring strategic investments in the EU.

5. A central role for the EIB. The EIB could take on an important role in the ESI financing programme by evaluating and selecting projects applying for ESI financing, building on its expertise as the central implementing institutions of the EFSI and InvestEU.

The EIB would be well placed to assess from a technical and economic point of view the projects brought to it by national coordinating institutions and other implementing partners.

6. Use the entire range of financial instruments to finance risks. ESI programmes should aim to maximise private sector investment by committing to finance the riskiest components of any investment project. To achieve this goal, the ESI Fund should make use of the full range of financial instruments, including equity, quasi-equity, credit guarantees, debt and subordinated debt. ESIs can require complex and diverse financing structures.

Therefore, it should be possible to adapt the financing structure on a case-by-case basis, choosing from a wide range of financial instruments. The mandate of the EIB and the ESI Fund should also allow development and use of new financial instruments in response to evolving market gaps.

7. Create a toolkit for identifying EU added value and additionality. As part of increasing the transparency and efficiency of EU investments, we recommend the creation of an explicit toolkit for the identification of EU value added.

This will be used in the selection of projects and will have the purpose of demonstrating why a project is better financed at the EU level and to what end. Equally, clear tools and procedures should be developed to assess additionality in order to maximise the impact of EU resources. Member states should be encouraged to use the toolkit in their assessments of strategic investments.

8. Set milestones and evaluate outcomes with transparent metrics and focus on results. To be able to evaluate outcomes and results, well-defined milestones, outcomes and result indicators should be put in place for each project. These milestones should be based on outputs and results and not processes.

Availability of the necessary tools and capacity to monitor projects continuously should be ensured. Third, in line with the aim of achieving long-term goals we offer a few recommendations that go beyond the EU's current budgetary structure and touch on necessary enablers for strategic investments.

9. Make progress with new own resources. The EU needs to make progress on increasing its own financial resources. If the EU has sufficient own sources of revenue, it can provide stable finance for ESIs, which can help avoid the stop-and-go tendency that has dogged investment programmes in the past.

A clearly agreed framework for increased own resources would also enhance the EU's ability to issue debt to fund strategic investments. The intergenerational aspect of many strategic investments, in particular investments to achieve climate objectives, would justify the funding via long-term debt.

10. Standardise procedures for project planning and financing applications. The EU is uniquely positioned to promote standardisation and coordination of procedures for large-scale strategic investment projects.

It should advocate the adoption of templates for similar projects across countries, and for uniformity in related procedures. Harmonised reporting would also facilitate ex-post assessments and the exchange of information.

11. Encourage other policies that enable ESIs. Several issues pertaining to regulation or policies will enable the promotion of ESIs. Investments in certain types of infrastructure and their operation require new sets of skills. Acquiring them via upskilling or reskilling needs to be an integrated part of the process to achieve optimal outcomes.

Similarly, the EU can also pursue certain activities as one, for example, procurement or coordinated regulation to facilitate the uptake of investments.

The EU can also assist member states in improving national governance frameworks for strategic investment, building on best practices in the region, and maximise synergies between national strategic-investment programmes and ESI financing programmes. The reforms connected to ESI funding should promote this.

12. Promote the creation of a capital markets union. The scale of investment needed implies the private sector will need to play a very significant role. While we recommend that the EU picks up the riskiest parts of investments to encourage private-sector participation, EU funds can only go so far.

The European economy lacks sources of capital more prepared to take on the risks of financing a future that is increasingly uncertain. The EU must make visible progress in encouraging the further development of capital markets and coordinate them at the EU level to exploit economies of scale.

One possible way ahead would be to revive the market for securitisation and to continue the progress made in 2022 in terms of significant risk transfer by euro area banks[23]. Establishing the capital markets union would also simplify the framework for crossborder capital investment and could prove to be a powerful enabler. ■

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Endnotes

1. See the European Commission's 2019-2024 priorities website.

2. See: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/stronger-europe-world/global-gateway_en.

3. Targets include, for example, having all public services accessible online and having 75 percent of EU companies using cloud services, artificial intelligence and/or big data; see https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en.

4. See: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/promoting-our-european-way-life/european-health-union_en.

5. A reform of the framework was agreed in principle in late December 2023; see Jeromin Zettelmeyer, 'Assessing the Ecofin compromise on fiscal rules reform', First Glance, 21 December 2023, Bruegel..

6. In other words, stronger institutions to manage public investments.

7. We follow the definition of gross fixed capital formation as provided in the European system of accounts (ESA 2010, paras 3.124-3.138). The performance of R&D that gives rise to new intellectual property products is classified as capital under ESA 2010. For more detailed information on R&D measure in ESA 2010 see Eurostat (2014).

8. Our examples are partially based on Buti et al (2023) and Pisani-Ferry et al (2023).

9. The reported figures in some cases include investment spending and funding for non-investment activities, when no breakdown was available.

10. In addition to the €723.8 billion under the RRF, NGEU contributes to other programmes including REACT-EU, InvestEU, the Just Transition Fund, RescEU and the European Agricultural Fund for Rural Development (EAFRD).

11. The Innovation Fund, funded by emissions trading system (ETS) revenues, supports low-carbon technologies and impactful projects in Europe for significant emission and greenhouse-gas reductions.

12. The Market Stability Reserve is a mechanism intended to tackle excessive surpluses of EU ETS allowances and to improve the system's resilience to major shocks by adjusting the supply of allowances to be auctioned.

13. The Brexit Adjustment Reserve supports EU countries negatively affected by Brexit, with a strong focus on those most

affected.
14. The cohesion policy funds encompass the European Regional Development Fund (ERDF), Cohesion Fund, European Social Fund Plus (ESF+), and Just Transition Fund (JTF).
15. See section 4.2 for a more detailed discussion on leveraging private investment under EFSI and InvestEU.
16. See section 4.2 for additional information on the impact of EFSI financing operations.
17. Maria Demertzis, 'Next Generation EU: an underused facility?' Cyprus Mail, 19 November 2022.
18. See Council of the EU press release of 8 December 2023, 'Recovery fund: Council greenlights amended national plans for 13 member states'.
19. Horizon 2020 (EE11 PDA), InnovFin Advisory, Connecting Europe Facility (CEF, through JASPERS), ELENA (European Local ENergy Assistance), European Investment Advisory Hub (EIAH), Employment and Social Innovation (EaSI) Technical Assistance, Natural Capital Finance Facility (NCFF) support facility, Smart Specialisation Platform for Industrial modern, CEF Programme Support Actions, European Energy Efficiency Fund (EEEF) technical assistance, City Facility, Private Finance for Energy Efficiency (PF4EE) Expert Support Facility, Islands Facility.
20. Detailed country case studies on the public investment management initiatives mentioned in this section and projects pursued can be found in Appendix 3.
21. For an extensive discussion of large project management see Flyvbjerg and Gardner (2023).
22. There are also country examples capturing the contradiction between the original purpose of EU funding and actual social benefits. See Toth et al (2023) for details on Hungary.
23.For a recommendation on the issue of securitisation, see European Central Bank, 'A new high for significant risk transfer securitisations', Supervision Newsletter, 23 August 2023.
24. See European Commission press release of 18 May 2022, 'Factsheet on Financing REPowerEU'.
25. The market maturity was a limitation on certain types of lending and equity financing. Countries with more developed markets ended up putting forward more proposals.
26. 75 percent of the guarantee is implemented by EIB Group.

27. See European Commission: https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en.
28. See Sandbag's website.
29. Lorna Booth, 'Goodbye PFI', House of Commons Library, UK Parliament, 30 October 2018.
30. Act of 31 December 2012 about Public Finance Planning.

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Appendix 1. Taxonomy of EU Investment Initiatives

Table A1. Financial information on 24 EU investment initiatives

REACT-EU	2021-2023	50.6	• NGEU	the forms laid down in the Financial Regulation	-
European Fund for Sustainable Development Plus	2021-2027	40	• EU budget guarantee	• Grants • Technical assistance • Guarantees • Equity • Blending operations worldwide	-
Connecting Europe Facility	2021-2027	33.71	• EU budget	• Grants • Procurement • Blending operation	-
EFSI	2015-2020	33.5	• EU budget guarantee • EIB resources	• Credit enhancement (intermediate loans, subordinated loans, guarantees • Loans • Equity • Venture debt	500
InvestEU Fund	2021-2027	26.2	• EU budget guarantee	• Credit enhancement (intermediate loans, subordinated loans, guarantees • Loans • Equity • Venture debt	372
Just Transition Fund	2021-2027	17.5	• EU budget • External assigned revenues	• Funding may be provided in any of the forms laid down in the Financial Regulation	30

STEP	2021-	14.5	• EU budget	• Dispersed through different funds so will depend on the relevant fund	160
EIC Fund	2021-2027	10	• EU budget guarantee • EIB	• EU budget guarantee	-
Digital Europe Programme	2021-2027	7.5	• EU budget	• Mainly grants, prizes, procurement • But funding may be provided in any of the forms laid down in the Financial Regulation	-
EU4Health	2021-2027	5.8	• EU budget • NGEU	• Funding may be provided in any of the forms laid down in the Financial Regulation	-
LIFE	2021-2027	5.4	• EU budget	• Mainly grants, prizes, procurement	-
Single Market Programme	2021-2027	4.2	• EU budget	• Mainly grants, prizes, procurement • But funding may be provided in any of the forms laid down in the Financial Regulation	-
EU Civil Protection Mechanism (rescEU)		3.3	• EU budget	• Mainly grants, prizes, procurement • But funding may be provided in any of the forms laid down in the Financial Regulation	-
Euratom Research and Training Programme	2021-2027	1.38	• EU budget • NGEU	• Funding may be provided in any of the forms laid down in the Financial Regulation	-
Social Climate Fund		-	• ETS 2	• Funding may be provided in any of the forms laid down in the Financial Regulation	72.2
Innovation Fund	2021-2027	-	• Monetisation of 530 million ETS allowances	• Grants • Blending operations	40

Appendix 2. Detailed descriptions of EU investment programmes

Investment Plan for Europe (2015-2020)

Description
EFSI is one of the three pillars of the Investment Plan for Europe (also known as the Juncker Plan) that aimed to revive investment in strategic projects around the continent to ensure that money reaches the real economy.

EFSI's purpose was to unlock EIB financing for economically viable projects that would have been considered too risky for EIB participation without the EFSI. EFSI itself was/is backed by a guarantee from the EU budget. It aimed at boosting long-term economic growth and competitiveness in the European Union.

The projects covered areas such as infrastructure, research and innovation, education, health, information and communications technology and other areas. EFSI had two windows: the Infrastructure and Innovation Window (IIW), managed by the EIB, and the SME Window (SMEW), managed by the EIF.

EFSI provided a €26 billion budgetary guarantee from the EU budget, complemented by €7.5 billion allocation from the own resources of the EIB. The EFSI managed to over-deliver, while mitigating the impact of COVID-19 on Europe's economy.

Implementation
As of 31 December 2022, EFSI financing approved by the EIB Group led to a total investment value of €524.9 billion, therefore surpassing the target set by policy makers. In terms of financing signed, the total mobilised investment is €503.0 billion (European Commission, 2023b).

European Commission (2022b) and EIB (2022b) found that the EU guarantee proved significant as it enabled the EIB Group to undertake riskier activities, in line with expectations when the EFSI was designed. EFSI also proved a relevant tool to mobilise private capital.

However, the different EIB evaluation reports have underlined some concentration in those member states with well-developed institutional capacities[25], possibly resulting in an unequal distribution of funds.

The availability of the EU Guarantee proved to be an efficient tool to considerably increase the volume of riskier operations by the EIB Group. In particular, the EFSI budgetary guarantee freezes less budgetary resources compared to financial instruments, as it requires limited provisioning needs compared to the level of financial engagement.

As of 2022, the cumulative amount of guarantee calls is modest at about €184 million. Given that this represents a relatively modest sum, it suggests that the EIB is capable of assuming greater risks. This relatively low amount could suggest that a guarantee from the EU is enough to unlock financing for the vast majority of projects executed under EFSI, without significantly increasing the burden on the EU budget.

On the other hand, the low default rate of projects could simply suggest that the projects were not very risky to begin with, and that the guarantee has not led the EIB to invest in significantly riskier projects. Therefore, the EU guarantee could be directed towards projects with even higher levels of risk.

Lessons to be learned

EFSI was the start of a paradigm shift towards a different way of using EU financial resources – away from grants and towards financial guarantees backed by the EU budget. This enabled the use of fewer resources for the same objectives and implemented the idea of attracting private sector financing for projects fitting public policy goals.

However, there is a trade-off between volume and impact, because to make a greater impact, a high provisioning rate is needed. One critique that comes out of the different evaluations is that some type of projects (eg. public sector projects of the municipalities, sustainable infrastructure, social infrastructure, and social economy) remained too small for the EIB intervention under the EFSI.

Therefore, opening the EU guarantee to new implementing partners would be favourable as this will also enable a better outreach of the EU guarantee and provide a local presence.

InvestEU (2021-2027)

Description
The InvestEU programme aims to enhance EU competitiveness, innovation, sustainability, and social cohesion. It is demand-driven and focuses on strategic, long-term goals in key policy areas that may lack funding, aligning with EU policy objectives.

The InvestEU programme consists of three components: the InvestEU Fund, the InvestEU Advisory Hub and the InvestEU Portal. The InvestEU Fund should support projects that are economically viable by providing a framework for the use of debt, risk sharing, and equity and quasi-equity instruments backed by a €26.2 billion guarantee from the Union budget and by financial contributions from implementing partners. It aims to trigger more than €372 billion in investments.

The InvestEU programme supports four main policy areas: i) sustainable infrastructure with €9.9 billion ii) research, innovation and digitisation with €6.6 billion, iii) SMEs with €6.9 billion, and iv) social investment and skills with €2.8 billion.

Implementation

InvestEU is a multifaceted financing initiative that goes beyond the EIB Group[26], involving various implementing partners such as national promotional banks and international financial institutions, as for example the European Bank for Reconstruction and Development (EBRD), the Council of Europe Development Bank (CEB) or the Nordic Investment Bank (NIB). The wider set of implementing partners is a key difference to EFSI.

Further, the project preparation and advisory support complementing InvestEU, the InvestEU Advisory Hub, is open to partnerships with national promotional banks that are not implementing partners. This partnership framework in financing and project preparation is an innovation vis-à-vis EFSI, which had supported EIB Group operations alone and whose advisory services were and are managed only within, and by, the EIB Group.

However, the limited public funds supporting InvestEU could pose a challenge in attracting transformative investments and sharing risks effectively. Some critical green transition projects may not be suitable for InvestEU financing, especially those lacking commercial viability.

While effective in unlocking investments for lower-risk projects like retrofitting buildings to increase energy efficiency, InvestEU's high leverage structure has limitations. It tends to prioritize projects with short-to-medium-term cash flows, relying on indirect instruments like loan guarantees.

Accountability and transparency issues also plague InvestEU. Furthermore, the lack of transparency makes it challenging to assess whether investments align with EU climate policies. The European Commission has not adequately published data through its climate tracking system, as legally required. Confidentiality further obscures the scrutiny of InvestEU's climate impact and the destination of intermediated funds.

To address this, the Commission should disclose how much financing aligns with the EU taxonomy for sustainable activities[27] and report on the actual climate-related outcomes of its financing operations, such as reductions in greenhouse gas emission (Findeisen and Mack, 2023).

Since InvestEU only started in 2021, it is too early to assess the risk profile of projects at the time of writing.

NextGenerationEU (2021-2026)

Description
NGEU is a temporary recovery instrument to support the economic recovery from the Covid-19 pandemic and build a greener, more digital and more resilient future for the EU. The programme is worth €806.9 billion as of 2023 and is scheduled to operate from 2021 to 2026. It is financed by the issuance of bonds and by the EU budget.

More than 50 percent of the long-term budget and NextGenerationEU are supporting modernisation, for example through: research and innovation (via Horizon Europe), fair climate and digital transitions (via the Just Transition Fund and the Digital Europe programme), preparedness, recovery and resilience (via the Recovery and Resilience Facility, rescEU and a new health programme, EU4Health).

In addition, the package pays attention to: modernising traditional policies, fighting climate change, and biodiversity protection and gender equality. The centrepiece of NGEU is the Recovery and Resilience Facility (RRF) – an instrument that provides grants and loans to support reforms and investments in the EU member states which is worth €723.8 billion.

Part of the NextGenerationEU, funds are also being used to reinforce several existing EU programmes, such as REACT-EU (€50.6 billion), Just Transition Fund (€10.0 billion), Rural Development (€8.1 billion), InvestEU (€6.1 billion), Horizon Europe (€5.4 billion) and RESCEU (€2 billion). We will here mainly talk about the RRF of which €385 billion of funds is given out in loans and €338 billion of funds in grants.

Under the programme's centrepiece, the RRF, the EU will distribute €385 billion of funds in loans and €338 billion in grants. To benefit from support under the Facility, EU governments have submitted national Recovery and Resilience Plans (RRPs), outlining the reforms and investments they will implement by end-2026, including clear milestones and targets.

The plans had to allocate at least 37 percent of their budget to green measures and 20 percent to digital measures. The Recovery and Resilience Facility is performance based. This means that the Commission only pays out the amounts to each country when they have achieved the agreed milestones and targets towards completing the reforms and investments included in their plan.

Implementation

The latest report from the European Commission, dated 25 September 2023, regarding the implementation of the RRF, reveals various outcomes. Until December 2022, the RRF had helped 1.43 million enterprises either through monetary or in-kind support and in the second half of 2022, over 4 million people have been trained with RRF support.

Moreover about 22 million megawatt hours (MWh) of savings in annual energy consumption were achieved by the end of 2022. Major progress has been made in (i) the continuous implementation of the RRF, (ii) increasing the transparency around its implementation, and (iii) protecting the financial interests of the EU by stepping up control and audit efforts.

Some member states are facing challenges in administering funds, partly due to administrative capacity issues or investment bottlenecks. Some other member states are facing difficulties in implementing the RRPs as initially designed due to changes in economic circumstances such as high inflation or supply bottlenecks.

The Commission is supporting all member states to accelerate the implementation and revision of their plans, including through the Technical Support Instrument. The revisions of RRPs and the addition of REPowerEU chapters have also impacted the disbursement schedule of RRF funds, as the first half of 2023 has seen a slowdown in the submission of payment requests, with member states focusing their efforts on the revision of plans and the addition of REPowerEU chapters.

In 2023, the Commission made also significant efforts to increase the clarity and transparency around the Facility's implementation. The Commission published, on 21 February 2023, its methodologies on (i) assessing the satisfactory fulfilment of milestones and targets, and (ii) calculating the suspended amounts in case of non-fulfilment of a milestone or target. Furthermore, the amendments to the RRF Regulation require member states to publish information on the 100 final recipients receiving the highest amounts of RRF funding.

One point of discussion is the evaluation of member states performances. NGEU is supposed to be a performance-based programme, in the sense that disbursement of funds is conditional on countries achieving milestones and targets. But as mentioned by Darvas *et al* (2023a), Article (2) of the regulation defines 'milestones and targets' as *"measures of progress towards the achievement of a reform or an investment."*

The expression *"measures of progress towards"* thus indicates a process, not necessarily the achievement of results. This is also observed by the European Court of Auditors (2023). Therefore, a clearer definition of 'performance-based' is needed, and should be based on output not rocesses.

There is also discussion surrounding whether the milestones and targets set aren't sufficiently ambitious. As mentioned in Corti *et al* (2023), Italy will successfully fulfil the milestones and targets but will likely not achieve the objectives of the measures included in its RRP – namely reducing regional and local inequalities in the provision of employment and childcare services. This could indicate that milestones and targets defined under RRF are too easy to achieve.

REPowerEU (2022-2026)

Description
REPowerEU, focuses predominantly on enabling an orderly and affordable phase-out of Russian gas by 2027. The plan covers four main areas: energy efficiency and savings; energy supply diversification; clean-energy transition acceleration; and investment and reform.

The REPowerEU plan has required massive investments and reforms. The EU has mobilised close to €300 billion - approximately €72 billion will be in grants and approximately €225 billion in loans (these are the loans that were uptaken in the RRF and is thus not new money).

This will include approximately €10 billion in missing links for gas and liquefied natural gas and up to €2 billion for oil infrastructure to end the import of Russian oil. The rest of the financing, 95 percent of the initial €300 billion, will go into speeding up and scaling up the clean energy transition. An extra €210 billion will be needed to achieve the programme objectives.

The Recovery and Resilience Facility (RRF) is at the heart of this funding. The REPowerEU proposal encourages member states to use their national recovery and resilience plans (RRPs) as a strategic framework for reforms and investments to ensure joint European action for a more resilient, secure and sustainable energy system. In order to align with RePowerEU, revisions to RRPs would incorporate new measures within a dedicated REPowerEU chapter.

Implementation

The European Court of Auditors (2022) pointed out in a report the limits to REPowerEU. Whilst REPowerEU targets the EU as a whole, the RRF is implemented through measures put forward by member states. This poses a risk in terms of the strategic response to the challenges ahead and may favour the priorities of individual member states rather than those of the Union as a whole.

The limited timeframe of the RRF in combination with the time needed to submit and approve the amendments to the RRPs may not be suitable for the some of the REPowerEU objectives. The preamble of REPowerEU (Regulation (EU) 2023/435) states that *"reforms and investments set out in the REPowerEU chapters which are necessary to improve energy infrastructure and facilities to meet immediate security of supply needs for gas should be eligible for financial support under the Facility even if they do not comply with the principle of 'do no significant harm.'"*

The REPowerEU targets are likely to have an impact on the environment and thus there might be a trade-off between the objective of secure energy supply and environmental and climate concerns, at least in the short run. However, given the strong focus in the RRF on green targets and climate, introducing an exemption from the principle of 'do no significant harm' may jeopardise one of its core values.

Thus, it may be useful at least to have an indication of the impact of potentially harmful measures to select those which represent an acceptable level of environmental and climate impact compared to the value added they

are expected to bring to the REPowerEU objectives. The fact that the REPowerEU chapters may be submitted at different times further impairs the inclusion of crossborder projects in RRPs.

STEP (2023-2027)

Description
STEP seeks to reinforce, leverage and steer EU funds to investments in deep and digital, clean and bio technologies in the EU, and in people who can implement those technologies into the economy. By strategically leveraging existing programmes like InvestEU, Innovation Fund, Horizon Europe, EU4Health, Digital Programme, European Defence Fund, Recovery and Resilience Facility, and cohesion policy funds, STEP anticipates generating up to €160 billion in new investments.

This ambitious programme will be funded with €14.5 billion from the EU Budget, implemented by an additional €7.5 billion EU guarantee into InvestEU, €0.5 billion allocated to Horizon Europe, €5 billion to the Innovation Fund, and €1.5 billion to the European Defence Fund.

Implementation
Climate Action Network (2023) Europe has highlighted several drawbacks associated with STEP. Firstly, there is no assurance that the supported investments will adhere to the do no significant harm principle. Additionally, STEP does not explicitly focus on climate action or directly contribute to achieving Green Deal objectives, contrary to the initial vision outlined in the Green Deal Industrial Plan.

Instead, it encompasses a broad spectrum of 'strategic' technologies. Lastly, it doesn't introduce new EU resources; rather, it reorganizes and repackages existing ones.

Connecting Europe Facility (2021-2027)

Description
CEF supports the deployment of high-quality, sustainable infrastructure in the transport, energy and digital sectors by encouraging both public and private investment. The CEF benefits people across all member states, as it makes travel easier and more sustainable, it enhances Europe's energy security while enabling wider use of renewables, and it facilitates crossborder interaction between public administrations, businesses and citizens.

It is divided into three components: transport, energy and digital. The energy budget of €5.84 billion should help the transition towards clean energy and complete the Energy Union, making the EU energy systems more interconnected, smarter and digitalised. The budget for CEF Transport is of €25.81 billion (including €11.29 billion for cohesion countries).

CEF Transport focuses on crossborder projects and projects aiming at removing bottlenecks or bridging missing links in various sections of the Core Network and on the Comprehensive Network. The budget for CEF Digital is of €1.8 billion and is managed by Health and Digital Executive Agency (HaDEA).

Implementation
CEF shall contribute, through its actions, 60 percent of its overall financial envelope to climate objectives. Implementation of the programme's 2014-2020 actions has also been directly impacted by COVID and geopolitical

crisis in Ukraine, thus it is too early to conclude whether the programme's targets will be achieved as the nature of large-scale infrastructure projects makes it difficult to already present information.

Digital Europe Programme (2021-2027)

Description
It focuses on bringing digital technology to businesses, citizens and public administrations. It will not address these challenges in isolation, but rather complement the funding available through other EU programmes, such as the Horizon Europe programme and the Connecting Europe Facility for digital infrastructure, the Recovery and Resilience Facility and the Structural fund. With a planned overall budget of €7.5 billion the Digital Europe Programme will support projects in five key capacity areas: in supercomputing (€2.7 billion), artificial intelligence (€2.5 billion), cybersecurity (€2 billion), advanced digital
skills (€700 million), and digital transformation of public administration and interoperability (€1.3 billion).

Implementation
Implementation is on track. Most projects implemented via grants or joint procurement will start implementation in early 2024. However, with the Russian invasion in Ukraine many countries had to reprioritise investments in other areas and some proposals have been affected mainly those that needed more national support.

Social Climate Fund (2025-2032)

Description
The Social Climate Fund will finance temporary direct income support for vulnerable households and support measures and investments that reduce emissions in road transport and buildings sectors and as a result reduce costs for vulnerable households, micro-enterprises and transport users. It should be implemented in 2025 and expect a budget of €23.7 billion for 2025-2027 and €48.5 billion 2028-2032.

The fund is based on the revenues of the Emissions Trading System 2 (ETS 2), covering fuel combustion in buildings, road transport and additional sectors (mainly small industry not covered by the existing).

Implementation
As pointed out by the European Economic and Social Committee (2021), stakeholders have been sceptical and even negative about extending emissions trading to buildings and road transport, pointing to the expected social and economic impact of an increase in heating and fuel prices on financially weaker households, medium-, small- and micro-enterprises and transport users.

Moreover, the fund is only partially dedicated to social compensation it also focuses on incentives of EV and decarbonisation. Furthermore, it is quite surprising that a fixed amount of €72.2 billion is proposed whereas it will be based on a volatile EU ETS market.

European Structural and Investment Funds (2014-2020)

Description
The European Structural and Investment Funds (ESI Funds) comprise five different funds and tries to increase smart, sustainable and inclusive growth, strengthen the institutional capacity of public administration, step up territorial and urban development and territorial cooperation.

The five funds, part of the MFF, included are the European Regional Development Fund (ERDF), European Social Fund (ESF), Cohesion Fund, European Agricultural Fund for Rural Development (EAFRD), European Maritime and Fisheries Fund (EMFF). The policy objectives pursued with the ESI Funds include: research and innovation, digital technologies, supporting the low-carbon economy, sustainable management of natural resources, small businesses, smart, sustainable and inclusive growth, employment, better education and training, strengthening the institutional capacity of public administration and urban development and territorial cooperation (Interreg).

Implementation
The 2014-2020 financial period ends at the end of 2023 under the so-called N+3 rule. End 2021, the ESI Funds unleashed a total investment of €731 billion, of which €535 billion was funded by the EU. The funds supported more than 4 million businesses and created over 310 000 new jobs, maintained over 44 000 jobs and created over 6 000 new jobs in the fishing and aquaculture sector.

It improved the energy efficiency of 460 000 households and increased the energy production capacity coming from renewable energy resources by more than 3 600 MW (the equivalent of around 1 800 wind turbines). Moreover, 55.2 million participants benefitted from the ESF and Youth Employment Initiative supported projects and ESI Funds helped 55.2 million people through employment, social inclusion, or education actions.

It also supported over 2.3 million projects in the agricultural sector and rural areas. Finally, 64 percent of the total rural population is covered by more than 3 650 LEADER Local Action Groups implementing Local Development Strategies supported by the EAFRD.

European Social Fund Plus (ESF+) (2021-2027)

Description
It corresponds to the main instrument for investing in people. With a budget of almost €99.3 billion for the period 2021-2027, ESF+ provides an important contribution to the EU's employment, social, education and skills policies, including structural reforms in these areas.

The majority of funding under the ESF+ (€98.5 billion) will be allocated under shared management with the member states. This means that the ESF+ Managing Authorities in each country will dedicate the money to projects that are run by a range of public and private organisation and responding to the country- and region-specific needs.

In addition to the shared management strand of the fund, the European Commission directly manages a smaller share (€762 million) of the ESF+ under the Employment and Social Innovation (EaSI) Strand. This side of the fund will support analytical activities, capacity building and transnational/crossborder cooperation to strengthen social protection and social inclusion, fair working conditions, equal access to the labour market, social entrepreneurship and labour mobility.

ESF+ brings together four funding instruments that were separate in the programming period 2014-2020: the European Social Fund (ESF), the Fund for European Aid to the most Deprived (FEAD) the Youth Employment Initiative and the European Programme for Employment and Social Innovation (EaSI).

In member states where the number of NEETs is above the EU average, 12.5 percent of the fund will be spent on combating youth unemployment. At least 25 percent of the budget is to be spent on promoting social inclusion, including the integration of non-EU nationals and at least 3 percent of the budget is to be spent on food aid and basic material assistance for the most deprived.

Similarly, member states with a level of child poverty above the EU average must use at least 5 percent of their ESF+ resources to address this issue.

Implementation

Due to the late adoption of the ESF+ in 2021, its implementation had a slow start in 2022. In total, nine countries (CZ, EL, HR, HU, LT, PL, RO, SI, and SK) transferred ESF+ budget to the ERDF and the CF, amounting to a total transfer of €3.9 billion. The transfers from other funds to the ESF+ amounts to €1.4 billion in total.

Gender equality is one of six thematic enabling conditions used for the first time in the 2021-2027 period. That means that gender equality is a prerequisite for the effective and efficient implementation of the specific objectives of the fund(s).

Performance assessments for the shared management strand and the direct management strand of the ESF+ will be provided once the implementation has taken off in 2023.

Innovation Fund (2018-)

Description
The Innovation Fund will contribute to greenhouse gas reduction by helping create the right financial incentives for new investments in the next generation of technologies needed for the EU's low-carbon transition. It is designed to take into account the lessons learned from its predecessor, the NER300 programme.

The EU Emissions Trading System (EU ETS) provides the revenues for the Innovation Fund from the monetisation of 530 million ETS allowances. The unspent funds from the NER300 programme, the Innovation Fund's predecessor, were also transferred to the Innovation Fund. The Innovation Fund's total funding depends on the carbon price, and it is estimated to about €40 billion from 2020 to 2030.

Implementation
A report by the think tank Sandbag (2023)[28], specialised in climate policy, pointed out some drawbacks of the Innovation Fund. They claim that grants made under the Innovation Fund should exclusively consider the value at technological risk, rather than the degree of innovation and that it should avoid upfront funding except for projects with a high technology risk.

Moreover, for a project's greenhouse gas (GHG) avoidance estimates to be as accurate as possible, they should be i) reviewed by the whole panel of experts, not just one ii) independently estimated by the expert panel for use in the rating of the other criteria using this information and iii) assess with reference to updated benchmarks to ensure a project's innovativeness and contribution to emissions avoidance.

Horizon Europe (2021-2027)

Description
The EU's key funding programme for research and innovation with a budget from €95.5 billion. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting, and implementing EU policies while tackling global challenges (climate changes, UN's Sustain- able Development Goals). It supports creating and better dispersing of excellent knowledge and technologies. It is the follow-up of Horizon 2020.

Horizon Europe consists of three pillars and one horizontal activity: €23.5 billion is allocated to Pillar I Excellent Science, €47.4 billion for Pillar II 'Global Challenges and European Industrial Competitiveness', €11.9 billion for Pillar III 'Innovative Europe' and €3.2 for Part 'Widening Participation and Strengthening the ERA'. Grants are the main form of support.

Implementation
Only 7 percent of Horizon Europe spending has been allocated to address biodiversity for the 2021-2022 period whereas target is 10 percent so need more efforts to address this issue.

REACT-EU (2021-2023)

Description
An initiative that continues and extends the crisis response and crisis repair measures delivered through the Coronavirus Response Investment Initiative and the Coronavirus Response Investment Initiative Plus.

Only implemented from 2021 to 2022 and financed by NGEU with a budget of €50.6 billion. REACT-EU captures only national-level data on the pre-pandemic situation and on the economic impact of the crisis on member states.

Spain and Italy, each with an allocation of more than €14 billion, are by far the two main recipients and together account for 57 percent of the total budget. In 2021 (€39.6 billion) and the rest in 2022 (€10.8 billion).

REACT-EU is not a new funding source, but a top-up to 2014-2020 European Regional Development Fund and European Social Fund allocations. It is delivered under shared management. This initiative will support investment projects that foster crisis-repair capacities and contribute to a green, digital and resilient recovery of the economy, including support for maintaining jobs, short-time work schemes and support for the self-employed.

However, it is not limited to that and can also support job creation and youth employment measures, healthcare systems and investment support for small and medium-sized enterprises.

Implementation

One and a half years after the start of REACT-EU, as of 30 June 2022, some member states still had large amounts to allocate, such as Ireland and Portugal with 38 percent and 25 percent unprogrammed resources respectively. At that date, only 24 percent of REACT-EU's allocation had been paid to member states.

The risk is that there will be a rush to spend available resources before the end of the period, potentially leading to insufficient attention being paid to performance and value for money considerations.

ERDF/Cohesion Fund

Description
ERDF is intended to help to redress the main regional imbalances in the Union. The Cohesion Fund provides support to member states with a gross national income (GNI) per capita below 90 percent EU27 average to strengthen the economic, social and territorial cohesion of the EU.

With a total budget of €274 billion, from which €48 billion for the Cohesion Fund and €226 billion for the ERDF. The Cohesion Fund contributes to environmental and trans-European transport network (TEN-T) infrastructure projects. The ERDF contributes to reducing disparities between the levels of development of the various EU regions, including by promoting sustainable development and addressing environmental challenges.

Implementation
The ex-post evaluations of the 2014-20 period shall be completed by the end of 2024.

Appendix 3. Case studies of national public investment management

The following section reviews good practices of public investment management with respect to the principles written by the (OECD, 2014).

Netherlands
In the Netherlands, several good practice examples of public investment management can be underlined. One example is the MIRT, which stands for Multi-Year Programme for Infrastructure, Spatial Planning, and Transport.

This involves projects where national and regional governments work together to improve the country's competitiveness, accessibility, and quality of life. The Ministry of Infrastructure and Water Management is involved, but other ministries and regional partners like provinces, municipalities, and NGOs can also join in.

The OECD also suggests effective coordination across government levels (Principle 2). In the Netherlands, a good example referring to this is the Association of Dutch Municipalities (VNG) that unites all municipalities, and the Association of Provinces (IPO) which looks after the provinces. Both focus on mutual learning and exchanging experiences. IPO's main job is representing the interests of provinces in national and EU processes.

With respect to Principle 4, when selecting projects, the Ministry of Infrastructure and the Environment have several criteria for selecting infrastructural projects to be (co-)funded by national government. One of them is the National Market and Capacity Analysis (NMCA).

The latter indicates where infrastructure capacity is not expected to be sufficient to reach the goals of National Policy Strategy for Infrastructure and Spatial Planning (i.e. the target values for traveling time), taking into account the expected development of mobility.

Netherlands have been particular efficient in water management. One reason behind this is the Rijkswaterstaat (RWS), which is the executive organization of the Ministry of Infrastructure and Water Management. Rijkswaterstaat manages, maintains, and develops the three major infrastructure networks of the Netherlands: the main road network, the main waterway network, and the main water system.

It is RWS's goal to assess bids by the total cost of construction and maintenance, using life cycle costing and total cost of ownership concepts. To calculate life cycle costs, RWS has developed the DuboCalc software, which

allows to calculate the environmental effects of a material, building or method. The software calculates life cycle environmental impacts in 11 areas using a life cycle assessment (LCA) database, converting these impacts into an environmental cost indicator (ECI) value for the proposed design. The materials proposed by the successful bidder become contract requirements and the ECI value of the final product is checked upon completion of the work.

UK

In the UK, we can put forward several good practice examples of public investment management. With respect to Principle 6 on mobilising private actors, an example can be the Private Finance Initiative. Private Finance Initiative (PFI) projects are a type of public-private partnership (PPP), used to fund major capital investments. PPPs refer to a wide range of different types of collaboration between public and private bodies.

The UK has been at the forefront of using PFIs to deliver public investment projects. However, it has also been majorly criticised for hugely raising costs of projects and in October 2018, the then-Chancellor Philip Hammond announced that the UK government would no longer use PFI[29].

The Office for National Statistics has developed over many years a comprehensive set of comparable statistics at neighbourhood level (municipalities). These publicly available data have been used both in national and local policies and as a decision tool by citizens.

Moreover, a Cities Policy Unit was created in 2011 with public, private, central and local stakeholders to help co-ordinate urban policy. The goal of the Cities Policy Unit is to work with both cities and government to help cities create new ideas and turn the ideas into successful plans.

Both these initiatives are a good example of Pillar 1 which focus on coordination across governments and policy areas. Since late 2011, urban policy has been centred on a growing number of City Deals in England that are being implemented in waves.

These deals are agreements between government and a city and allow a greater degree of responsibility to English cities. City deals require better horizontal (across departments) and vertical (between the government and the cities) coordination, and local capacity.

To engage public, private and civil society stakeholders throughout the investment cycle (Principle 5), the UK uses Local Strategic Partnership (LSP). Which is a non-statutory body that brings together different parts of the public, private, voluntary and community sectors working at a local level. They have no legal powers or resources of their own.

To mobilise private actors and to diversify the sources of funding (Principle 6), the government launched Local Enterprise Partnerships (LEPs). These partnerships between local authorities and businesses decide on local priorities for investment in roads, buildings and facilities.

What concerns Principle 9, the UK has a fiscal framework to support debt sustainability and affordability (IMF, 2022). The revised Charter for Budget Responsibility sets out how UK's management of public finances operate.

The Charter do not set numerical debt targets or limits but includes a fiscal mandate to have public sector net debt (excluding the Bank of England) as a percentage of GDP falling by the third year of the rolling forecast period. Then there is also the Office of Budget Responsibility (OBR) that provides authoritative independent fiscal forecasts and assesses the long-term sustainability of public finances.

The OBR produces detailed five-year forecasts for the economy and public finances twice a year, which the government uses to produce its Autumn and Spring Budget documents.

Finally, the UK also has a medium-term fiscal framework (MTFF) that aligns budget preparation and public investment plans with fiscal policy. The Charter of Budget Responsibility stipulates how the MTFF works and the interaction between the Treasury and the OBR during the budget process.

In 2020, was presented the National Infrastructure Strategy (NIS). The latter plans to transform UK infrastructure to level up the country, strengthen UK's Union and achieve net zero emissions by 2050. The NIS is thus the overarching plan for economic infrastructure and encompasses investment across transport, energy, water and wastewater, waste, flood risk management, and digital communications.

Italy

In Italy several good practice examples of public investment management can be highlighted. The existence of the Inter-ministerial Committee for Economic Planning (CIPE) is a good example with respect to Principle 1 of the OECD.

CIPE is the main body responsible for the coordination and horizontal integration of national policies, as well as aligning Italy's economic policy with EU policies. It has been renamed into the Inter-ministerial Committee for Economic Programming for Sustainable Development (CIPESS), as of 1st January 2021.

The role of this Committee's mandate is to steer economic programming towards the National Sustainable Development Strategy objectives in the context of Agenda 2030. There also exist the 'Conference of Regions and

Autonomous Provinces' which ensures a political dialogue and vertical co-ordination between the regional and national governments.

It is a political body of coordination between the regions of Italy and their presidents. In fact, joint documents are prepared by the Conference and are later presented during the meetings of the State-Regions Conference and the Unified Conference.

Conform with Principle 3, Basilicata provides successful examples of horizontal co-operation across regions and across municipalities. A good example of horizontal co-operation is the Programme Agreement concerning the management of the water resources transferred from Basilicata to Puglia by the Ionico-Sinni water system signed in 1999.

Furthermore, to ensure a more efficient horizontal cooperation in 2014 the Delrio Law transformed the Provinces of Italy in a reduced number of broader administrative entities.

Finally, Basilicata also invested heavily in monitoring and evaluation to support decision makers. The regional level has a Public Investment Evaluation Unit (NVVIP) under the Department for structural funds, which is responsible for monitoring and evaluating all public investments in the region and for checking the consistency of strategic projects with respect to the regional development plan and the annual financial plan. The unit also performs impact evaluations of public investment projects on employment and production (Principle 8).

Ireland

From the technical assistance report from the (IMF, 2017), several good practices of public investment management have been highlighted. The report points out the good alignment of investment and planning. The National Planning Framework and the National Development Plan 2021-2030 combine to form Project Ireland 2040.

The NPF sets the vision and strategy for the development of Ireland to 2040 and the NDP provides the enabling investment to implement that strategy. This could refer to the Principle 1 of the Recommendation of the OECD.

To ensure enhancing projects and a good programme governance Ireland has the National Investment Office and the government has recently implemented the External Assurance Process, which will allow for independent scrutiny of public projects at key decision-making stages of the project lifecycle which will ensure taxpayer's money is spent wisely and projects are delivered on time and on budget.

With respect to Principle 8 and Principle 10, thus to improve transparency and to learn from the past Ireland has updated the Spending Code that now requires publication of business cases and post-project reviews (Conroy *et al* 2021).

Furthermore, on recommendation of the IMF, Ireland has implemented an investment tracker which focuses mainly on projects and programmes with costs greater than €20 million. The tracker serves to highlight the diverse range of infrastructural projects throughout Ireland.

An example of good practice of Principle 6 on mobilising the private sector is the Construction Sector Group. The Construction Sector Group was set up in 2018 tasked with maintaining a sustainable and innovative construction

sector that would be able to deliver on long-term commitments. The Construction Sector Group is chaired by the Secretary General of the Department for Public Expenditure and Reform.

Principle 7 states to reinforce the expertise of officials and institutions to have a better management of public investment. A good example of practice is the Irish Commercial Skills Academy (CSA) that was setup in 2019.

The CSA offers training on best practice approaches for effective delivery throughout the lifecycle of a project. Their aim is to enhance the skillsets of key spending departments and public sector bodies. Or for example the InfraNet. The latter is a forum for experts to critically examine public investment governance, reforms and innovations. The goal is to engage with experts in public sector and delivery bodies to share best practice, issues and solutions.

Finally, to align with Principle 4, there exist the Irish Government Economic and Evaluation Service (IGEES). The IGEES seeks to improve policy formulation and implementation by providing and building economic and analytical expertise across the Irish civil service (OECD, 2020).

France

To align with Principle 8, in 2012 the French government took the decision[30] to subject all public projects of a certain importance to a socioeconomic assessment that until than was reserved for certain areas such as transport. It has been based on two pillars (Baumstark et al, 2021). The support of project leaders and the organization of counter-expertise was ensured by CGI (now SGPI).

In the analysis of public investment management in France, the roles of key entities, namely BPI France, CDC, and SGPI, are pivotal.

The *Secrétariat général pour l'investissement* (SGPI) is a good example the practice Principle 1 and Principle 2. SGPI has a central role in ensuring coherence in the state's investment policy. It is involved in the decision-making processes related to contracts between the state and investment management entities and also coordinates the preparation of project specifications and monitors their alignment with government objectives.

Moreover, it is responsible for the overall evaluation of investments, both before and after implementation. Finally, it compiles annual reports on programme execution and supported ministerial evaluation mechanisms. The SGPI, under the authority of the Prime Minister, is responsible for ensuring the coherence and monitoring of the State's investment policy through the implementation of the France 2030 plan.

This unprecedented plan builds on the achievements of the Programmes of Investments for the Future (PIA), notably PIA 4, endowed with €20 billion. France 2030 is overseen by the SGPI on behalf of the Prime Minister and implemented by the Agency for Ecological Transition (Ademe), the National Agency for Research (ANR), Bpifrance, and the Banque des Territoires.

In the past, SGPI had a primordial role in the implementation of the European instrument, EFSI, in France. This institution was able to communicate around EFSI towards project promoters, act as a contact point and monitor and issue brochures of EFSI projects being financed. This is believed to have fostered ownership of EFSI in France (Wilkinson *et al* 2022).

Bpifrance and *Caisse des Dépôts et Consignations* (CDC) are examples on how to mobilise financial institutions for a better management of public investment (Principle 6). CDC is a special institution responsible for administering deposits and consignments, providing services relating to the funds entrusted to its management, and performing other legally delegated functions of a similar nature.

It is responsible for protecting popular savings, financing social housing and managing pension funds. It also contributes to local and national economic development, particularly in the fields of employment, urban policy, the fight against banking and financial exclusion, business creation and sustainable development.

This group carries out tasks in the public interest that support public policies pursued by the State and local communities. It supports the housing sector, the regions (Banque des Territoires), the environment, financing businesses and the daily lives of French people (Ciclade, Mon compte formation).

Bpifrance is a French public sector investment bank. It is a joint venture of two state owned enterprises: the CDC and EPIC BPI- Groupe (formerly EPIC OSEO). Bpifrance's goal is to favour the growth of the French economy by helping entrepreneurs thrive. It plays a significant role in the management of public investment.

Bpifrance's 2022-2025 strategic plan covers the priorities of the France 2030 Investment Plan. Bpifrance as main operator for financing the Investments for the Future Programme for French startups, SMEs, and intermediate-sized enterprises was and is still very successful.

Another example on the efficiency of the French government on mobilising financial institutions (Principle 6) is the Agence France Locale created in 2013. Agence France Locale is 100 percent owned by French local authorities. Its mandate is to raise cost-efficient resources in capital markets by pooling together the funding needs of all member local authorities. It aims to provide French local authorities with alternative funding sources.

A more precise example of Principle 3, to ensure a coordination across subnational governments, in France is the state-region planning contracts (OECD, 2017). The *Contrat de plan État-région* (CPER) have been in operation since 1982 and are important tools in regional policy in terms of planning, governance and co-ordination.

In 2016 the State-Metropoles Pacts was launched, which aim at empowering new sub national entities, the metropoles (MAPTAM law, 2014). They will support urban innovation at the metropolitan scale through financial partnering in some key investments.

An example of good practice of Principle 2 in France is the public establishment for inter-municipal co-operation (EPCI). There are more than 36 000 communes in France and the government has long been against mergers and thus has encourages municipal cooperation.

There are about 1,254 EPCI with own-source tax revenues aimed at facilitating horizontal co-operation. They are governed by delegates of municipal councils and must be approved by the State to exist legally.

To encourage municipalities to form an EPCI, the central government provides a basic grant plus an 'inter-municipality grant' to preclude competition on tax rates among participating municipalities. EPCIs draw on budgetary contributions from member communes and/or their own tax revenues.

Europe's under-the-radar industrial policy

Ben McWilliams, Giovanni Sgaravatti, Simone Tagliapietra and Georg Zachmann outline the trade-offs European governments must confront to meet the challenge of decarbonising their countries' economies

Executive summary

The different ways in which European Union member state governments add levies to the price of electricity creates huge discrepancies in the prices paid by consumers. Europe's energy transition depends upon increasing electrification of the economy and increasing the share of that electricity produced by renewable sources. Both factors raise the importance of electricity taxes set by governments.

The energy crisis drew attention to this: as electricity prices soared, governments responded with billions of euros in subsidies to protect households and companies.

While the acute phase of the energy crisis has passed, growing concerns about industrial competitiveness create political pressure for governments to continue with such subsidies or tax exemptions. High profile examples include the French reform of nuclear-power generated electricity pricing, and a political debate in Germany over how aggressively to subsidise the electricity price paid by energy-intensive firms.

We frame the debate on intervention in electricity pricing around five distributional dilemmas concerning the recuperation of electricity expenses: 1) whether to raise general or electricity taxes, 2) the split between household and companies, 3) the split between energy-intensive and non-energy intensive companies, 4) crossborder effects, and 5) trade-offs in attracting new clean-technology manufacturing factories.

Priorities according to these distributional criteria will differ by country, but these factors should be central to discussions. Governments must recognise that efforts to lower prices artificially for one group of consumers will raise prices for others, including with crossborder implications. The current compromises in the French and German cases do not pose substantial issues to the integrity of the European single market and do not penalise non-energy-intensive domestic consumers excessively.

1 Introduction

The European Union successfully navigated the 2022 energy crisis, and it is now more energy secure and more resilient against energy shocks (McWilliams *et al* 2023). However, gas and electricity prices in the EU have remained persistently above their pre-crisis levels. The prospect of a persistent energy-price disadvantage compared to major competitors might be more challenging for the EU's industrial competitiveness than the energy crisis itself[1].

European policymakers are now confronted with the double challenge of decarbonising their countries' economies, implying increased electricity consumption, while maintaining industrial competitiveness. This challenge brings electricity policy to the forefront of industrial policy.

Varying taxes and tariffs mean different consumers in the same market pay vastly different electricity prices. In the coming decade, European energy consumption will shift increasingly to electricity and decisions made by government over these levies will become ever more significant, with economic, political and societal consequences.

In this Policy Brief we discuss the main trade-offs facing governments in this respect. We outline the impacts of the energy crisis, during which high and volatile electricity prices stimulated billions of euros in government subsidies.

We then discuss the growing electrification of European economies and the growing role for government in distributing the costs of this transition across society. We discuss the specific cases of electricity pricing debates in France and Germany. We conclude by outlining the five essential distributional trade-offs governments must confront when setting electricity taxes:

1. Recovering costs through electricity tariffs or general taxation,

2. The split of taxes between households and industry,

3. The split of taxes between energy-intensive and the remaining industry,

4. Crossborder impacts of subsidies; and,

5. Trade-offs to consider when attracting clean technology manufacturing.

In Germany, the extent to which government should use electricity policy to support energy-intensive firms has been debated extensively

2 The lasting impact of the crisis

The effect of the energy crisis on electricity prices has been dramatic, with wholesale prices peaking in August 2022 above ten times the 2019-2020 average price and differences between EU countries widening. the electricity mixes in different countries are fundamental in setting the price of electricity. Government support schemes for certain technologies to a great extent define each country's electricity mix.

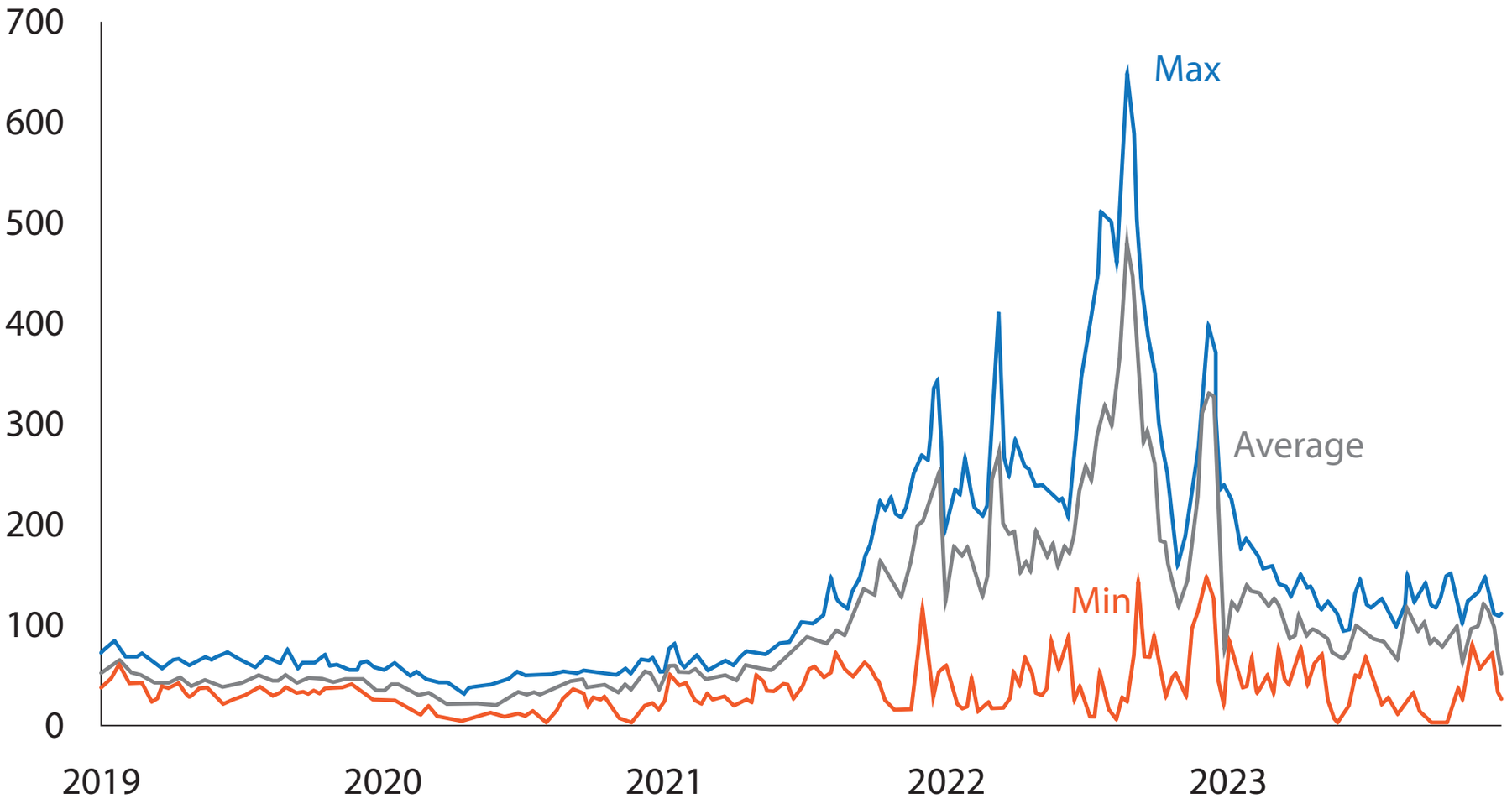
Figure 1 illustrates this. It shows the weekly average minimum and maximum electricity prices in the EU, excluding islands. In the past three years, Sweden and Italy have consistently set the minimum and maximum prices in the EU. This reflects past policy choices, with Sweden betting on nuclear and renewables, while Italy relies to a much greater extent on natural gas.

Figure 1 also shows that while wholesale electricity prices decreased in the second half of 2023, the price differential remains larger than before the energy crisis, with a higher upper limit. In the first half of 2023, EU wholesale prices fluctuate on average around €100/MWh, compared to a range of $30-$50/MWh across key United States markets, approximately $75/ MWh in Japan and $60/MWh in India.

Intervention in electricity prices is part of the industrial policy toolkit of governments. France has the Regulated Access to Historic Nuclear Energy (ARENH) system (see section 5), designed to *"give French customers the comparative advantage of the low production costs of the historical nuclear plant pool"* (Cours des Comptes, 2022).

In Germany, certain industrial consumers benefit from a dozen exemptions, including exemption from the renewables surcharge (EEG, from Erneuerbare-Energien-Gesetz – Renewable Energy Sources Act) to keep their electricity prices lower[2].

Figure 1. European min, max and average wholesale weekly electricity prices, €/MWh



Source: Bruegel based on Energy Charts.

However, since the COVID-19 pandemic, government intervention in the economy has dramatically increased. After Russia's invasion of Ukraine, support was channelled towards mitigating the energy-price shock.

Total energy subsidies in the EU rose from €177 billion in 2015 to €216 billion in 2021 and spiked at an estimated €390 billion in 2022 (European Commission, 2023a). Natural gas and electricity subsidies increased the most in 2023, tripling from €15 billion and €20 billion to €46 billion and €64 billion, respectively.

Exceptional energy support measures allowed under the EU's March 2022 Temporary Crisis and Transition Framework for State Aid (sections 2.4 and 2.7)[3] were due to expire at the end of 2023, before EU governments successfully lobbied for a six-month extension until June 2024[4].

Subsidies to support business affected by the energy shock have been generally approved under the EU state aid crisis frameworks, approval granted to more than €672 billion in aid since March 2022[5]. Much of the approved support extends beyond 2023. The largest shares were for Germany (53 percent of the total, or €356 billion), and France (24 percent, equivalent to €161 billion).

Temporary loosening of EU state aid rules has made such largess possible, but in 2024 the EU fiscal rules – the Stability and Growth Pact, which governs how much debt governments can build up – will be replaced by a new framework (see Darvas *et al* 2023), requiring fiscal adjustment for all countries with debt above 60 percent of GDP and/or deficits above 3 percent (this includes Germany).

With energy prices remaining stubbornly above their pre-crisis levels, and an international trend of more active industrial policy (for example, the Inflation Reduction Act in the US), Germany and France wish to extend substantial subsidies for domestic industry[6].

German government interventions to reduce electricity levies and fees for energy-intensive companies were the largest among the five major EU countries (Table 1). Retail prices for energy-intensive companies in Spain have increased less than in any other major EU country, driven by government intervention in the pricing mechanism and increasing shares of renewables.

The energy-supply component of retail prices paid by energy-intensive industry increased most dramatically in Italy, where natural gas sets the price of electricity in 90 percent of hours – more than in any other EU country (Gasparella *et al* 2023). Poland is the only country where the tax component of electricity prices for energy-intensive companies went up over the period.

3 Electrified Europe

Electricity is the future of the European energy system. Consumers are already swapping gas boilers for heat pumps and petrol cars for electric vehicles. Consequently, the share of final energy demand met by electricity is set to grow.

In 2021, electricity provided 23 percent of the EU's final energy demand[7]. This share is projected to grow to 30 percent in 2030, and 50 percent in 2050, in scenarios that see the EU achieve its emission reduction targets (European Commission, 2020b).

Rapid installation of solar panels and wind turbines means renewable energy sources will meet an increasing share of this electricity generation. In 2019, wind was 13 percent of EU electricity generation, increasing to 15 percent by 2022. Over the same period, solar has increased from 4 percent to 7 percent[8].

EU leaders have set a target for renewables to meet 42.5 percent of final energy demand by 2030. This implies that renewables will meet 65 percent to 70 percent of electricity demand (also including generation from hydro and biofuels) (European Commission, 2022).

Table 1. Electricity price changes for energy-intensive industry from 2021 to 2023 (eurocents/kWh)

	Price including taxes (excl. VAT), HI 2021	Change in energy supply component	Change in tax component (excl. VAT)	Price including taxes (excl. VAT), H1 2023
France	6.55	6.67	-0.39	12.83
Germany	10.99	0.91	-3.63	17.27
Italy	9.12	11.3	-0.37	20.05
Spain	6.96	3.22	-0.41	9.77
Poland	8.5	8.6	4.07	21.17
EU average	8.33	8.57	-0.99	15.91

Note: Prices refer to the retail electricity price paid by energy-intensive industry and are an unweighted average of the three highest consumption bands reported by Eurostat (above 20 GWh/year). We take prices from the first half of each year.
Source: Bruegel based on Eurostat.

A major consequence is that the number of hours in which renewables can meet total electricity demand will increase. Consequently, renewables will be responsible for setting market prices more frequently (prices in European electricity markets are set by the source which provides the last unit of supply required to meet demand[9]).

For a better sense for the magnitude of this change, we performed an intuitive exercise. We extrapolated from the national hourly output from wind, solar and hydro in selected countries in 2022 using projected capacities for 2030 and compared this with projected hourly demand.

We then summed the renewable output for every hour of the year and compare this to demand. This exercise showed that renewables could meet total demand in Spain for 25 percent of hours in 2030, and in Germany for 30 percent of hours, compared to 0 percent of hours in 2022[10].

These numbers are intended only as an illustration of the scale of the changes coming. The number of hours for which renewables will be at the margin cannot be projected because of too many areas of uncertainty. Gasparella *et al* (2023), for example, came to a different conclusion, finding that electricity price setting will still be dominated by fossil fuels in 2030.

While the pace of change can be debated, renewable generation will ultimately dominate. This phenomenon will transform the operation of electricity markets, reducing the share of fuel costs in final electricity bills. To a certain degree, this reduction will be offset by an increase in fees and tariffs.

These include network tariffs (payments for maintaining and expanding the electricity grid), capacity mechanism payments (to power sources, such as gas power plants, that must be paid to remain on standby) and renewable levies (to pay the capital costs of renewable plants).

4 The growing role for government: allocating costs

Final electricity prices paid by households and companies (hereafter referred to as retail prices) are already influenced strongly by regulatory choices. Only one-third of the average retail electricity price paid by EU households in 2021 related to the cost of energy, while the other two-thirds was taxes (Figure 2).

Taxes weigh more on the final price paid by consumers when the volumes of electricity contracted are smaller. In the coming years, taxes, levies and other regulated components will make up an even greater share of prices, and governments will continue to decide how these costs are split between consumer groups.

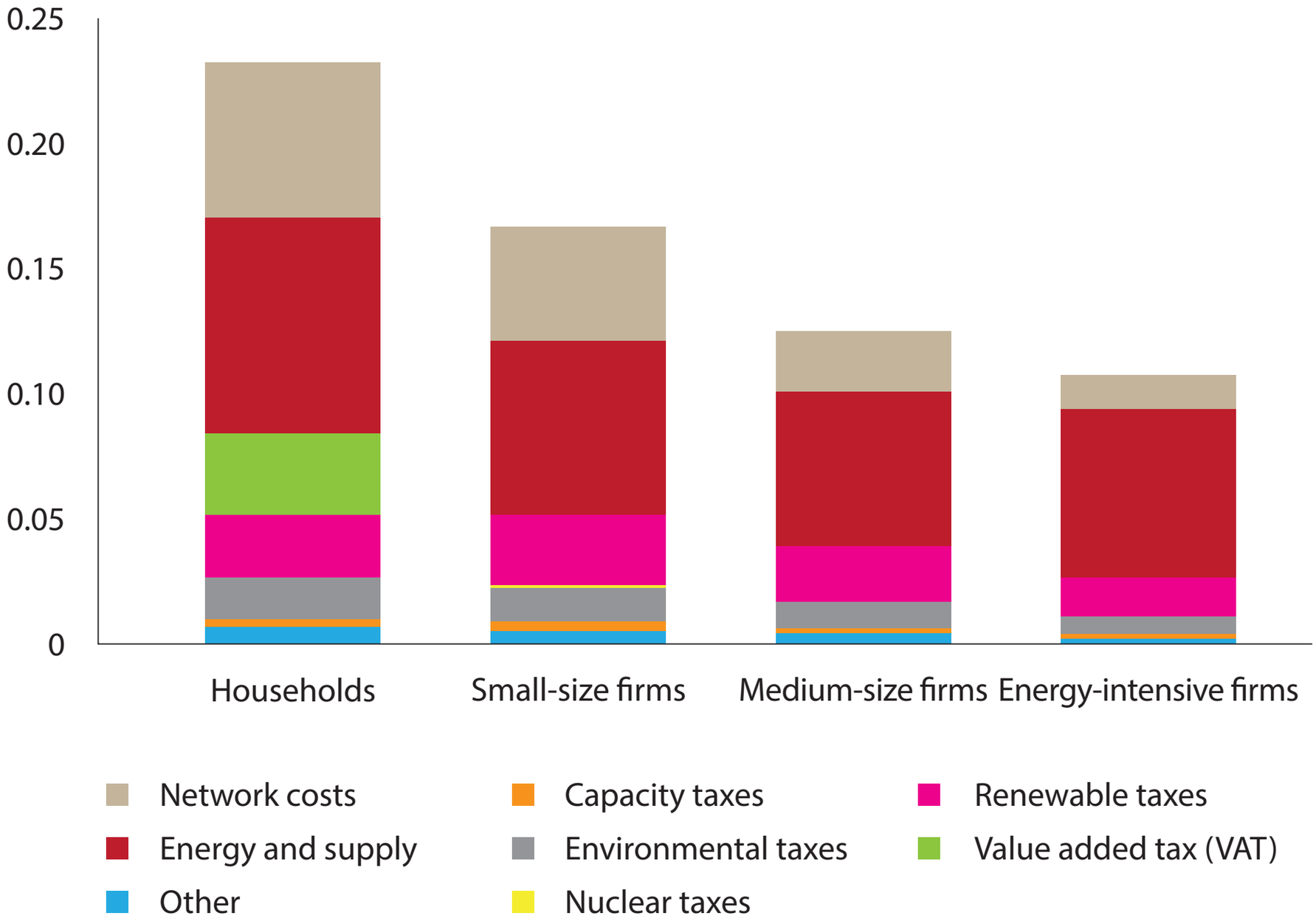
Instruments for influencing final prices include tax exemptions, reduced levies and compensatory mechanisms. For example, energy-intensive industries pay far lower network costs compared to households and less energy-intensive companies (Figure 2).

The numbers involved are very significant. In Germany, industrial consumers benefit from a broad range of overlapping rules and exceptions (German Ministry of Finance, 2023). In 2023, reductions in electricity taxes for industry were estimated to be €1.7 billion.

Reduced levies for offshore wind and combined heat and power plants amounted to an additional almost €1 billion. A further €3 billion was used to offset the increase in electricity prices paid by industrial consumers because of the EU emissions trading system[11].

The existence of a single price zone across Germany also benefits electricity-intensive companies in southern and western regions, which enjoy lower wholesale prices at the expense of higher network costs that they do not pay fully.

Figure 2. Retail electricity prices by component and user type, €/KWh, EU (2021)



Note: Firms are generally eligible for VAT refunds, and that is the case also for some renewable taxes, such as the EEG surcharge in Germany. Small firms are the Eurostat consumption band between 20 and 499 MWh, medium firms are between 2 and 19.9 GWh, and energy-intensive firms between 70 and 149.9 GWh. Households refers to the TOT_KWh Eurostat consumption band.
Source: Bruegel based on Eurostat.

A report on energy costs, taxes and the impact of government interventions (European Commission, 2020) found that energy-intensive industries and agriculture typically pay the lowest taxes relative to the amount of energy consumed, while road transport sectors pay the most.

The study highlights that energy-intensive industry accounts for 18 percent of energy consumption in the EU but only 2 percent of energy-tax revenues, while agriculture accounts for 3 percent of energy use and 0.5 percent of energy-tax revenue. Transport accounts for 29 percent of energy consumption and 60 percent of energy-tax revenue[12]. For instance, energy-tax rates on energy-intensive industries in Japan are twice those in the EU.

Network tariffs are especially likely to increase. The investment need up to 2030 for repowering European electricity grids has been estimated at €584 billion by the European Commission (2023b). To recover the costs of this investment through electricity bills, regulators will need to increase average network tariffs by 1.5 cents to 2 cents per kWh[13].

If consumers pay this equally, the average rise in annual household electricity bills would be €40 to €50. If current trends continue, and additional network costs are shouldered disproportionately by households, the figure would be even higher. Reform of the EU electricity market design, agreed by the EU institutions in December 2023[14], has also opened the path for substantial continued government support for renewables, which may be added to bills in the form of renewable tariffs (Zachmann *et al* 2023).

In this context, European – particularly the French and German – governments are locked in discussions over the introduction of new tools to cut the price of electricity faced by domestic firms.

5 A French trait d'union and a German bridge too far

In France, the most significant mechanism affecting market prices was created in 2010 – the Regulated Access to Historic Nuclear Energy (ARENH) scheme. A large share of the French electricity supply comes from nuclear plants operated by the state-owned Électricité de France (EDF).

From 2011 until 2025, ARENH allows competing electricity retail suppliers to buy electricity produced by EDF nuclear power plants at a fixed price (of €0.042/kWh), which they then sell on to final consumers. The volumes formally covered are 100 TWh[15], or approximately 25 percent of the country's total production.

The distributional effects of ARENH depend on the price level and average annual cost of nuclear production from EDF. Analysis by the French Court of Auditors assessed that at the beginning of the scheme in 2011, the fixed price was above EDF's cost of production (€0.032/ kWh), hence it only limited excess profits.

Since then, the average unit cost of production has increased and is by now above the fixed price set by ARENH (in 2021 the Court estimated EDF's production cost at €0.047/kWh). The implication is that EDF makes a loss by selling power at an artificially lower price to competitors, deflating average prices.

In November 2023, EDF and the French government agreed on a mechanism to replace ARENH after its termination on 31 December 2025. The mechanism envisages a claw-back by taxing at 50 percent all the revenues made from the nuclear production feet when the wholesale price goes above €78/MWh, and at 90 percent when the wholesale price is above €110/MWh.

These thresholds were decided to guarantee consumers a net average wholesale price of about €70/MWh for the next 15 years. The price was deemed by the government to be adequate to deliver the decarbonisation and re-

industrialisation of the country, including by reducing EDF's debt and allowing for the construction of new nuclear power plants[16].

Although a final legal text is not available at time of writing, it seems clear that the scheme will cover all existing nuclear generation, but will exclude new nuclear power plants such as Flamanville 3 in north-western France.

Abandoning ARENH should also give EDF the opportunity to renegotiate and expand long-term contracts in their portfolio, targeting energy-intensive industrial consumers[17].

The revenues collected by the state from the new scheme will be redistributed among all consumers, though it is not yet clear what will the distribution key will be (but given the current government's focus on re-industrialisation, one would expect industry to be the first beneficiary). To be compatible with EU competition law, the mechanism should redistribute revenues equitably to consumers based on their consumption[18].

The preliminary agreement envisages a central role for the French Commission for the Regulation of Energy, which will be in charge of estimating the exact production volumes and revenues of the nuclear feet. Redistribution should also reward consumption during of-peak hours and by season, in order to encourage load shifting. The amounts would be redistributed to all end consumers in the form of a payment passed through suppliers with an obligation to pass it on.

In Germany, meanwhile, the extent to which government should use electricity policy to support energy-intensive firms has been debated extensively. In May 2023, the German ministry for Economic Affairs and Climate Action proposed a 'bridge electricity price' for energy-intensive firms.

The idea was to guarantee to a selection of companies from energy-intensive industries a price of €0.06/kWh for 80 percent of their electricity consumption, to aid their international competitiveness. The subsidies would amount to between €2 billion and €9 billion annually[19].

However, this proposal was opposed by the German finance ministry and many economists (including Bernhardt et al, 2023). A finance ministry advisory board feared that excessive subsidies would impede necessary structural adjustment and highlighted that energy-intensive consumers already benefit from a variety of tax exemptions.

In November 2023, the government agreed in principle on a modified scheme. Electricity taxes would be reduced for all manufacturing companies to the EU minimum level of 0.05 eurocents per kWh (from 1.54ct/kWh).

Most other European countries already have tax rates at the minimum level. Energy-intensive firms were largely exempt from the tax anyway, so this move is more beneficial for non-energy-intensive firms, which were paying the full rate.

The plan would also extend existing support measures for energy-intensive industries, based on reimbursing costs arising from European carbon taxes, but no fresh support would be given to energy-intensive firms. The government had already announced a €5.5 billion subsidy to stabilise network fees for all consumers[20].

The agreement was therefore focused on reducing electricity prices for all companies, rather than only energy-intensive companies. This suggests that concerns about harming overall economic growth by supporting only a handful of energy-intensive firms were heeded.

However, whether and when the plan will be implemented is unclear because of a November 2023 German Constitutional Court on strict enforcement of public financing limits[21]. This might necessitate a new discussion of the planned electricity tax cuts.

6 Transforming European electricity: who will pay?

During the 2020s, governments will spend billions of euros transforming electricity grids. Exactly how to distribute these costs across society implies several trade-offs:

1. Recovering costs through electricity tariffs or general taxation,

2. The split of taxes between households and industry,

3. The split of taxes between energy-intensive and the remaining industry,

4. Crossborder impacts of subsidies; and,

5. Trade-offs to consider when attracting clean technology manufacturing.

A first principle is that any tax exemption or public support for a certain consumer type implies an increase in costs for other consumers, for both fiscal and physical reasons. Fiscally, when one group is exempted from paying taxes, these taxes must be collected elsewhere. The physical reason relates to the functioning of electricity markets.

Government subsidies reduce the incentives for recipients to reduce electricity consumption, through substitution, energy efficiency or relocation. In the short run (up to a few years), electricity supply is relatively fxed[22].

Therefore, an increase in electricity consumption by one group must be offset by an equal decrease elsewhere, or prices for all other consumers increase, until demand and supply balance again.

6.1 Electricity tariffs vs general taxation

Currently, governments recover costs for renewable and grid subsidies by adding them to electricity bills (eg. 'network tariffs'). The logic is that the costs of providing a good in addition to the good itself, such as electricity, should be met by those consuming it. For example, dedicated road-traffic taxes and charges generally pay for expenditure on road infrastructure for European countries (Schroten, 2017).

The alternative is to finance renewables, networks and other necessary investments through general taxation. Public goods such as education are funded in this way, based on the principle that they benefits society as a whole. A similar argument could be made for electricity consumption.

During 2022 and 2023, as electricity prices soared, many governments made the decision to temporarily shift electricity taxes onto the general budget[23]. It remains to be seen whether this will set a precedent for the coming years. Electricity prices have dropped substantially and will likely drop further, suggesting tariffs might be revived.

However, achieving climate goals requires households and companies to substantially increase electricity demand. Lowering tariffs on electricity bills is one option to encourage such behaviour.

6.2 Industry vs households

Within electricity markets, the starkest difference in tax treatment currently concerns households and companies (Figure 2). The standard decision European governments have taken is to impose a larger share of energy taxes on households to subsidise the electricity consumption of companies. As governments push households to consume more electricity, pressure will grow to reverse this policy.

In the past this was perceived as less of an issue as household electricity consumption was seen as a good proxy for affluence (relating to ownership of consumer goods) and consumers were not very sensitive to higher prices. This has changed as consumers can increasingly choose between 'clean' electricity for transport and heating, and fossil fuels. Hence, relative prices matter for the speed of the desired transition.

The average household in Germany currently consumes around 3,500 kWh electricity per year[24]. Before the crisis, with a typical household retail price of €0.20/kWh this resulted in an annual bill of €700. The same average household might have also spent €1,500 to fuel a car and €1,000 to heat their home with natural gas.

The household will shift both expenses onto their electricity bill if they install a heat pump and buy an electric car. A heat pump is estimated to increase consumption by 4,900 kWh and an electric car by 3,000 kWh.

Therefore, while the average household energy bill would decrease, electrification implies that the annual average household electricity bill may grow from €700 to €2,300[25]. Distributional decisions on renewable tariffs will become much more relevant.

6.3 Taxing energy-intensive vs general industry

Governments also decide to distribute costs between industry depending upon the volume of their energy consumption. Typically, this involves lowering the bills of energy-intensive firms. The rationale is that for these firms, energy costs make up a large share of final production costs, and typically they face substantial international competition.

Providing them with cheaper access to energy is seen as necessary for keeping them competitive on global markets. The relative importance of energy-intensive industries varies significantly across the EU, which influences rates of taxation (see the annex).

The economic logic of subsidising energy-intensive firms is controversial. Some level of support is justified as compensation for the higher carbon costs in the EU compared to international competitors.

However, companies that are energy intensive typically produce lower value added per unit of electricity consumption. They also employ fewer people (Figure 3 summarises this for Germany).

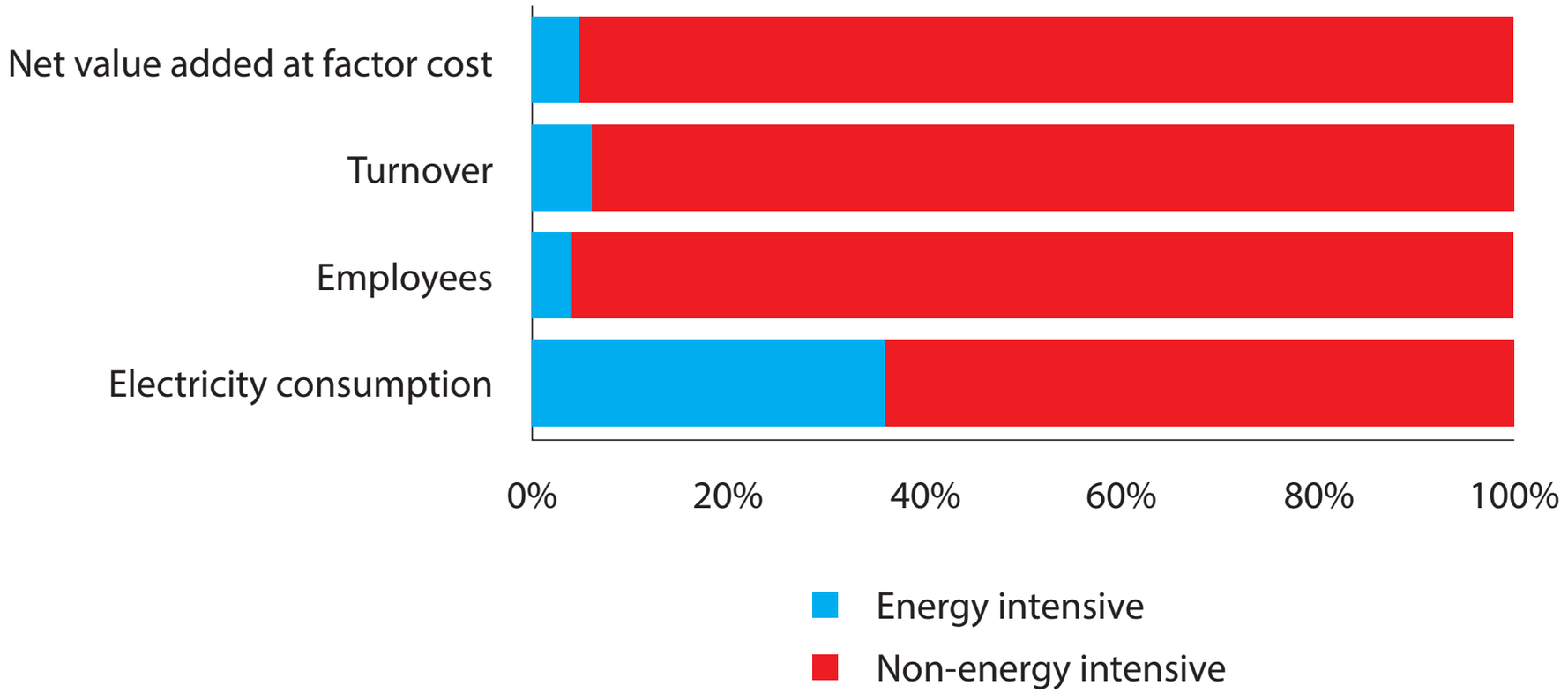
Therefore, any intervention which raises electricity consumption by such firms has the first-order effect of shifting consumption toward firms that transform electricity into lower value added, potentially slowing down economic growth. There is a risk of path-dependency where subsidies become locked in (Fouquet, 2016).

There are two counterarguments to this. The first is that the view ignores second-order effects, and the second is that the goods produced by energy-intensive industries have 'economic security' value. The second-order effects argument is that energy-intensive firms produce goods that are vital inputs for manufacturing stages further along the value chain. The argument follows that if energy-intensive firms were to slow production, there would be ripple effects onto other sectors of the economy (Krebs, 2023).

We question this argument on intuitive and empirical grounds. Intuitively, one of the most prominent arguments for energy-intensive subsidies is that firms face fierce international competition. This suggests well supplied markets in which international competitors could replace domestic production.

The energy price shock of 2022 provided an empirical test of this hypothesis. The result was that substantial drops in industrial production from energy-intensive firms were not passed through to the rest of the economy.

Figure 3. German energy-intensive vs non-energy-intensive industries (% of total industry value)



Note: energy-intensive industries include the following WZ codes 1411, 1711, 1712, 1920, 2011, 2013, 2016, 2314, 2410, 2442, 2443, 2444, 2445, 2451.
Source: Bruegel on DeStatis data.

In 2023, output from energy-intensive manufacturing in the EU was 14 percent less than in 2021, while output from overall manufacturing increased by 3 percent[26]. This evidence is a strong rebuttal of the argument that domestic supply chains depend on local energy-intensive production.

It suggests a reality in which trade and substitution along value chains mutes any impact. A detailed description of this is found in Moll *et al* (2023), who found overall industrial production to be decoupled from production in energy-intensive sectors.

The second counterargument is that certain products are critical to a country's economic security and should be protected. This argument has merit; however, the definition of a product's contribution to a country's economic security is more nuanced than simply that sector's average consumption of electricity.

While there may be a correlation between electricity consumption and contribution to economic security, it is not one-for-one. Supporting an industry or firm on the grounds of economic security should instead be on a case-by-case basis.

6.4 Between European countries

EU governments have different capacities to support national industries. The absence of European coordination runs the risk of an intra-European subsidy race that will harm the internal market and especially those countries with more limited fiscal space (similarly to what happened in the semiconductor sector; Garcia-Herrero and Poitiers, 2022).

The consequences will be to artificially increase the competitiveness of energy-intensive companies in countries that offer support, relative to European neighbours.

The dynamics discussed above in relation to skewing electricity consumption away from other consumers very much also apply between countries. Any increase in one country's consumption means that other countries in the internal electricity market must consume less and will face higher electricity prices.

The situation is like that during the energy crisis when European governments competed in a subsidy race, which ultimately raised the price of a limited supply of gas.

6.5 Whether to attract clean technology manufacturing

The production of many clean technologies involves electricity-intensive manufacturing stages, such as the refining of polysilicon for solar panels, or the production of battery cells.

The EU's proposed Net Zero Industry Act (NZIA; not yet finalised at time of writing) would set a goal for domestic manufacture of at least 40 percent of total EU demand in most clean-technology sectors. European governments are rolling out subsidies to attract clean-technology factories.

Just like legacy energy-intensive production, this new wave of clean tech will face the same dynamics in competing for electricity generation. The numbers are substantial. Meeting 40 percent of the EU's solar supply domestically will require the capacity to refine polysilicon for producing 30 GW solar wafers, which will consume around 24,000 GWh per year or 1 percent of total EU electricity demand today[27].

Meanwhile meeting 40 percent of battery demand will require 220 GWh cell production, consuming 13,000 GWh per year or 0.5 percent of current EU electricity demand[28]. This does not take into account the additional electricity requirements for raw material extraction and refining. The huge energy consumption of these facilities implies a major role for policy and industry in deciding where to locate them.

7 Conclusions

Germany and France have so far resisted the temptation to generously subsidise energy-intensive industry. This is good news. This would have had consequences for the integrity of the European single market and non-energy intensive domestic consumers. Their debates show that electricity policy is central to industrial policy. This will become even more the case in the coming years. First, electricity's share of final energy demand will grow, with transport and demand sectors in particular shifting consumption to electricity.

Second, the share of renewables will grow. This implies that actual market prices will decrease. However, there will be a growing share of taxes for governments to distribute between consumers. We identify the following five areas as critical for framing future debates on electricity pricing policy:

i) recovering expenses via electricity tariffs or general taxation,

ii) the relative tax split between households and industry,

iii) the relative tax split between energy-intensive and non-energy-intensive industry,

iv) the crossborder effects of one country's subsidies, and

v) high electricity consumption associated with the manufacture of clean technologies that Europe is looking to attract. ■

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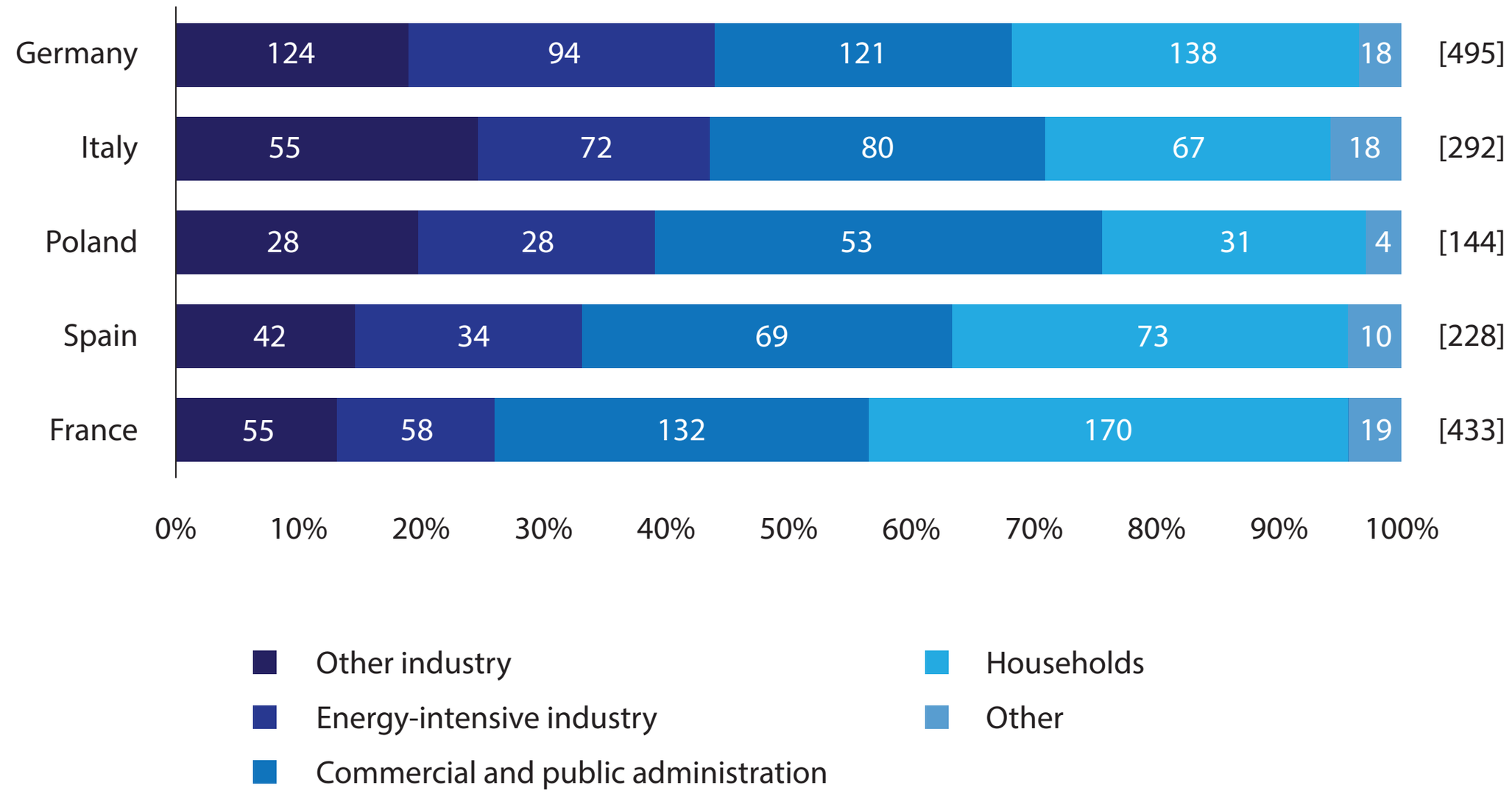
Annex A1. Country variation in the importance of energy-intensive industries

The importance of the energy-intensive industrial sector in overall electricity consumption varies by country within the EU. The share is highest in Germany with 25 percent of electricity consumption going to energy-intensive firms, and lowest in France at just over 10 percent.

Energy-intensive electricity demand in Germany is almost equal to total Polish electricity demand, or half of total Spanish electricity demand (Figure 1A).

Figure A1. Share of electricity consumption by consumer type, TWh, 2021 (totals)



Note: energy-intensive industry includes basic metals, chemicals, non-metallic minerals and paper and pulp.
Source: Bruegel based on Eurostat.

Endnotes

1. French and German ministers, for example, have called for measures to tackle Europe's disadvantage on energy. See Jonathan Packroff, 'Germany's Habeck calls for 'Zeitenwende' on industrial subsidies', Euractiv, 24 October 2023, and Euronews with AFP, 'Europe needs 'coordinated, united and strong response' to massive US subsidies - Le Maire', Euronews, 7 November 2022.

2. See BAFA press release of 21 December 2017, 'Special compensation regulation contributes to the stabilization of the EEG levy'.

3. C/2023/1188, available at https://eur-lex.europa.eu/eli/C/2023/1188/oj.

4. See European Commission press release of 20 November 2023, 'Commission adjusts phase-out of certain crisis tools of the State aid Temporary Crisis and Transition Framework'.

5. Approved support refers to budgeted allocation and does not necessarily correspond to final disbursement.

6. See, for example, Varg Folkman, Giorgio Leali and Aoife White, 'France and Germany risk EU rift over energy subsidies', Politico, 26 October 2023.

7. See https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview#Final_energy_consumption.

8. See Ember electricity data explorer.

9. For example, if renewables provide 90 percent of supply but the missing 10 percent is provided by natural gas, the price will be set equal to the price of gas.

10. The exercise was done using ENTSO-E data (ENTSO-E, 2022), and was based on announced government plans available to ENTSO-E for their 2022 analysis. The Spanish government has since increased targets.

11. The introduction of the emissions trading system, which puts a carbon price on fuels used to generate electricity, raised average wholesale prices. European governments are permitted under state aid to provide 'indirect cost compensation' to compensate for this.

12. Fuel taxes also address strong externalities, including paying for public road infrastructure.

13. This assumes financing costs between 5 percent and 7 percent for the period 2024-2030, and repayment of the principal in 40 years.
14. See Council of the EU, 'Electricity Market Reform'.
15. In reality the volumes sold by EDF at a regulated price are much higher. In 2022, EDF reported providing 120 TWh to alternative suppliers under ARENH and around an extra 55 TWh to households at regulated tariffs established under the French Energy Code, adding to the wholesale ARENH price capacity guarantees, transmission and marketing costs, as well as a normal rate of return on investment. Moreover, in 2022 EDF reported supplying 75 TWh at capped prices and about 25 TWh of grid losses also sold at the ARENH price (EDF, 2022, p.37).
16. See French government consultation document of 21 November 2021, 'Projet de dispositif de protection des consommateurs d'électricité à partir du 1er janvier 2026'.
17. André Tomas, 'Prix de l'électricité: après son accord avec l'État, EDF devra convaincre ses clients industriels', Ouest France, 22 November 2023; BFM Business, 'EDF va proposer des contrats adossés à des actifs nucléaires aux plus gros consommateurs', 21 November 2023.
18. Even then, it might raise some concerns if effective electricity taxes are negative and hence below EU minimum values.
19. For our calculations, we assumed the subsidies would have covered the 2,200 energy- and trade-intensive companies that were exempted from paying the renewables levy in 2021. They consumed approximately 120 TWh (out of total German industrial demand of 220 TWh), 80 percent of which would be about 100 TWh.
20. See German government press release of 9 November 2023, 'Energie bezahlbar halten'.
21. In Germany, a strict no-debt rule (the so-called 'debt brake) is applied to government finances. On the impact of the Constitutional Court ruling on government climate spending, see Georg Zachmann, 'Bypassing the German debt brake and continuing climate spending', First Glance, 30 November 2023, Bruegel.
22. Adding new generation capacities to the electricity grid takes a few years. Therefore, increasing electricity supply in the short run requires operating existing facilities at higher capacities. Concretely, this means raising output from natural gas and coal plants. Global natural gas markets remain very tight which limits room for manoeuvre, and raising output from coal plants is limited by environmental regulation as part of the EU's ongoing phase out.

23. See Bruegel Dataset, 'National fiscal policy responses to the energy crisis'.
24. See Benjamin Wehrmann, 'What German households pay for electricity', Clean Energy Wire, 16 January 2023.
25. Household consumption increases from 3,500 kWh per annum to 11,400 kWh. A heat pump increases consumption by 4,900 kWh (Schlemminger et al 2022) and an EV by 3,000 kWh, if driving 15,000 km at 195Wh/km. Constant price of 0.20 eurocents per kWh. Average fuel price for car estimated as 15,000 km driven at six litres per 100km efficiency and a fuel price of €1.70/litre. Natural gas consumption assumed at 12,000 kWh with a retail price of 8 eurocents per kWh.
26. Author's analysis on Eurostat database sts_inpr_m.
27. Assuming 3,000 tonnes of polysilicon are required per gigawatt of solar wafer capacity, and 270kWh electricity is required to refine 1kg of polysilicon (Hallam et al 2022).
28. Assuming 60 kWh electricity demand per kWh cell production (Davidsson Kurland, 2019).

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Making industrial policy work

The decarbonisation of the automotive industry is creating a skills shortage. Conor McCaffrey and Niclas Poitiers argue for the EU to get more involved in skill policies

The transition from cars powered by the internal combustion engine to vehicles powered by electric batteries implies a fundamental shift in the types of skills required by the automotive industry. However, the industry faces significant problems in finding suitable workers.

Surveys show that the lack of skilled labour is seen by firms as a problem of similar magnitude to high energy costs. Against the background a general skills shortage in the European Union, the shortage of skilled labour represents a major impediment to the development of a European battery industry.

The European Battery Alliance Academy is the main component of the EU's strategy for tackling this problem. It develops training courses and materials to assist local training providers and serves as a blueprint for skills policies in other industries. However, given the scale of the challenge, it represents more a symbolic than a substantive answer to the challenge.

More should be done. The limited powers of the EU in labour market policies hold up a union-wide solution. In the short term, the training programmes developed by the European Battery Alliance Academy[1] could more explicitly target demographics that are underserved by private training providers. In the medium term, the EU should rethink its labour market competences in order to develop a social pillar to underpin the European green transition.

1 Introduction

Industrial policy[2] is back. Though the European Union has limited powers in relation to industry[3], recent years have been marked by a shift towards targeted EU support for specific industries[4]. The European Chips Act (Regulation (EU) 2023/1781) and the proposed EU Net Zero Industry Act (NZIA) are the two most prominent examples of this change, with the range of measures introduced or planned including regulatory changes, public funding through national state aid and trade defence measures (see for example Kleimann *et al* 2023; Tagliapietra *et al* 2023; Poitiers and Weil, 2022a).

Given the importance that companies, and especially SMEs, put on the shortage of available skilled workers, current policy responses are not satisfactory

However, this shift has largely overlooked one of the primary production factors: labour. While the United States explicitly framed its Inflation Reduction Act (IRA) as a worker-centric industrial policy[5], and the EU has also highlighted the importance of skilled workers in its industrial policy communications, the skills-relevant parts of these policy packages have arguably been underdeveloped.

This discrepancy is especially apparent in the lithium-ion battery industry, which manufactures the rechargeable batteries used to power electric vehicles (EVs). The automotive industry is one of the largest sectors in the EU, responsible for 10 percent of manufacturing employment[6].

The shift from internal combustion engines (ICE) to electrification of the European automotive fleet necessitates massive investments and a fundamental shift in production technology. This implies stranded assets, in terms of both intellectual property and production facilities, but also in terms of skills.

Companies will not be able to capitalise on the ICE technology they developed in the past and workers who specialise in this technology will also find fewer opportunities to benefit from their skills. As part of its broader attempts to foster a domestic battery industry, the EU has put forward policies to develop the required skills, which are often put forward as a template for skills policies in other clean-tech industries.

However, as we discuss in this paper, despite the widely recognised importance of skills for industrial policy and the significant role that availability of skilled workers plays in investment decisions, the EU is yet to find a convincing strategy in this area.

Given their importance, making skills a more substantive pillar of EU industrial policy should be a priority. In this paper, we look at EU skills policies in the battery industry as an example for how skills policy in the EU currently works and how it could be improved. The European Battery Alliance Academy (EBA Academy) is the primary tool[7].

It provides a cost-effective instrument aimed at addressing the expected skills shortage in this growing sector. However, more funding and care should be put, in particular, into targeting those workers who might not find training through private sector programmes.

Overall, we recommend that the role of the EU in skills policy be rethought, to establish a more direct link between EU green policies and labour-market opportunities.

2 Workers and industrial policy

The relationship between industrial policy and labour markets can be seen from two perspectives: whether interventions can create jobs (treating employment as an output) or whether they can facilitate access to skilled labour (treating it as an input). These two perspectives are not mutually exclusive.

For instance, a skills shortage may occur in the short term before the growth of a targeted sector generates further employment. The EU's proposed Net Zero Industry Act walks a line between these two positions by emphasising that growing clean-tech industries in the EU *"requires significant additional skilled workers which implies important investment needs in re-skilling and upskilling"* but this also *"has a great potential for quality job creation"* (European Commission, 2023a, p.32).

However, assessing the relative importance and potential of the labour market as an input and output for industrial policy is important in framing the debate and determining policy priorities.

2.1 The labour market as an output?

In some cases, an increase in employment in the targeted industries has been framed as one of the primary objectives of industrial policy. Perhaps the biggest proponent of this framing has been US President Joe Biden, who

has stressed repeatedly that one of the main goals of his green industrial policy is to revitalise the manufacturing sector and create jobs[8].

Similar ambitions have been voiced by EU leaders, with Internal Market Commissioner Thierry Breton arguing that European industrial policy is needed to build a manufacturing base and create jobs for Europeans[9].

However, the results of policies enacted thus far, as well as forecasts for future growth, cast doubt on the ability of industrial policy to act as an engine for job creation. Despite much fanfare, the 170,000 new jobs announced in the year following the passage of the US IRA failed to equal even an average month's net employment gains over the same period[10].

Bistline *et al* (2023) forecast only limited employment gains, and even the study cited by the White House to advertise the IRA projected only 150,000 new manufacturing jobs by 2030 (Foster *et al* 2023). A literature survey by Cameron *et al* (2020) suggested that the net employment gains in the EU by 2050 from the green transition (the key aim of some EU industrial policies) will be positive but small.

For the battery sector, estimates vary but tend to suggest that the shift away from ICE automotives to EVs will have a net negative impact on employment in the European automotive value chain up until 2040[11]. This includes new jobs associated with the growth of the nascent lithium-ion battery sector.

Within this sector, batteries will become increasingly important as a share of employment: the International Energy Agency has estimated that, in a scenario of policies introduced to reach net zero emissions by 2050, EV and battery manufacturing jobs would make up over two-thirds of global automotive sector employment by 2050, up from just 8 percent in 2022 (IEA, 2023, Figure 1).

In other words, while expanding the European battery sector might fail to generate net employment growth across the automotive value chain, it could serve to mitigate the job losses expected from a decline in the ICE sector.

Given that the impact of the green transition on labour markets is expected to be uneven across various groups and locations (Vandeplas *et al* 2022), well-targeted green industrial policies could be used to avoid the negative local labour-market outcomes associated with previous energy transitions[12].

However, from a macroeconomic perspective, the net employment benefits of industrial policy to the EU appear to be negligible. Therefore, from a European perspective, the focus should be on the labour market as an input for industrial policy.

2.2 A shortage of skilled workers

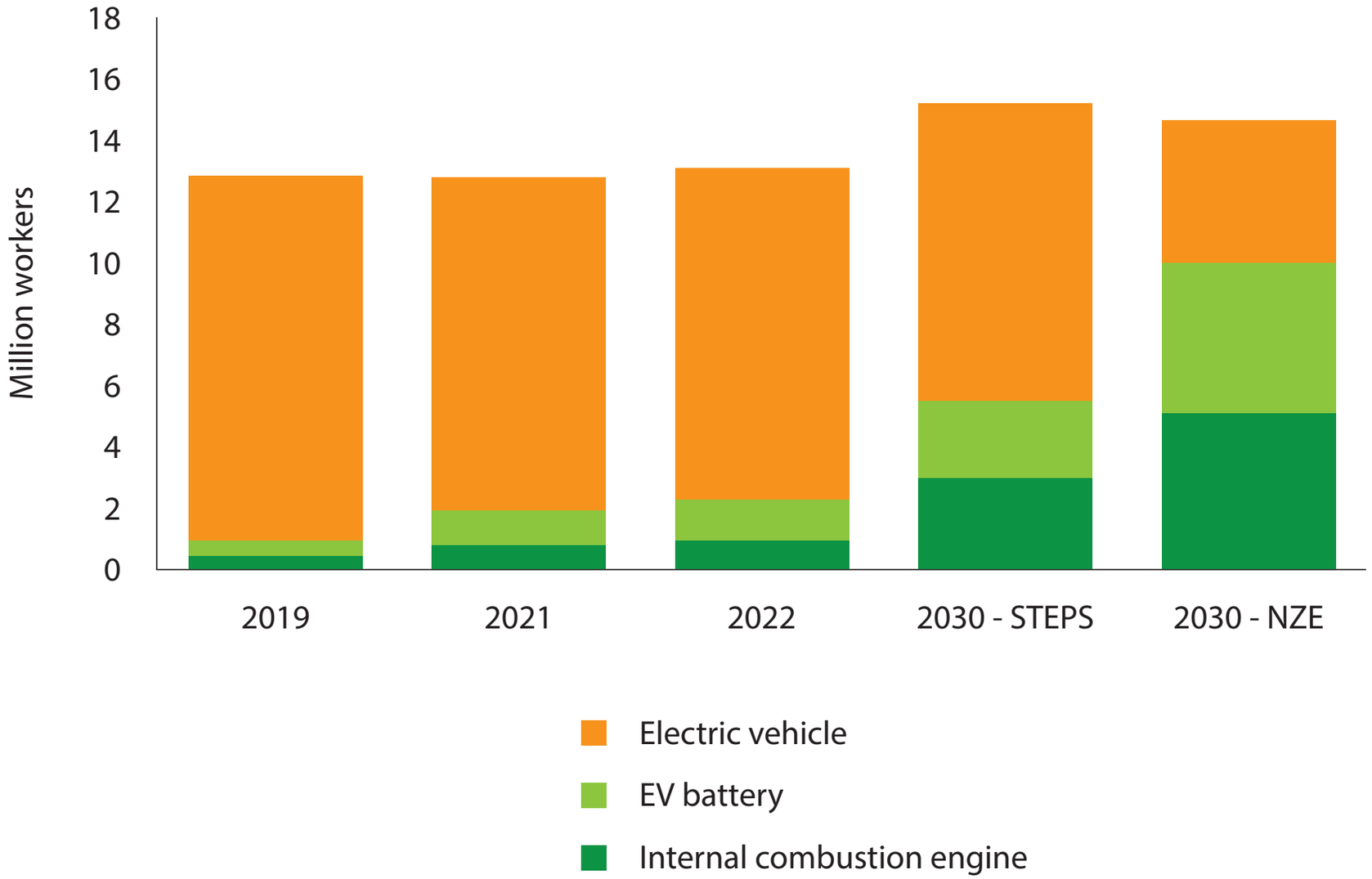
The ongoing skilled-worker shortage workers across the EU makes the need for skills-based policies as part of a European industrial policy more apparent.

Along with inflation and excessive burdens on firms, European Commission President Ursula von der Leyen has identified labour and skills shortages as one of the three major economic challenges for European businesses[13]. Former European Central Bank President and former Italian Prime Minister Mario Draghi has also pointed to a lack of skilled workers as a main weakness in the EU[14]. Firm-level surveys support these claims.

Over 80 percent of EU firms report that a lack of skilled workers represents either a major or minor obstacle to investment (Figure 2), with numbers broadly consistent across countries and economic sectors (EIB, 2023).

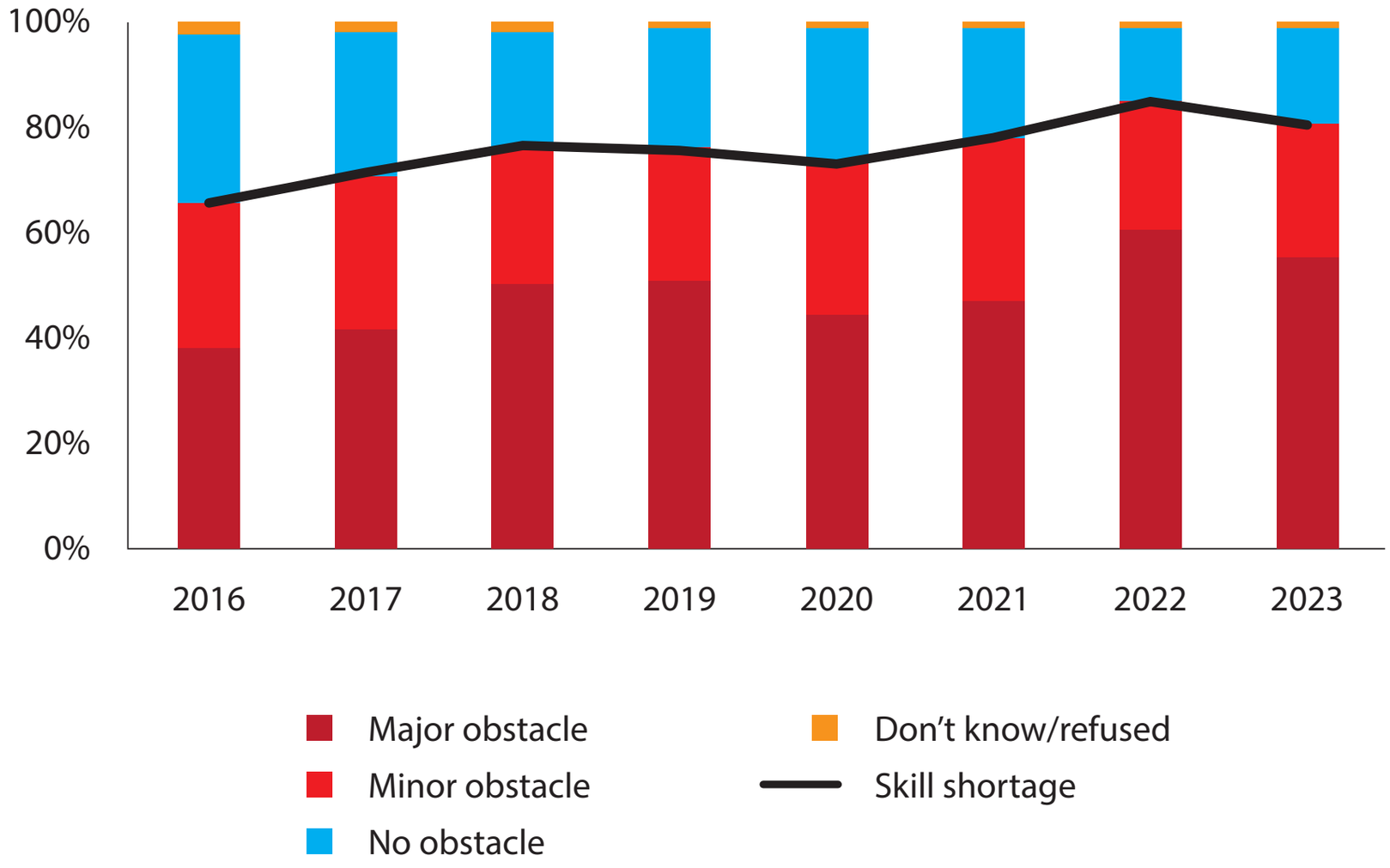
The share of companies reporting that this has been an obstacle rose from 65 percent in 2015 to over 80 percent in 2022, and the share of those identifying it as a major obstacle has risen strongly. When juxtaposed with other

Figure 1. Estimated global employment in the automotive manufacturing sector



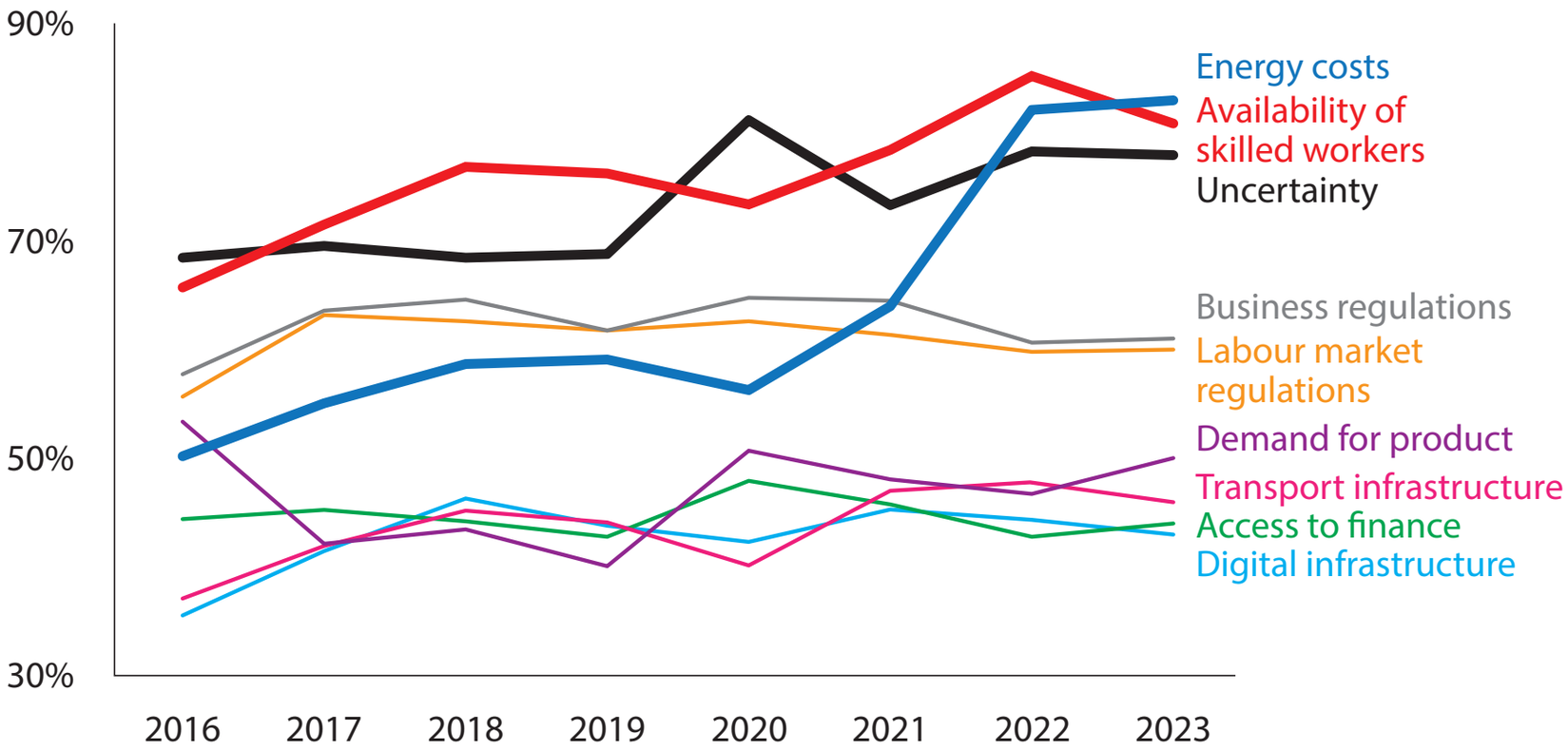
Note: Electric vehicles include workers in battery supply chains. STEPS = IEA Stated Policies Scenario; NZE = IEA Net Zero Emissions by 2050 Scenario.
Source: Bruegel based on IEA (2023).

Figure 2. The impact of a lack of skilled workers on European firms' investment decisions



Note: Answers to "Thinking about your investment activities, to what extent is availability of staff with the right skills an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?". Skill shortage is the sum of those answering major obstacle or minor obstacle. The year refers to the survey year, with the reference year the previous calendar year.
Source: Bruegel based on European Investment Bank Investment Surveys.

Figure 3. Obstacles to EU firms' investment decisions



Note: Answers to "Thinking about your investment activities, to what extent is an obstacle? Is it a major obstacle, a minor obstacle or not an obstacle at all?". Values reported are the sum of those answering major obstacle or minor obstacle for the given factor. The year refers to the survey year, with the reference year the previous calendar year.
Source: Bruegel based on European Investment Bank Investment Surveys.

potential deterrents to investment, a lack of availability of skilled workers has ranked as one of the top two factors each year since the survey began (Figure 3).

According to the European Central Bank, labour, which encompasses associated costs, skills and shortages, was the most cited factor when firms were asked which factors would motivate shifts of production or operations out of the EU (Attinasi *et al* 2023).

Data from the November 2023 Eurobarometer survey on skill shortages further reinforces this point (Eurobarometer, 2023a). More than half (54 percent) of small and medium-sized enterprises (SMEs) and 72 percent of large companies (250 employees or more) across the EU reported that finding employees with the right skills was among their most serious problems; it was by far the most cited challenge, consistent across both countries and industrial sectors.

Both SMEs (38 percent) and large firms (41 percent) were most likely to answer that workers with vocational training were the most difficult to recruit, with more highly qualified workers apparently relatively less scarce[15].

National reports stress the same message. For instance, the German Economic Institute reported a shortage of 600,000 workers across the German economy in 2022[16]. According to the Association of German Chambers of Industry and Commerce, as of November 2023, half of German firms faced labour shortages, with almost 2 million jobs unfilled across the economy[17].

Similarly, in its European Semester 2023 country report, the European Commission blamed labour shortages in key industries in France for creating *"bottlenecks in the transition to a net zero-economy"* (European Commission, 2023b, p.15).

Box 1. Skills shortages versus labour shortages

Even if skill levels are excellent, it cannot compensate for a shortage of workers themselves. Part of the documented shortfall in skilled workers across Europe is a consequence of a very tight labour market in general, with both the employment and job vacancy rates (74.6 percent and 2.9 percent respectively) reaching all-time highs/lows in 2022 (European Commission, 2022b). When asked for the reasons behind the aforementioned labour shortage, the two dominant answers from SMEs were that applicants were insufficiently skilled or experienced (54 percent) but also that there were not enough applicants of any skill level (56 percent) (Eurobarometer 2023a).

Without wider measures to address labour supply in general, up- or re-skilling measures alone will not be enough to solve the widespread skilled labour shortages in the EU, especially considering that the ageing population will lead to a smaller EU labour force (European Commission, 2023d). However, given that industrial policy is intended to support selected industries, we focus on the challenge of equipping the particular workforce with the skills it needs, notwithstanding the wider challenge facing the EU.

2.3 Battery sector

In the burgeoning battery sector, and indeed the clean-technology sector in general, the problem of skilled-labour shortage that we have documented seems to be even stronger.

While granular data is limited, available indicators suggest that the sectors critical to the green transition are experiencing growing labour shortages (European Commission, 2023c). As far back as 2018, the Strategic Action Plan on Batteries published by the European Commission identified a skills gap in the battery sector (European Commission, 2018)[18].

In 2023, the Commission (2018, p.15) described the transport and storage (ie. batteries) sector as *"already experiencing persistent labour shortages."* The same theme has been emphasised repeatedly by stakeholders in interviews. For instance, the CEO of Northvolt, one of the few large European battery producers, described in February 2023 labour issues as *"probably the number one limiting factor"* in their production[19].

The largest labour demand in this industry is for vocationally trained workers, with approximately 85 percent of roles requiring this level of education and no more (Stolfa, 2023). This is also the level of education for which firms report having by far the greatest difficulties in recruiting (Eurobarometer, 2023a).

Just under half (49 percent) of SMEs operating in the mobility-automotive-transport industrial sector reported that they faced difficulties recruiting workers with vocational qualifications, more than double the share that reported the next most common education level of worker shortage[20]. This shortage in vocational roles is common across the clean-energy industry (IEA, 2023).

In the battery value chain, approximately 90 percent of the jobs created will be downstream, eg. in areas including electric vehicle manufacturing, installation and repairs (for a detailed breakdown of job positions in the downstream component see EIT InnoEnergy, 2023); see Box 2 for a description of the battery value chain).

The Commission often cites an estimate of 800,000 workers in need of up- or re-skilling across the battery value chain by 2025[21]. More interesting than the estimated figures[22] is the breakdown along the value chain, with approximately 90 percent of the estimated skill shortage in the downstream component (Fraunhofer Institute, 2021). The industry will require more mechanics and technicians than electrochemists, for example, and training programmes should be designed to reflect this.

This also highlights another uncomfortable reality for the sector: the EU is currently facing a severe shortage in relevant blue-collar positions, including motor vehicle mechanics and repairers, electrical engineering technicians and electrical mechanics and fitters (IEA, 2023). EU firms identified in particular technicians as a role in which there are shortages (Eurobarometer, 2023).

This also represents a challenge for policy measures as the less-educated and less-skilled workers who would be expected to fill these rolls have historically been less likely to undergo training (European Commission 2023d; Güner and Nurski, 2023).

Such challenges are not unique to the EU. Economies all over the world and specialising in different parts of the battery value chain have encountered similar problems. From extracting raw materials in the Democratic Republic of Congo or Australia, to battery production in South Korea, the US or Japan[28], firms grapple with the challenges of finding skilled labour.

Box 2. The lithium-ion battery value chain

The value chain of lithium-ion batteries can be divided into three broad categories: upstream, battery production and downstream.

Upstream *encompasses the mining, processing and refining of raw materials; the workforce ranges from supply chain analysts to mining engineers[23]. **Battery production** entails firstly cell-component manufacturing, eg. the production of the cathode and anode materials that make up batteries, and then pack production (producing the cells before assembling the pack). The roles and skills needed for this stage include compliance managers, process engineers and calibration technicians. Finally, the **downstream** component captures applications, mainly in electromobility but also in stationary storage applications, such as storage of power produced from renewable sources[24], as well as second life (ie. recycling, which is becoming increasingly important because of regulatory changes and shortages of raw materials[25]). This is the part of the value chain that is expected to see the most demand for workers, for roles including automotive engineers and installation technicians. Some profiles, such as researchers and logistics managers, are required along the entire supply chain (for a detailed discussion, see IEA, 2022).*

Except for some raw material mining, China dominates the global battery value chain[26]. Production is also highly concentrated among a small number of firms. Rather than focusing on comparative advantage and therefore a particular segment of production, the European Battery Alliance defines its mission as "to ensure an unbroken value chain in Europe"[27]. For this to be achieved, workers will be required at each of the stages outlined above.

In the battery sector, this has led to the development of a global race for talent[29]. Furthermore, it is not only with other countries that the European battery sector must compete for skilled workers, but also with other growing European industries including the solar[30] and semiconductor[31] sectors, which require similar skill profiles and are facing workforce challenges of their own.

While claims of labour scarcity can seem over-hyped, with the reasonable assumption that the jobs will be filled if the pay is high enough, the impacts can be concrete. For instance, a lack of skilled labour was cited by TSMC as the reason for a delay in opening a semiconductor plant in Arizona in August 2023[32]. Attempts to grow and support this sector via industrial policy should therefore take this challenge seriously.

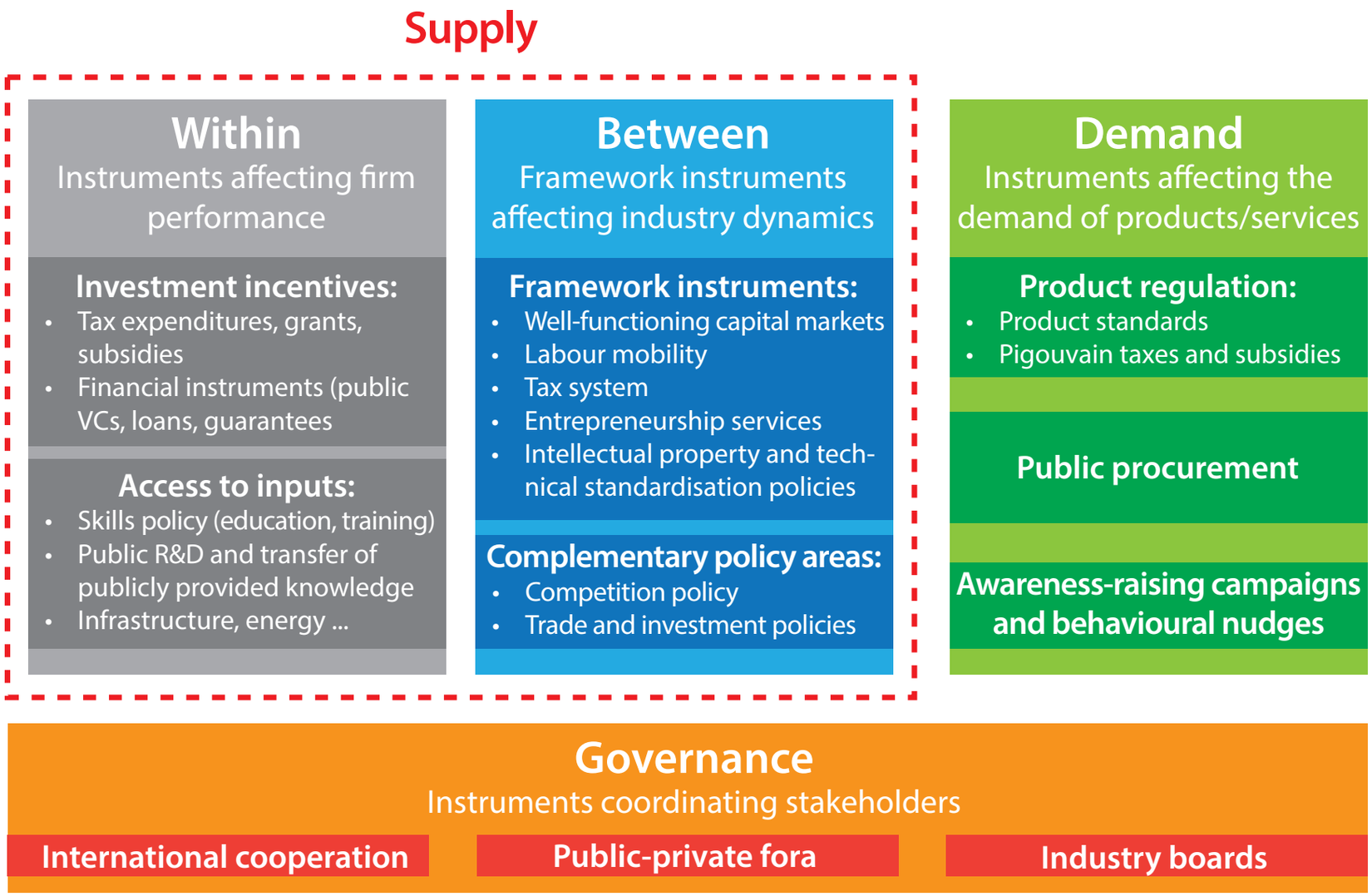
3 Policy responses

Before discussing the instruments put forward by the EU, it is useful to look at a theoretical framework appropriate for their assessment. In their taxonomy of instruments of industrial policy[33], Criscuolo *et al* (2022a) categorised policies as demand-side, supply-side or governance instruments (Figure 4).

On the supply-side, production-focused instruments, a further distinction is made between 'within' instruments, the policies that shape firms' internal efficiency, and 'between' instruments, which instead shape the dynamics between firms.

Labour-market instruments fall into both categories of supply-side instruments: policies that increase general access to skills are considered 'within' instruments, while those that affect the allocation and movement of workers between firms are considered 'between' instruments.

Figure 4. Categories of industrial policy instruments



Note: The policies listed in each category above are examples, not an exhaustive collection.
Source: Criscuolo et al (2022a).

The new wave of industrial policy has consisted more of the former than the latter, with efforts made to counter skilled-worker shortages across various sectors. Such measures have historically been found to improve growth and productivity, and act as important complements to investment incentives (Criscuolo *et al* 2022b).

For instance, Hanlon (2020) found that the development and maintenance of a pool of skilled workers played an important role in the British shipbuilding industry's maintenance of a dominance advantage over its North American rivals in the decades leading up to the First World War.

These skills-focused instruments have always formed important, if often overlooked, parts of industrial policy. In Singapore in the 1970s, the government established training institutes and business schools and also liberalised immigration to help supply the managers, engineers and technicians needed for the rapid industrial change the country was undergoing (Yeo, 2016).

Towards the end of the same decade, universities in Ireland provided one-year courses and expanded technical programmes to train electrical engineers to match increased demand arising from industrial agreements (Cherif and Hasanov, 2016). A polytechnic institute was created in the 1990s to train workers in Guanajuato, Mexico, as part of a multi-faceted strategy to attract automotive manufacturers (Cherif and Hasanov, 2016).

Labour-market instruments remain important facets of industrial policy. In their quantification of industrial policy measures across nine OECD countries, Criscuolo *et al* (2023) found large variations between countries. For instance, the share of industrial policy grants and tax expenditures in 2021 that went to jobs and skills measures ranged from 35 percent in France to less than 1 percent in Israel.

Policymakers in EU countries have put forward a range of measures to address skilled-labour shortages as part of the post-COVID-19 wave of green industrial policies. In Sweden, one of the European leaders in this sector, the 2020 national strategy to develop a competitive battery industry identified provision of access to a skilled workforce as a key area for partnership between government and industry (Fossil Free Sweden, 2020).

The Swedish national research and innovation institute has provided training programmes for workers along the battery chain[34], while regional authorities have worked with firms and universities to align training and education with industry needs[35].

France[36] and Germany[37] have each launched battery training schools to address skills shortages, with France also increasing funding for training in clean-tech sectors[38] and Germany reforming immigration laws to attract more foreign workers[39].

Beyond the battery sector exclusively, Slovakia, Finland, Denmark, Spain and Malta have all introduced various measures to enhance the skills needed for the green transition (European Commission, 2023d). Fourteen EU countries included in their post-COVID-19 Recovery and Resilience Plans measures targeting green skills and jobs, together amounting to approximately €1.5 billion, or roughly 0.25 percent, of total RRF expenditure[40].

These efforts have not been limited to the EU. In the US, access to some industrial policy funding has been made conditional on firms implementing labour measures, including apprenticeships for the IRA[41] and childcare in the Science and Chips Act[42]. The Biden Administration has also increased funding for apprenticeships and training programmes to improve the supply of advanced manufacturing workers and to support the policies enacted[43].

The skills shortage we have documented has prompted a reaction at the EU level. Beyond industrial policy, various measures have been enacted to try to ease the constraint, notwithstanding limited EU powers in this area. The five-year European Skills Agenda launched in 2020 set out 12 actions to improve skill levels across the EU[44].

For instance, the Pact for Skills, the first flagship action enacted under this Skills Agenda, has mobilised over 1,000 stakeholders (including firms, social partners, national authorities and training institutes) across 14 different industrial ecosystems to cooperate on up- and re-skilling needs (European Commission, 2022)[45].

Efforts have also been made under the Agenda to improve the recognition of skills and qualifications issued in other EU countries. 2023 was designated the European Year of Skills, with many events and initiatives organised to highlight training and employment opportunities. In November 2023, the European Commission also issued a Skills and Talent Mobility package, which includes proposed measures to ease hiring from non-EU countries and proposes higher targets for inter-EU training mobility[46].

Regarding financing, the state-aid exemption threshold for skill measures was raised in March 2023 from €2 million to €3 million, increasing the ability of national governments to support training schemes[47]. Various EU budgetary programmes included in the 2021-2027 Multiannual Financial Framework – the EU's budget – including the European Social Fund Plus and Just Transition Mechanism, contain resources earmarked to support green skills (European Commission, 2023f), though precise details on their allocation are difficult to quantify.

While none of these measures is likely to significantly reduce the skills shortage in Europe, they do show that the Commission is at least aware of this challenge and is making efforts to address it. This also holds true in its approach to industrial policy.

The European Chips Act includes measures to support the development of 'competence centres', with the intention of boosting access to internships and apprenticeships. Work on a European Chips Skills Academy, supported by €4 million of Horizon+ funding, is in progress to solve skilled-worker shortages in the semiconductor sector[48].

Addressing the skills shortage in green technologies also formed one of the pillars of both the Green Deal Industrial Plan (European Commission, 2023a) and the proposed NZIA. The Commission has placed the onus of solving these skills constraints on proposed 'net zero industry academies' for the respective clean-tech sectors. These are to be modelled on the European Battery Alliance (EBA) Academy (European Commission, 2023e), which we discuss next.

3.1 Skills measures in the battery sector

When it was established in late 2017, the European Battery Alliance (EBA) – an industrial alliance bringing together stakeholders across the battery value chain – identified development of a skilled workforce as one of the priority actions facing the industry[49].

As a result, the need to develop a highly skilled workforce across the value chain was included in the Commission's 2018 Strategic Action Plan on Batteries (European Commission, 2018), and the need to address this skill shortage has been consistently raised at the annual high-level meeting of the EBA[50]. The EBA Academy was launched in 2022 for this purpose.

Directed by EIT InnoEnergy and supported with €10 million of seed funding from REACT-EU, the EBA Academy is designed to support the training efforts of national and regional authorities to address this skills bottleneck. It has three main purposes: identifying future skill needs; designing and providing training corresponding to these needs; and issuing certifications to accredit the training provided.

Despite claims in the Green Deal Industrial Plan that the EBA Academy *"will train, reskill and upskill approximately 800,000 workers by 2025"* (European Commission, 2023e, p.16), the target in the proposed NZIA is for the academy to upskill 100,000 workers by 2025, with the hope that other workers will benefit indirectly (eg. from 'train-the-trainers' initiatives).

Complementing previous work by the Alliance for Batteries Technology, Training and Skills (ALBATTS, an EU-funded four-year project launched in 2019)[51], the first pillar of the EBA Academy is to identify the job roles that both are and will be in demand across the value chain.

A range of methods is used for this purpose, including analysing online job postings and engaging with stakeholders and experts. To date, over 600 unique roles and profiles have been identified (EIT InnoEnergy, 2023). The various skills, and the level of expertise in those skills, that each role requires are established and documented in a report known as a 'skills compass'.

For instance, a quality technician would be required to be an expert in 'quality assurance processes', while also having a much more limited awareness of 'environmental health and safety' (EIT InnoEnergy, 2023).

Once these required skills have been identified, the Academy then produces training material to correspond to these needs. These training packages span both the educational qualification spectrum (ie. from Masters' programmes to short-term vocational training material)[52] and the value chain. The Academy then works with firms and local training providers (eg. community training centres, universities or national battery schools, as in France) in EU countries to deliver the training to workers[53].

There is a wide variety in the courses offered: some are hands-on and intended to be delivered on-site by experts, with others designed to be accessed online and completed asynchronously.

Finally, the EBA Academy issues certifications to graduates detailing the training that has been received, so that it can be recognised by firms across the European battery sector. At the time of writing, exam-based and Europass-compatible[54] certification was available for three courses[55], with work ongoing to expand this to six other courses.

As of December 2023, approximately 50,000 workers and 90 'trainers' (out of targets of 100,000 and 100 by 2025 respectively) had received training through the Academy[56]. The average age of participants was 34, with men making up 50.5 percent of learners. Memoranda of Understanding had been signed with 11 governments to avail of this support, with courses provided in 10 languages.

Associated language costs have proved to be a significant burden for the Academy, given the frequent modification and updating of the courses on offer.

4 Policy lessons

Access to skills is a bottleneck in developing a European EV supply chain. Given the rapid expansion of a sector directly linked to the decarbonisation of transport, coupled with the current overreliance on China for supply, public intervention to facilitate this shift is justified.

However, the role of EU-level policy to provide a public good in this regard is not straightforward. Education and labour markets are national responsibilities, and local and state governments are often better equipped than the EU to provide training programmes that fit the specific requirements of local labour markets. The EBA Academy provides some returns to scale by developing training programmes that will be useful in many locations.

However, it also exemplifies the current lack of EU investment in skills. Compared with the €6.1 billion in subsidies in the two battery Important Projects of Common European Interest[57] and hundred million euro state-aid packages that can be expected as part of the Temporary Crisis Transition Framework (TCTF[58]), the €10 million in seed funding over three years to support the labour needs looks rather meek.

Nevertheless, there is a political case for the EU to act to provide support for reskilling the workforce. The decarbonisation plans that necessitate phasing out ICE vehicles were developed and implemented at the EU level. The EU will thus likely be seen as at least partly responsible for job losses that occur during the transition.

At the same time, the EU is greenlighting billions in subsidies for capital investment in the sector. Without a plan to also support labour, such a policy would rightly be perceived as lopsided. Given the importance that both large companies and SMEs give to the skills shortage, a more involved EU skills strategy would also signal that these concerns are taken seriously at the highest political level.

This is especially important considering that 70 percent of SMEs think that the EU is not doing much to help companies like theirs tackle skill shortages (Eurobarometer, 2023b).

Making subsidies conditional on labour-market measures, as done in the US under the IRA and the Chips and Science Act, might not be the first option for the EU. Given the limited labour market effect that is expected from the IRA (section 2.1), this represents mostly a symbolic act that will benefit only a small number of workers (Poitiers, 2023).

In the EU, where labour-market instruments with general coverage are available and protection of labour rights is more stringent in general, there would be less justification for such measures.

Furthermore, the constitution of labour markets is a national competence and linking EU industrial policy to changes in the governance of labour relations in EU countries would require support from the member states.

Beyond skill shortages directly, two challenges should be considered when designing EU labour policies that support the battery industry. The first corresponds to demographics. Because of demographic change, the EU working-age population decreased by 2.6 percent between 2009 and 2022, and is expected to fall by about the same amount between 2022 and 2030, and by 6.8 percent in total between 2022 and 2040 (European Commission, 2023c).

Simultaneously, the green transition is expected to lead to a shift in demand for labour. As discussed above, certain job profiles will be more in demand, while demand for others will decrease. Older workers with skills profiles linked to a decrease in employment opportunities might not find it worthwhile investing in new skills without public support.

The economic incentives to invest into reskilling are much lower for older workers and their employers, which have a shorter prospective return on such investments than for younger workers, meaning that there may be a particular role for policy in addressing this issue.

Given these demographic challenges, the EU should also target for roles in the battery sector young people who are not in education, employment or training (11.7 percent of young people in 2022; European Commission, 2023c) and women (who in Germany make up just 24 percent of the battery-production sector; Arnold-Triangeli *et al* 2023).

While the measures announced under the Skills and Talent Mobility Package in November 2023 may help to facilitate the hiring of workers from outside the EU, the global race for talent in this sector means that the EU should not rely on immigration to ease this skills shortage.

The second challenge concerns the location of jobs. Given the limited geographical mobility of workers, and the potential mismatch between the regions dependent on the automotive industry for jobs and the location of new battery production plants, localised negative labour market shocks will pose a challenge and have the potential to undermine political support for the green transition (see Cameron *et al* 2020, for a breakdown of regions particularly at risk).

A successful industrial policy should help reskill older workers and mitigate the negative effects of the green transition on local communities, while making it easier for workers to move for new employment or training opportunities.

The EU has taken some initial steps into this direction. The TCTF links the eligibility of clean-tech manufacturing projects for subsidies to those projects benefitting poor regions in the EU (Tagliapietra *et al* 2023).

While such a link is not explicit in the IPCEIs, countries including France and Germany have used industrial subsidies to incentivise the location of battery factories in poorer regions such as Eastern Germany[59] or Northern France[60].

Given the dual constraint of limited EU competence in both industrial policy and skills, the EBA Academy is a useful EU instrument to complement national policies. Its ability to address the identified skills shortage seems limited at best, but it is a relative cost-effective instrument that does appear to provide a useful resource to training providers across the EU.

However, there are a few areas for improvement. Based on the average learner age reported previously, the EBA Academy seems to mainly reach younger workers, and is not well equipped to target specific labour markets and demographics that might be underserved by private training providers.

While the burden of this may rest more on local or national authorities, more focus should be placed on targeting older or financially constrained workers, who otherwise may not be able or willing to take up the courses offered.

The EBA also needs a stronger profile and should engage more with SMEs, which will become more important players in the battery sector (eg. once EV repairs and maintenance become more widespread) and of which 65 percent are unaware of EU skills policies (Eurobarometer 2023b). Work should continue on expanding the credentials provided, as this is recognition of training is crucial for both firms and learners.

Finally, there is a risk that the different clean-tech skills programmes will directly compete against each other, and a strategy should be devised to identify synergies and avoid such competition. This should be feasible now that the solar, hydrogen and battery skills institutes are all under the same umbrella of the InnoEnergy Skills Institute.

More generally, the social and labour aspects of EU industrial policy should be rethought and given more prominence. The EBA and the Just Transition Fund provide early steps in this regard, but the current lack of competences at the EU limits what can be done. This is regrettable, as it limits the EU's ability to form a well-balanced industrial policy.

5 Conclusions

Despite the significance of skilled-labour shortages as a bottleneck in the development of a European battery supply chain, an ambitious policy response at EU level is lacking. The EBA Academy, which provides training solutions, is the headline EU skills initiative to tackle this bottleneck. While it receives relatively little funding, the EBA Academy is a potentially valuable and low-cost tool. However, it could be improved by more explicitly targeting those workers who might not receive training without public support.

Given the importance that companies, and especially SMEs, put on the shortage of available skilled workers, current policy responses are not satisfactory. While we argue that labour markets should be mostly considered as an input and not an output in industrial policy, there are political benefits in linking EU green policy with skill policies. Therefore, we argue for EU member states to allow the EU to get more involved in skill policies. ■

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Endnotes

1. The academy was rebranded in early 2023 to become the storage component of the wider InnoEnergy Skills Institute. For clarity and ease, we refer to it as the EBA Academy in this paper.

2. Defined by Juhász et al (2023, p.4) as "government policies that explicitly target the transformation of the structure of economic activity in pursuit of some public goal".

3. As defined in Article 6 of the TFEU, the EU only has competence "to carry out actions to support, coordinate or supplement the actions of the member states" in the area of industry.

4. While an 'EU industrial strategy' had been on the Council of the EU agenda since at least 2017, this refers more generally to improving the performance of European firms and strengthening the single market, not to establishing domestic manufacturing bases in certain sectors. A timeline of the Council's position on industrial policy.

5. See The White House, 'Fact sheet: President Biden Takes Historic Step to Advance Worker Empowerment, Rights, and High Labor Standards Globally', 16 November 2023.

6. Source: ACEA 'Employment trends in the EU automotive sector', 22 September 2023.

7. The academy was rebranded in early 2023 to become the storage component of the wider InnoEnergy Skills Institute. For clarity and ease, we refer to it as the EBA Academy in this paper.

8. See for instance The White House, 'Remarks by President Biden on the Inflation Reduction Act and Bidenomics', 15 August 2023.

9. As detailed in his September 2023 remarks at the Bruegel Annual Meetings.

10. Niclas Poitiers, 'The manufacturing jobs boom that isn't', First glance, Bruegel, 29 August 2023.

11. The European Association of Automotive Suppliers estimated that 275,000 jobs will be lost on aggregate across the EU, EFTA and the UK between 2020 and 2040 (CLEPA, 2021); Boston Consulting Group (Kuhlmann et al 2021) put net European losses at 50,000 by 2030.

12. Diluiso et al (2021) detailed that 130 of the coal transitions between 1860 and 2020 included in their literature analysis were associated with negative labour market outcomes (higher unemployment and job losses). Only five were linked with positive outcomes.

13. See '2023 State of the Union Address by President von der Leyen', 13 September 2023.
14. Henry Foy and Martin Arnold, 'Mario Draghi delivers downbeat outlook for EU economic growth', Financial Times, 8 November 2023.
15. The next highest responses were secondary education for large firms (22 percent), and no level in specific for SMEs (20 percent), meaning that the share of both large and small companies that answered vocational level was almost double that of the next answer.
16. Nick Alipour, 'Germany's skilled labour shortage puts vital industries at risk', Euractiv, 30 November 2023 (updated: 1 December 2023).
17. Reuters, 'Half of German companies face labour shortages despite economic stagnation - survey', 29 November 2023.
18. This action plan was heavily informed by the European Battery Alliance, which identified building a skilled labour force as one of the key actions required to develop a European battery sector.
19. Richard Milne, 'Northvolt: the Swedish start-up charging Europe's battery ambitions', Financial Times, 14 March 2023. For more stakeholders pointing to the skills shortage as a significant issue for the European battery sector, see EIT InnoEnergy, 'TÜV SÜD and EIT InnoEnergy launch partnership to combat skills shortage in battery sector', 21 October 2022.
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21. See for instance the 2023 Green Deal Industrial Plan (European Commission, 2023e)
22. The estimates appear to be based on a report by the Fraunhofer Institute (2021) and seem to outweigh the estimates detailed previously.
23. Each stage in the value chain requires a huge range of jobs, with those listed here merely a sample. For a more complete list of roles along the value chain, see EIT InnoEnergy (2023).
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41. Apprenticeship USA, 'Inflation Reduction Act Apprenticeship Resources'.
42. See The White House, 'ICYMI: Experts Agree: Chips Manufacturing and National Security Bolstered by Childcare'.
43. For more details, see The White House, 'Factsheet: To Launch Investing in America Tour, the Biden-Harris Administration Kicks off Sprint to Catalyze Workforce Development Efforts for Advanced Manufacturing Jobs and Careers', 6 October 2023.
44. See European Commission news of 1 July 2020, 'Commission presents European Skills Agenda for sustainable competitiveness, social fairness and resilience'.
45. The European Commission (2022) estimated that, as a result of the Pact, by the end of 2022 almost 2 million individuals were "reached by upskilling and/or reskilling efforts", over 15,000 training programmes were updated or developed, and almost €160 million was invested in upskilling and reskilling. However, without a counterfactual it is difficult to determine the actual impact of this initiative.
46. See European Commission press release of 15 November 2023, 'Commission proposes new measures on skills and talent to help address critical labour shortages'.
47. See See European Commission press release of 9 March 2023, 'State aid: Commission amends General Block Exemption rules to further facilitate and speed up green and digital transition'.
48. A European Chips Skills Academy to solve skilled-worker shortages in the semiconductor sector is also in progress and is supported by the Erasmus+ programme; see Nick Flaherty, 'Semi launches €4m European Chip Skills Academy', EE News Europe, 14 April 2023.
49. See European Battery Alliance.
50. For the 2023 takeaways, see '7th High-Level Meeting of the European Battery Alliance, main takeaways by the Chair Maroš Šefčovič and the Council Presidency', undated.

51. For an in-depth account of all the EU policy measures, introduced to support the battery sector, including those centred around skills, see ECA (2023).
52. Based on our conversations, the greatest demand is for short-term training.
53. The Academy is designed to be self-sustaining, and as such does not provide its content for free. It enters into commercial arrangements with LTPs, who can then charge learners for the training provided. In some instances, this training can be subsidised by local authorities or other relevant organisations.
54. The Europass profile is an online portal that allows workers to document their education, training and experiences. See https://europa.eu/europass/en/stakeholders/education-and-training.
55. Fundamentals on Batteries, Battery Storage Basics and Battery Management Systems.
56. Data from an internal EIT InnoEnergy report shared with Bruegel.
57. IPCEIs are state aid exemptions granted by the Commission in order to support major cross-border innovation and infrastructure projects, including the industrial deployment of innovative technologies. They have been used to support large battery, hydrogen and chip projects (for an overview, see Poitiers and Weil, 2022b). For the battery sector, see the Commission's overview on approved IPCEIs.
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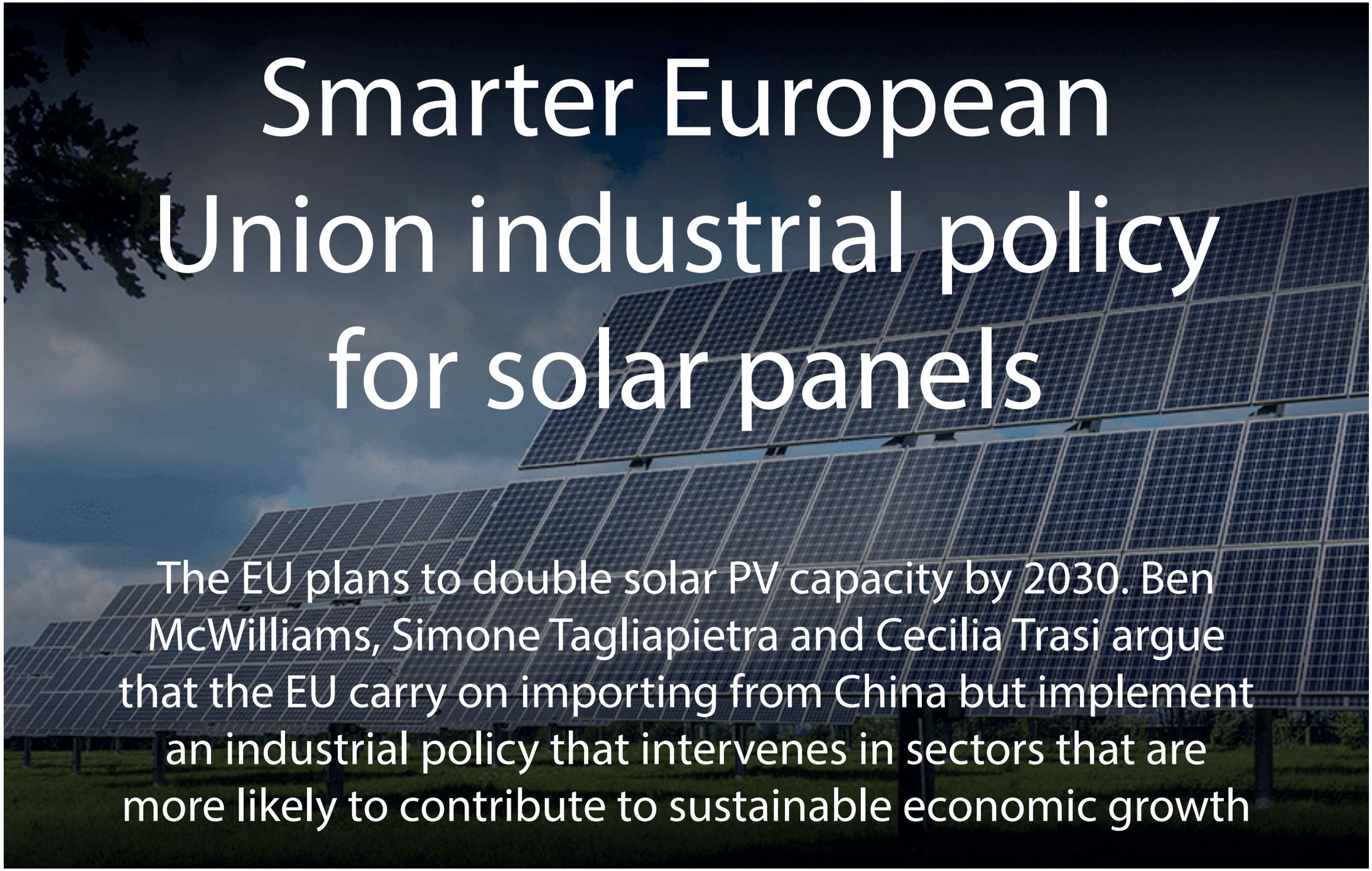


Smarter European Union industrial policy for solar panels

The EU plans to double solar PV capacity by 2030. Ben McWilliams, Simone Tagliapietra and Cecilia Trasi argue that the EU carry on importing from China but implement an industrial policy that intervenes in sectors that are more likely to contribute to sustainable economic growth

Executive summary

The European Union plans a major increase in solar PV capacity from 263 GW today to almost 600 GW by 2030. If nothing changes, this expansion will be based almost exclusively on solar panels imported from China, which supplies over 95 percent of solar panels used in the EU. This dependence has raised concerns about EU economic security and geopolitical vulnerabilities, especially in light of recent global disruption.

The EU has agreed in principle a non-binding 40 percent self-sufficiency benchmark for solar panels and other identified strategic technologies, to be approached or achieved by 2030. However, for the solar sector specifically, there is no strong economic justification for an import-substitution approach. Such a strategy risks increasing the costs of solar panels, slowing deployment and creating industries that are over-reliant on subsidies.

EU solar manufacturing subsidies are not appropriate based on criteria of European production alone. Subsidies could, however, be justified on innovation grounds, by supporting new solar products that have a real chance to develop into sustainable industries that contribute to climate goals.

To address concerns about short-term dependence, alternative tools should be employed: accelerated solar deployment, strategic stockpiling and gradually diversifying import sources. In the longer term, recycling of solar panels deserves greater attention and funding.

In terms of strengthening economic resilience relative to China, Europe should implement an industrial policy that intervenes in sectors that are more likely to contribute to sustainable economic growth and alleviate decarbonisation bottlenecks.

1 The 'kingpin' of Europe's energy transition

Solar power promises to be a major engine of Europe's energy transition. By 2030, European Union countries aim to reach the target of almost 600 gigawatts[1] of installed solar photovoltaic (PV) capacity as set out in the European Union's Solar Energy Strategy (European Commission, 2022a) – up from around 263 GW today[2].

If this target is met, solar PV will become the largest source of electricity production in the EU by capacity. Not only that, but the rate of solar deployment will be faster than any other; plans for increasing wind capacity, for example, aim at reaching around 500 GW by 2030, up from 200 GW today (European Commission, 2023a).

The European solar revolution is, and will continue to be, predominantly 'made in China'

This European solar revolution is, and will continue to be, predominantly 'made in China'. In 2022, over 95 percent of Europe's solar panels came from China[3], which has established itself as the global hub for solar PV manufacturing (IEA, 2023).

Chinese solar panels are becoming cheaper and also more innovative (ETIP PV, 2023). This is good news for the EU as it enables the acceleration of the deployment of solar energy in a cost-effective manner. However, such a high import dependency on a single supplier could expose the EU to the economic risks related to high market concentration and, potentially, to the risks related to an eventual geopolitical use of this dominant position.

Pandemic-related supply chains disruptions, the energy crisis, the increasing assertiveness of Chinese export controls on critical raw materials and competitiveness pressures arising from the United States's Inflation Reduction Act, have worried and continue to worry European policymakers.

This has led to a fresh debate on how to define and pursue economic security and, more tangibly, to a revival of new industrial policy initiatives aimed at fostering EU competitiveness and geopolitical resilience in clean technologies and critical raw materials (European Commission, 2023b).

In February 2024, the EU institutions agreed in principle on the Net-Zero Industry Act (NZIA), with the aim of supporting domestic manufacturing of clean technologies, such as solar PV, as strategic projects. Part of the NZIA is a plan to ensure that EU manufacturing of strategic net zero technologies 'approaches or reaches' a benchmark value of 40 percent of the EU's deployment needed by[4].

This approach risks relying heavily on import substitution. This is controversial because it disregards the costs of promoting self-sufficiency compared to the use of cheaper imports and, more broadly, because it signals a turn towards protectionism (Tagliapietra *et al* 2023a).

Furthermore, adopting a flat benchmark value for different technologies in which Europe has a very different starting positions and very different growth potentials is not economically rational. In this context, this Policy Brief evaluates specifically the case of solar PV manufacturing.

We start by describing the characteristics of solar PV supply chains, and then outline the diverging historic and current trajectories of Europe and China in solar PV manufacturing. We evaluate the economic case for European intervention to stimulate domestic manufacturing, finding that there are no clear decarbonisation or economic growth benefits from doing so – leaving mitigating the risk of over-dependence on Chinese imports as the only justification. Even this risk should not be exaggerated. Innovation and not domestic content should be the defining criteria for manufacturing subsidies.

2 Solar PV manufacturing and the EU's situation

2.1 Understanding solar PV supply chains

Any industrial policy strategy in the solar sector should be rooted in an understanding of the complexities of solar PV supply chains. The solar industry encompasses so many manufacturing processes that the concept of 'public support for solar PV manufacturing' is an oversimplification.

The production of a solar panel begins with quartz (SiO2), commonly found in sand. This is transformed into polysilicon by an energy-intensive process of melting and purification. Polysilicon is used for the production of solar panels, semiconductors and electronic devices. China accounts for around 80 percent of global polysilicon production capacity (IEA, 2022).

Around 35 percent of global polysilicon production capacity is located in Xinjiang, a Chinese region under international scrutiny for violation of human rights and forced labour involving Uyghurs and other Muslim-majority groups (Box 1).

Europe has 11 percent of global polysilicon production capacity (Bettoli *et al* 2022), amounting to 26 GW in 2023 (SolarPower Europe, 2023). However, this capacity is largely used to deliver higher quality polysilicon for semiconductor production, not for solar panels (Basore and Feldman, 2022).

Within the solar industry, polysilicon is melted to form ingots, which are then sliced into thin wafers. This is a capital- and energy-intensive process, which benefits heavily from economies of scale. Almost all current ingot and wafer manufacturing is in China, with half of global capacity coming from just eight Chinese plants (Basore and Feldman, 2022).

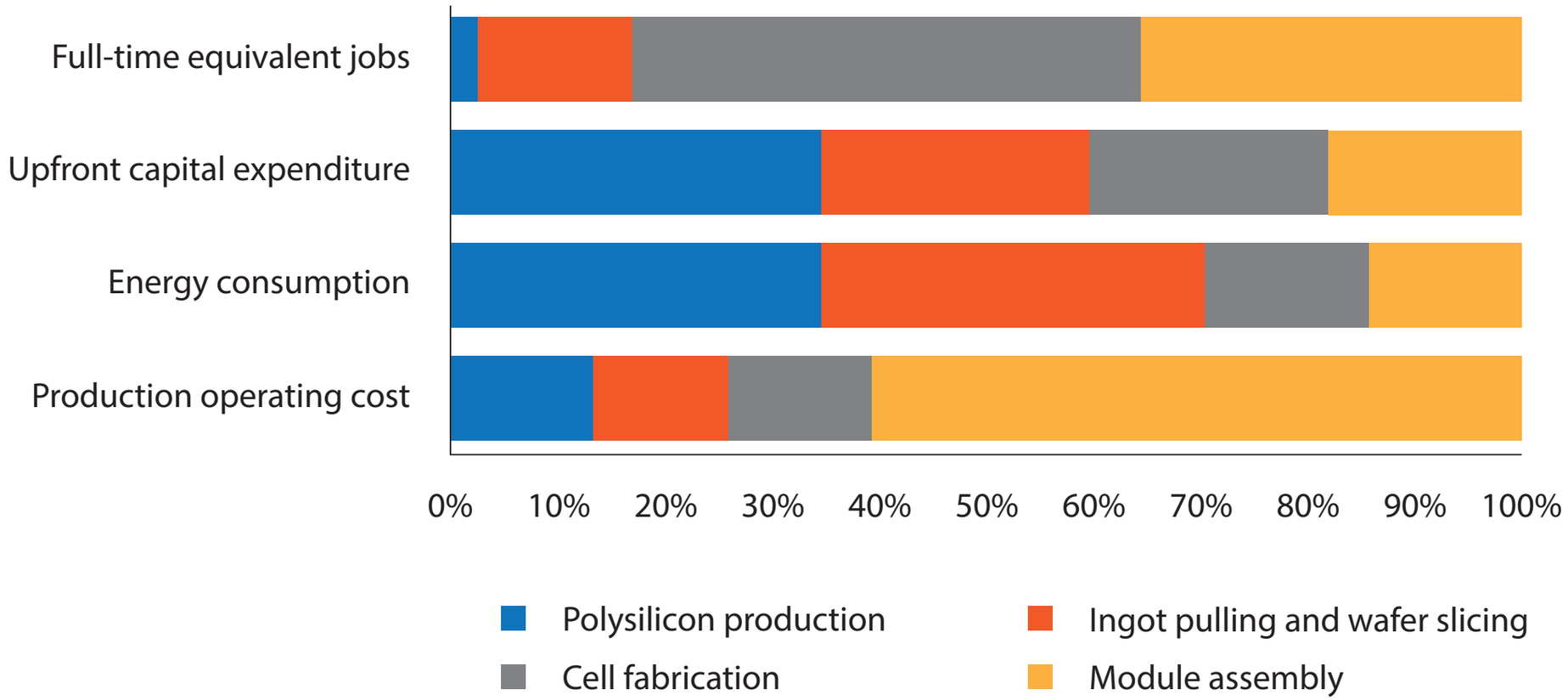
Wafers are then processed to produce cells in a highly automated system. Finally, cells are assembled into modules and sandwiched with other components including glass and aluminium frames. Along this value chain, the earlier stages are capital- and energy-intensive, while later stages account for the greater share of jobs and production cost (Figure 1).

Operating at the end of the value chain, module assemblers outside China typically import solar cells – the core component of the module. Module-assembly factories do not require high investment or substantial set-up time (ETIP PV, 2023). Production lines can be deployed in just one or two years.

This means factories can be paused and then restarted quickly and easily. Many of the new factories planned in the EU will focus on module assembly because it is flexible and can adapt quickly to changes in the market or in policy. The EU has 10 GW capacity for assembling modules but this currently operates at only about 10 percent capacity[6].

The estimated capacities of European manufacturers at each stage of the value chain are shown in Figure 2. This contrasts with estimated deployment in 2023 of 60 GW.

Figure 1. Distribution of economic indicators across the solar manufacturing chain



Source: Bruegel based on Woodhouse et al (2021), ESIA, BNEF.

Box 1: Forced labour in the solar supply chain

Allegations of forced labour have been made about polysilicon factories in Xinjiang, China. State-sponsored work programmes have been criticised for their coercive nature, often under the guise of poverty alleviation and anti-terrorism strategies. Evidence reported by the United Nations indicates that many Uyghur workers are subjected to conditions tantamount to forced labour and enslavement, unable to refuse work without the threat of re-education and internment (OHCHR, 2022). Further research highlighted that several major solar companies are implicated in the use of forced labour. Firms including Daqo, TBEA, Xinjiang GCL and East Hope, which account for more than a third of global solar-grade polysilicon supply, are implicated.

The issue extends beyond China, with evidence of forced labour also found in Malaysian factories5, but the Chinese industry's dependence on supply from Xinjiang, combined with opaque reporting practices, complicates the avoidance of products produced using forced labour (Crawford and Murphy, 2023). This has led to a call for greater transparency and accountability within the industry.

The international response to these findings has varied. Following the anti-dumping and countervailing duty tariffs in place since 2012, 2015 and 2018, the United States blocked the import of solar panels and components from China with the Uyghur Forced Labor Prevention Act, in force since 2022 (The White House, 2021). The United Kingdom, under its Modern Slavery Act, requires companies with turnover above £36 million to report their efforts to prevent modern slavery in their supply chains.

In 2022, the European Commission (2022b) proposed an EU market ban on products made with forced labour. The regulations require companies to conduct due diligence to ensure that solar panels are produced ethically and sustainably.

If the EU wishes to use import substitution to reduce dependency on China, it must have a granular industrial policy that supports the development of all stages of the solar manufacturing value chain[7]. While a sole focus on module assembly will have the biggest jobs and economic impact, it will not improve import resilience as producers would remain reliant on imported cells.

It will be difficult for the EU to develop substantial capacities in earlier value-chain stages, which are capital- and energy-intensive, especially as energy prices have remained somewhat elevated since the 2022 energy crisis (McWilliams *et al* 2024).

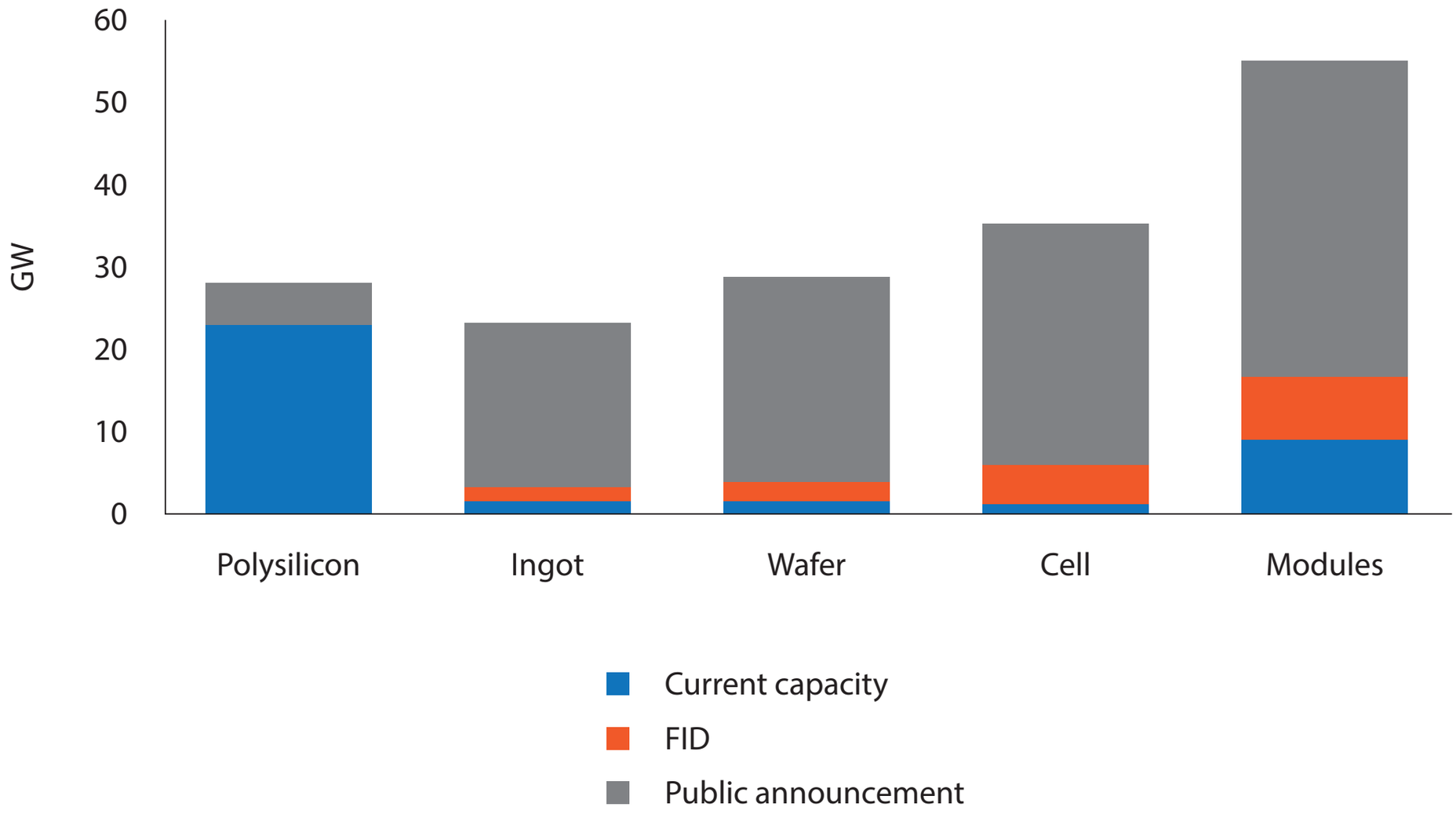
2.2 Solar PV manufacturing: the diverging trajectories of Europe and China

To understand the EU's lack of developed solar PV manufacturing, one needs to appreciate China's success.

China's solar PV industry emerged in the mid-1990s to address domestic needs, but rapidly became global. Chinese regions with favourable solar potential but limited access to other cheap and clean electricity sources started to look with interest at deployment of solar energy as a way to accelerate electrification (Zhang *et al* 2021). By 2003, China's solar energy installed capacity had soared to 45 MW, from 7 MW in 1995.

On the manufacturing side, foreign investment bolstered the sector's expansion. Chinese firms such as Suntech significantly boosted the sector's growth by raising funds through overseas IPOs. Notably, around 80 percent of China's solar panels were exported to the European market during this period (Cao and Groba, 2013), driven by the generous feed-in-tariffs provided by EU governments to accelerate the deployment of solar energy (Grau *et al* 2012).

Figure 2. Solar manufacturing expansion in Europe up to 2026



Note: capacities are estimated as of 2023. FID = final investment decision.
Source: Bruegel European Clean Tech Tracker (forthcoming).

China's export-oriented strategy resulted in significant advancements in production capacity and quality, along with substantial cost reductions. These developments played a key role in advancing the global rise of solar power. By 2008, the industry had experienced a tenfold increase in manufacturing capacity, establishing China as the global frontrunner in solar PV manufacturing (Zhang *et al* 2021).

The 2008 financial crisis led to a downturn in international demand for solar panels, compelling the Chinese government to pivot towards the domestic market. Massive solar energy deployment subsidies were rolled out, resulting in the production of solar PV cells increasing eight-fold between 2009 and 2011, while production of wafers grew tenfold and of polysilicon eighteen-fold (Zhang *et al* 2021).

These measures reduced manufacturing capacity costs and saw Chinese capacity grow at twice the global rate, solidifying its dominance in global solar PV manufacturing (Grau *et al* 2012). This rapid expansion resulted in significant oversupply worldwide, which together with a 70 percent drop in polysilicon prices[8], led to drastically increased competition in the global solar PV market (Carvalho *et al* 2017).

This surge in cheap Chinese solar panels became an existential threat to European manufacturers, leading to a significant decline in some segments of Europe's PV industry. Many European solar panel manufacturers struggled to compete with the low-priced imports, resulting in closures and a reduction in market share.

In 2011, Solarworld (a major German manufacturer) and Prosun (at the time, the representative ogranisation of European solar-panel manufacturers), petitioned the European Commission for anti-dumping and anti-subsidy investigations into Chinese solar panels.

In 2012, the European Commission initiated a major investigation and determined that the appropriate value of a Chinese solar panel sold in Europe ought to be 88 percent higher than its then selling price[9].

The Commission proposed the 'price undertaking' agreement[10], under which Chinese companies were permitted to export solar products to the EU duty free up to an annual limit of 7 GW, provided the price stayed at or above €0.56 per watt.

Exports exceeding this quota or priced below the minimum threshold were subject to anti-dumping duties, intended to increase the selling price of Chinese panels in Europe by an average of 47 percent starting in August 2013.

China responded with anti-dumping and anti-subsidy investigations into EU wine imports but the EU measures were nevertheless renewed in 2015 and 2017, with the duties reduced to 30 percent and the minimum import price adjusted to align with global market rates.

Ultimately, in August 2018, the Commission removed the anti-dumping tariffs, considering it beneficial for the EU after evaluating the needs of producers against those of users and importers of solar panels[11]. This decision was influenced by the EU's goal of increasing the deployment of solar energy and by the reduction in the costs of solar components, which allowed import prices to align with world market prices.

Furthermore, the European industry did not gain any advantage from the reduced market presence of Chinese imports that resulted from the imposed measures. Instead, the EU's solar market share declined further, primarily because of increases in imports from countries in South Asia[12].

And yet, every cloud has a silver lining. The competitive pressures, while forcing some Western firms out of the market, also spurred innovation among the remaining European companies, particularly those with a significant pre-existing base in innovation (Carvalho *et al* 2017; Bloom *et al* 2021).

Most importantly, the overall decrease in solar equipment costs, largely attributed to Chinese manufacturing, significantly lowered the levelised cost of energy[13] for solar PV, making it a formidable competitor to coal and gas in electricity generation (Carvalho *et al* 2017). In this context, the expansion of Chinese manufacturing had a positive impact on the solar sector at the global level (Andres, 2022; IEA, 2023a).

2.3 Europe's solar-panel dilemma: cost-efficiency vs geopolitical resilience

More than 90 percent of solar panels deployed in the EU are still imported from China, primarily because of their low price. In 2022, Chinese solar panels were estimated to be the cheapest in the world at $0.26/watt (Woodhouse *et al* 2021).

Solar panels produced in Germany were approximately 40 percent more expensive, at $0.38/watt. This disparity was largely driven by higher input costs, both in terms of energy (additional $0.05/watt) and labour (additional $0.04/watt).

Since then, a drop in polysilicon prices has further depressed the price of solar PV modules. In 2023, the price of Chinese solar panels dropped by over 40 percent, likely widening the price gap with the remaining European production. Bettoli *et al* (2022), prior to the surge in energy prices in Europe, estimated a $0.09/watt gap between European manufacturers and 'leading industry cost levels'.

The difference was mainly driven by higher input costs in Europe (energy, labour and capital costs) and by lack of access to the critical raw materials needed for these technologies.

Since the price increases driven by supply-chain shortages between 2020 and 2022, module prices have crashed at record speed, reaching as low as $0.15/watt in September 2023 (Figure 3). Meanwhile, the EU has dramatically increased imports of Chinese solar panels to an average of 9.5 GW per month in the first nine months of 2023. This compares to total deployment in the EU in 2022 of around 36 GW.

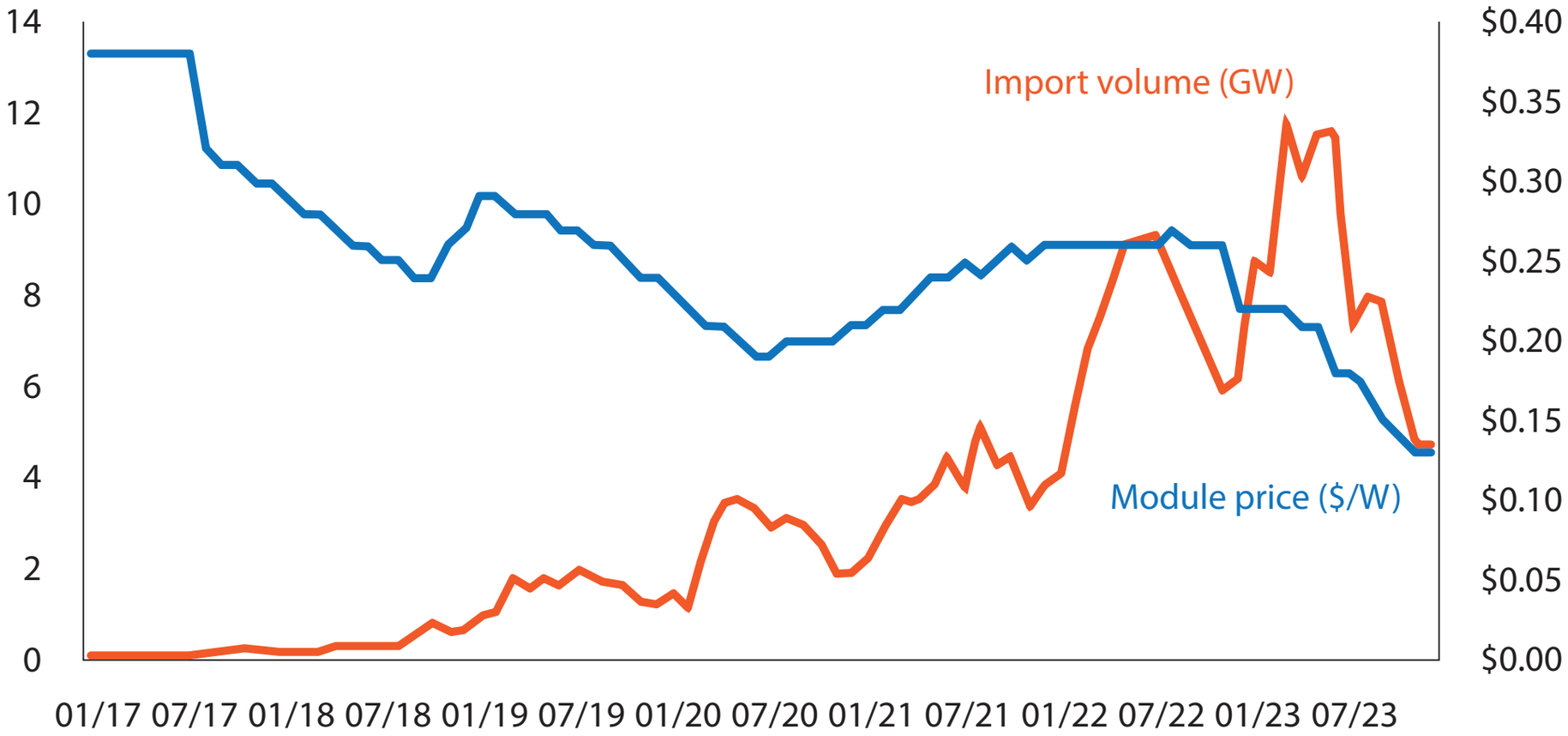
Attempts in the US to stimulate domestic solar PV manufacturing offer another perspective on this cost differential. Support under the US Inflation Reduction Act is estimated at between $0.11 and $0.18 per watt (Bettoli *et al* 2022), meaning that public support will closely match, and possibly exceed the total cost of producing a solar panel in China. The US has also implemented tariffs on the import of Chinese solar panels[14], a step the EU has not taken so far.

For European solar PV manufacturers the current situation is a deja-vu, as competing with their Chinese counterparts has once again become extremely difficult. The examples of Norwegian Crystals and Norsun, ingot and wafer producers respectively, illustrate the challenge.

In August 2023, Norwegian Crystals filed for insolvency[15], while the following month Norsun announced a temporary wafer-production suspension because of an oversupply of low-priced Chinese modules causing inventory buildup and disruption in the value chain[16].

In January 2024, the European Solar Manufacturing Council wrote to the European Commission asking for emergency measures[17]. The Council wrote that around half of the EU's module assembly capacity was at risk of shutting down.

Figure 3. EU imports of Chinese solar panels, volume (GW) and price ($/watt)



Source: Bruegel based on Ember dataset of Chinese solar PV exports.

Under current market conditions, European producers can hardly compete with their Chinese counterparts. Solar producer industry groups have called for anti-dumping measures against Chinese solar panels[18] and for additional trade measures to prevent solar panels produced with forced labour from entering the EU market (ESMC, 2023). The ghost of the 2013 tariffs on Chinese solar modules is looming again.

However, calls from European solar PV manufacturers for trade measures against Chinese panels are in stark contrast to what importers and installers of solar panels want. They warn the European Commission against initiating a trade defence investigation that could lead to the imposition of tariffs on Chinese solar PV products[19].

The primary concern of these European companies is that implementing trade barriers on Chinese products would limit their access to essential, high-quality and affordable components necessary for the EU's solar-power value chains.

This is particularly crucial given the EU's limited domestic solar-panel manufacturing capacity. Imposing tariffs on Chinese solar products, they fear, could severely restrict the entire EU solar-power market.

These two contrasting positions illustrate Europe's dilemma when it comes to solar PV manufacturing: how to strike the right balance between economic efficiency and geopolitical resilience, without slowing-down the green transition. In response, a reflection is needed on the reasons why the EU should or should not support domestic solar PV manufacturing in the first place.

3 Evaluating Europe's case for solar manufacturing industrial policy

The current political consensus in Europe favours the approach under the Net-Zero Industry Act (see section 1) – that the EU should increase domestic manufacturing for solar and other technologies, setting an indicative benchmark to get close to or achieve a 40 percent share of deployment covered by domestic production.

This suggests, in part at least, an import-substitution strategy that marks a break with traditional European thinking rooted in principles of free trade and markets. A clear economic rationale is necessary to justify this shift.

3.1 Scoring solar against economic intervention criteria

Industrial policy involves government efforts to change the structure of an economy, by encouraging resources to move into sectors deemed desirable for future development, in a way that would otherwise not be driven by market forces alone (Meckling, 2021).

We consider there to be three reasons why the EU might want to support domestic manufacturing of clean technologies: 1) facilitating decarbonisation; 2) fostering green growth and creation of green jobs; 3) boosting geopolitical resilience (or strategic autonomy) in sectors considered to be important for the EU economy.

In the case of solar panels, there is no strong economic case for EU support for the first two justifications, and at best a weak case for the third.

First, the EU does not need domestic solar PV manufacturing to accelerate its decarbonisation. The global solar PV market is vastly oversupplied, and the EU is currently importing twice the volume of solar panels it manages to deploy[20], creating a stockpile equivalent to well over one year's annual deployment.

All indicators point to a further increase in this over-capacity, as Chinese companies expand aggressively, countries including the US and India ramp up their policy support to domestic manufacturing.

Overall, announced solar PV manufacturing expansion suggests that global capacity will double to over 1,000 GW by 2024-25 (Buckley and Dong, 2023), with China expected to maintain its 80 percent to 95 percent share of global

supply chains (IEA, 2024). In 2023, global capacity ranged between 800 GW and 1,200 GW for different value-chain stages (IEA, 2023b).

Meanwhile, the IEA has calculated that the world should achieve annual installations of 650 GW solar by 2030 to be on track for net zero by 2050 (IEA, 2021). The speed of EU decarbonisation will continue to be defined by its capacity to speed-up deployment rather than by supply-side bottlenecks.

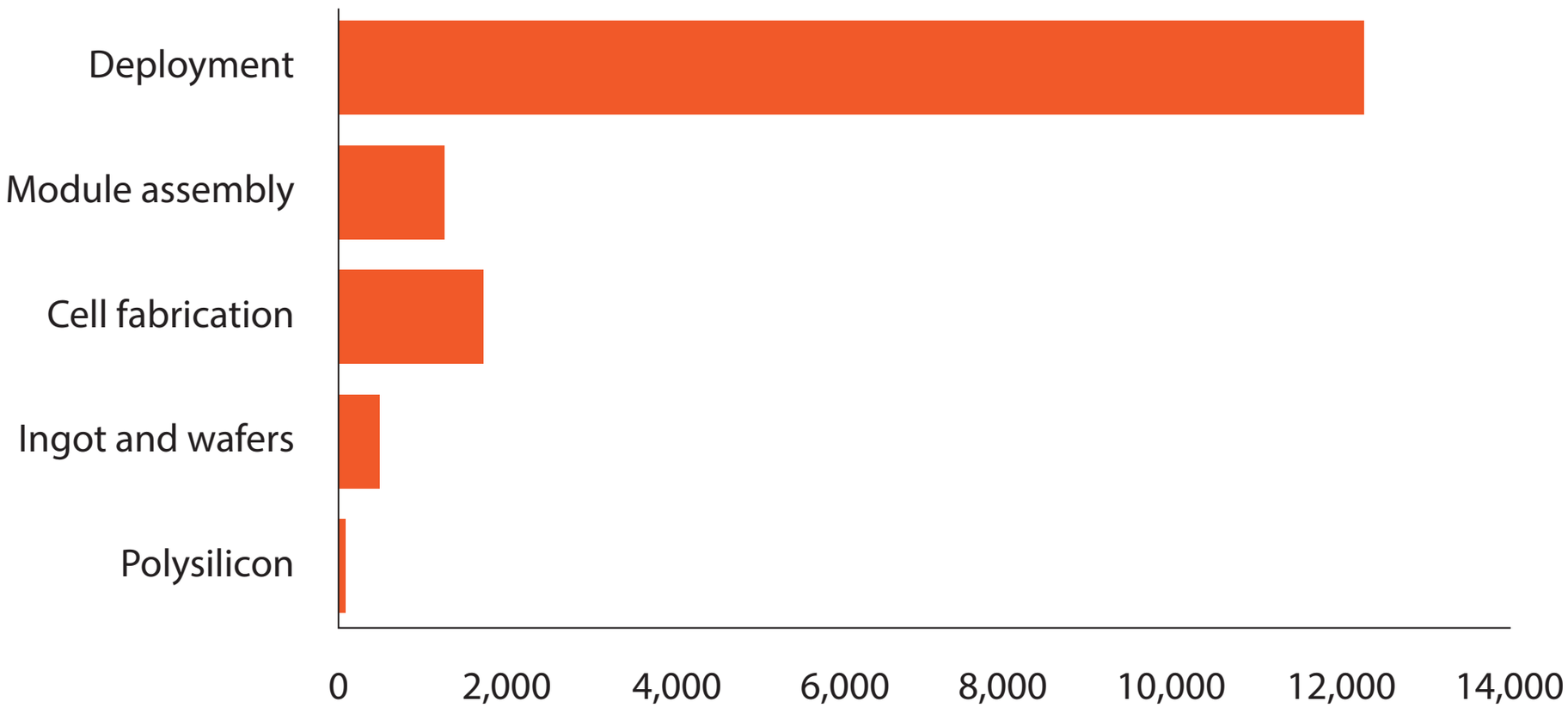
Second, the EU should not expect solar PV manufacturing to foster job creation and economic growth. In fact, the opposite might be true. Figure 4 shows that most solar-related jobs are in deployment rather than manufacturing. Solar PV manufacturing is not as job-intensive as deployment.

To create jobs in this sector, the EU would thus better focus on accelerating the deployment of solar energy. Imposing trade restrictions on Chinese solar panels would lead to higher costs, slowing deployment of panels and, possibly, a net-negative job effect. That would occur if more jobs were lost from a slowing of deployment than new jobs were created in possible new manufacturing facilities.

When it comes to economic growth, it is difficult to expect solar PV manufacturing to provide a major contribution, given that the EU has no comparative advantage in producing the existing generation of solar panels, and it is not clear where any unrealised advantage might lie.

This leaves the third reason – resilience – as the only possible justification for supporting domestic manufacturing. The EU is fully dependent on China for solar panels and at least two conventional risks are associated with this.

Figure 4. Full-time equivalent jobs per 1 GW solar PV manufacturing or installation capacity



Source: Bruegel based on Ignaciuk (2023).

The first is the economic risk that China might in the future make use of its predominant position in global solar PV manufacturing to distort the market and artificially obtain additional economic rents.

The second is the geopolitical risk that China might restrict solar-panel exports to certain countries to pursue geopolitical goals. The extent of both risks is unclear today.

3.2 The 'China risk'

There is no evidence that China currently abuses its solar manufacturing market power to artificially extract economic rent. The solar market is vastly over-supplied, and historically profit margins have been tight and even negative.

It is currently more likely that the Chinese state provides an artificial advantage to domestic producers through, for example, cheap land and loans, allowing them to export at lower prices[21].

Were China to begin extracting rents from solar exports, the competitiveness position of non-Chinese producers would improve, encouraging a gradual growth in manufacturing capacity elsewhere. An even more dramatic risk would be if there were a sudden interruption of all exports of Chinese solar panels, for whatever reasons.

Consider, for instance, a scenario in which the EU reaches a decision on forced labour in China and decides to ban associated imports of certain products, including solar panels[22]. Or consider a scenario in which China deliberately restricts the solar panel exports to Europe as a result of flaring geopolitical tensions.

Comparisons with the cut-off of Russian gas to Europe are far-fetched. While the Russian gas disruption created significant and immediate issues because of the need to heating homes and run power plants, an interruption in

the supply of a manufactured goods like a solar panel is different. It would lead to a delay in the deployment of new solar panels, but would not affect the functioning of those already installed.

To measure the impact of such an event, one would have to estimate the resulting delay in European deployment of solar panels. This is understood as the time period between the end of Chinese supply and coming online of new supply.

In Figure 5, manufacturing lead times for different stages of the value chain are estimated at between one and four years. These might be expedited in the extreme case of a sudden disruption, much like Europe was able to accelerate the deployment of liquified natural gas infrastructure following the Russian invasion of Ukraine.

4 Resilience priorities for solar policy

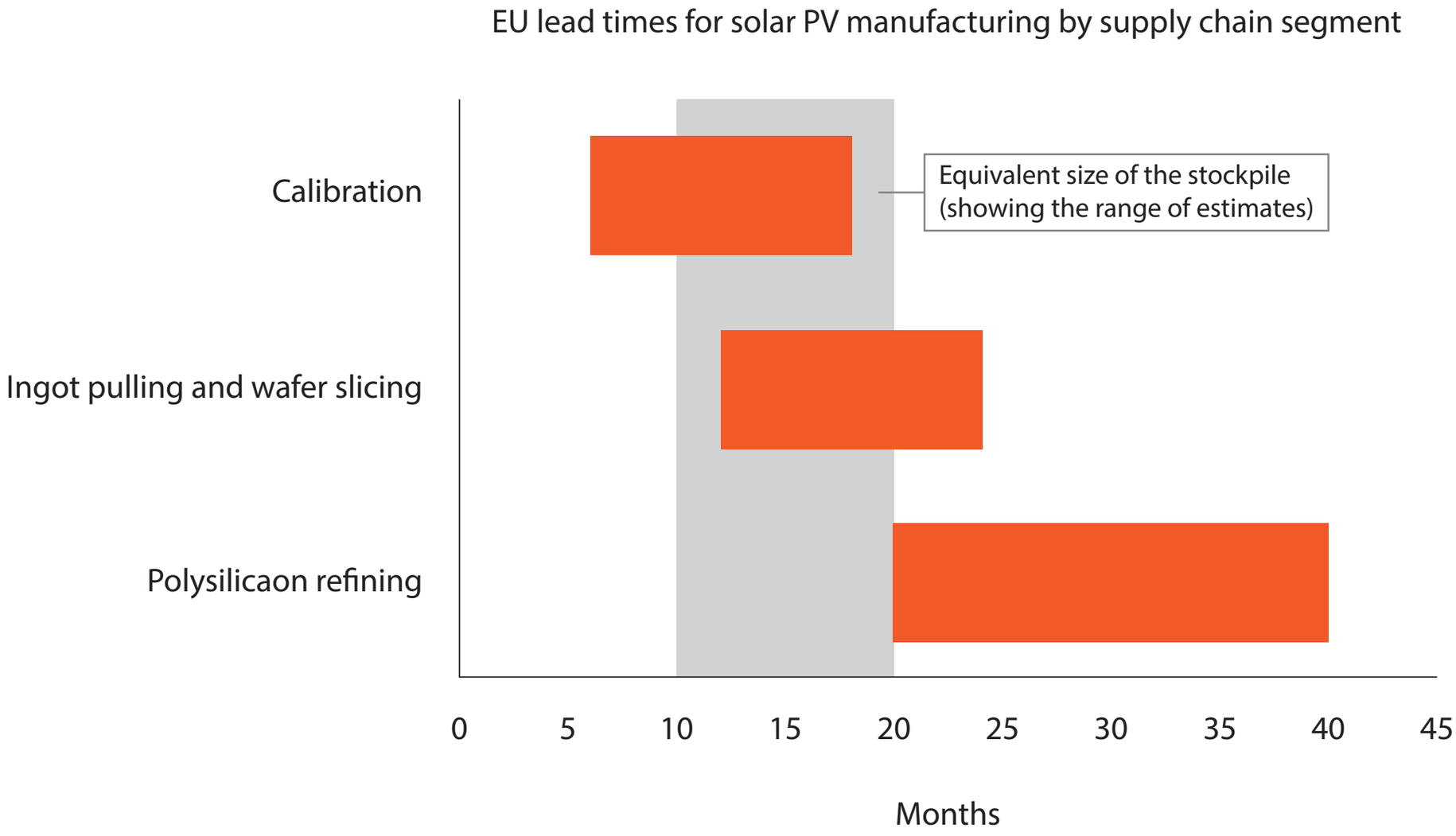
4.1 Stockpiling as a buffer solution

European companies already have a stockpile of an estimated 40 GW of solar panels[23], equivalent to almost one year of total EU deployment (section 3.1). The resilience benefit of a stockpile is that it provides breathing space for industry to respond in case of a sudden event that disrupts imports while continuing business-as-usual deployment.

Figure 5 shows the size of the current stockpile in terms of current monthly installations, and the estimated time it would take to build new factories for key components of the solar value chain.

The figure shows that if all imports were ended tomorrow, the EU could develop its own manufacturing capacities, while running down its stockpile to continue current deployment rates, facing disruptions counted in months, not years.

Figure 5. The EU's solar buffer



Notes: The figure shows the size of stockpile in months' worth of deployment and the months needed to build new facilities.
Source: Bruegel based on IEA (2022).

If policymakers deem the risks of an immediate disruption to imports sufficiently high, the EU might explore more formal stockpiling arrangements to ensure supply-chain reliability. For example, it could require major importers to maintain a stockpile equivalent to three months (or more) of current import levels.

Frequent turnover of the stockpile should ensure that only the latest technology of panel is maintained. As global supply is diversified, this requirement can gradually be replaced by a requirement to demonstrate import resilience in case of disruption to a main supplier.

Stockpiling is a tried-and-tested approach, in line with current IEA recommendations for oil imports, which are substantially more important for economic security. Countries must maintain oil reserves equivalent to a minimum of 90 days' worth of net oil imports[24].

A solar stockpile is a relatively cheap tool for addressing import concern risks. A rough estimate is that the costs of storing 20 GW solar panels would be from €400 million to €550 million annually[25]. That is around 10 percent of the total value of the panels at current prices (around €4 billion). By comparison, to provide these same 20 GW of supply, estimates based on US Inflation Reduction Act subsidy rates suggest a cost of around €2 billion annually in subsidies offered for the first years of a plant's operation[26].

While the EU might offer substantially lower subsidies than the US, they will still far exceed the costs of storing panels. From a short-term resilience perspective, stockpiling is cheaper.

4.2 Accelerating solar deployment

Accelerating the deployment of solar panels should be a much higher economic-security priority for Europe than developing its own manufacturing capabilities. This is because reliance on imported fossil fuels poses a greater threat to Europe's economic security than reliance on imported solar panels.

Solar deployment is accelerating, with 56 GW installed in 2023 (SolarPower Europe, 2023), exceeding the annual installation of 54 GW needed to meet EU energy targets[27]. A combination of steadily decreasing solar costs and increased policy attention is driving this growth.

The European Commission has described the deployment of solar energy as the 'kingpin' of efforts to end dependency on Russian fossil fuels. Governments are encouraged to create 'go-to areas' where permitting is accelerated for renewable projects to hasten deployment (European Commission, 2022).

With no shortage of supply, policy efforts should be most concerned with guaranteeing and possibly exceeding current targets. This requires a continued focus on permitting and grid connection. Developers are ready to build, but they need permission from agencies and they need destinations for all the generated power.

In the coming years, this challenge will intensify as optimal locations become utilised. Grids will also face increasing pressure from large volumes of electricity generation aligned with periods of sunlight.

4.3 Gradual import diversification

The NZIA benchmark of meeting, or getting close to, a certain proportion of deployment needs with domestic manufacturing disregards the costs of promoting self-sufficiency compared to the use of cheaper imports (Tagliapietra *et al* 2023a).

Regrettably, no impact assessment has been performed to evaluate whether disrupting imports of solar panels would harm or improve overall EU energy and economic security. Economic resilience is hampered more by a high concentration of imports rather than high overall import volumes (Welslau and Zachmann, 2023).

It will be difficult to immediately diversify imports given Chinese dominance; however, in the second half of this decade it will likely become easier as heavily subsidised supply will come online in the US.

The EU might also act by supporting those countries with a comparative advantage (eg. potential for cheap electricity), but which need to develop their manufacturing capacities (BloombergNEF, 2021). The EU's Global Gateway initiative to support green and digital infrastructure development in partner countries[28] could serves as a strategic tool in this respect.

With investment commitments of up to €300 billion by 2027, this initiative is geared towards establishing sustainable and resilient supply chains across various sectors, including ensuring access to critical raw materials essential for solar PV technologies.

Its main regional focus is on Africa, where the EU has already pledged a significant investment of €150 billion with the Africa-Europe Investment Package.

5 Innovation, rather than European content, should justify manufacturing subsidies

5.1 Risks of intervention justified by domestic content

The notion of economic resilience as a justification for solar PV manufacturing subsidies is questionable, but clearly drives current European public discourse on the issue.

For example, the NZIA foresees resilience criteria in public procurement, meaning that governments can explicitly penalise bids from outside of Europe by providing additional subsidies to bids that prove European content.

This would bring with it two risks. First, given that European producers are currently highly uncompetitive compared to their Chinese counterparts, any policy that limits the ability of foreign competition will increase solar panel prices. The effect is likely to be slower solar PV deployment and slower decarbonisation.

Second, such a policy risks creating an industry that is completely dependent on subsidies. There is no guarantee that European solar manufacturing will be competitive with foreign competition once subsidies expire.

This is especially the case with the current generation of solar panels, on which Chinese companies benefit from huge economies of scale. Instead, Europe must focus on innovation and developing the next generation of solar PV if it is to stand any chance of growing some market share.

5.2 Support innovation in manufacturing

The manufacture of solar cells is a fast-moving sector, in which innovation drives substantial change and there is still plenty of space for further innovation. Companies that lead and commercialise such innovation may be able to carve out market shares in future solar products.

The best chance for Europe to develop some solar leadership is to support innovation and the commercialisation of emerging solar technologies, including new semiconducting technologies such as perovskite (Box 2). The EU has an established tool for supporting early-stage innovation: the Innovation Fund. This fund receives its revenues from the EU emissions trading system, and its size is expressed in terms of permits.

Therefore, the recent rise in the price of permits from close to €20 per tonne of emissions to above €60 per tonne (reaching above €100 in early 2023) resulted in a substantial expansion of spending capacity. Part of this surge can be channelled toward new solar technologies.

Box 2. Innovation in solar cells

A solar cell contains a semiconductor material that transforms light energy into electrical energy. Innovations focus on how to enhance the efficiency of this transformation, and on reducing the cost and energy requirements of solar panel manufacture. Around 95 percent of today's solar panels use cells with a silicon-based semiconductor material. Typical innovations include adding layers of material to the cell to improve the absorption and conversion of light energy.

For instance, a major ongoing industry shift is toward TOPCon cells, in which an additional insulating layer enhances electrical conductivity. An advantage of TOPCon cells is that they essentially rely on the current manufacturing supply chain.

Silicon-based solar cells installed on houses are based on single-junction architecture, with one layer of semiconducting material. For applications involving space travel, multi-junction cells are used instead: these have multiple layers of semiconducting material, improving efficiency but at a much higher cost. A major challenge for the manufacturing process is to reduce these costs to make them commercially viable for use on Earth.

A perhaps more radical innovation is the use of new semiconductor material, such as perovskite. A range of layers including plastics, metals and glass can be coated with this crystal-based material. A current industry focus is to combine a layer of perovskite material with a silicon-based cell (known as a tandem cell). This has the potential to substantially improve efficiencies as its production requires much less energy than crystalline silicon PV cells. The technology is not yet commercialised, but Oxford PV aims to bring its manufacturing plant in Berlin soon online. Alternative cell designs include 'thin film' such as cadmium telluride. These cells are made by depositing thin layers of semiconductor material onto a base layer. First Solar runs an integrated thin-film facility in the US serving about 15 percent of the overall domestic solar market.

Several facilities currently under construction have received funding from the Innovation Fund. Projects are evaluated against five criteria: 1) effectiveness of reducing greenhouse-gas emissions, 2) degree of innovation, 3) project maturity, 4) replicability, and 5) cost efficiency.

Funding involves a competitive process against other clean technologies with the idea of ensuring that European public money is targeted to the most promising projects. The approach contrasts with that taken under the US Inflation Reduction Act, which allows all projects meeting broader criteria apply for tax credits. The EU approach maximises the chance that supported projects contribute to sustainable economic growth.

Other EU-level instruments also support early-stage innovation in clean technologies. The Horizon Europe research programme spearheads the EU's commitment to innovation with a €95.5 billion budget, emphasising climate and sustainability.

It includes the European Research Council (ERC) and the European Innovation Council (EIC) to nurture early-stage innovation. The ERC will allocate over €16 billion from 2021-2027 to pioneering research projects, while the EIC, with a €10.1 billion fund, offers startups and smaller companies financial backing through grants and equity, focusing on clean energy and smart technologies.

The European Institute of Innovation and Technology (EIT), supported by a €2.9 billion Horizon Europe budget, cultivates cross-sector partnerships for global challenges, with a significant portion dedicated to green industrial policy.

Reinforcing the EU's innovation ecosystem, the European Investment Bank (EIB) supports investments in clean energy, efficiency and renewables. In 2022, the EIB allocated €17.5 billion to transport and industrial sectors, with

€3.3 billion targeting clean technology projects and €10.4 billion for energy projects, including €4.4 billion for renewable energy.

Finally, InvestEU, an EU initiative to stimulate private investment in innovation and the green transition[29], has a €26.1 billion EU budget guarantee to stimulate private investment in strategic areas, including sustainable infrastructure and innovation (Tagliapietra *et al* 2023b).

European subsidies are less successful at growing new technologies from demonstration to commercial status (McWilliams and Zachmann, 2021). This is a problem as the cost of financing is higher for emerging technologies and often is not provided by the market.

Public support for the commercial growth of technologies that offer a radical advantage over the current generation of solar panels is more likely to lead to the development of economically sustainable industries in Europe.

Radically new technologies might enable a new start for a competitive, self-sustaining EU eco-system of cell manufacturing. Developing and bringing to scale next-generation panels could contribute to the goal of accelerating decarbonisation, within the EU, but, importantly, also beyond.

The deployment of much utility-scale solar PV across Europe is driven by government auctions or subsidies[30]. To stimulate innovation, governments might increase available subsidies if developers can demonstrate certain characteristics of the manufactured panels.

To further promote innovation, governments could offer enhanced subsidies or higher bid limits for developers that show their solar panels excel in, for example, peak efficiency, low-light performance, recyclability and energy input requirements.

Maximum bid prices or even separate auctions could be designed for developers who can prove the use of an innovative panel design. Similar criteria should drive any support offered by the EIB.

5.3 Support innovation in recycling

In the EU, solar recycling is a legal requirement under the Waste Electrical and Electronic Equipment Directive[31]. The directive sets minimum waste collection and recovery targets for different product categories. Solar panels are in a category of electronic waste with a target set at 85 percent for recovery and 80 percent for reuse and recycling.

Producers of solar PV panels are responsible for the disposal and recycling of the modules they sell in the EU. A scheme financed by panel manufacturers and importers funds the collection of end-of-life panels, with pilot recycling lines in certain countries.

Effective recycling reduces reliance on imported materials. The EU can play a role in scaling up this industry by expanding funding and support mechanisms. Initiatives such as those under Horizon Europe[32] and EIT RawMaterials Innovation Hub Central & West[33] are paving the way.

6 Conclusions

The approach under the NZIA of setting an indicative benchmark of about 40 percent for home production of different technologies raises significant concerns, which solar panels make plain. Supporting solar manufacturing

Box 3. Recycling of end-of-life solar panels

The most widespread solar-panel recycling technology recovers only the aluminium frame, copper-containing junction box and sometimes the front glass panel. The central technical hurdle is the high-purity separation of encapsulated materials, which is vital for the economic viability of the recycling process (Granata *et al* 2022).

The value of recovered materials varies, with silver, copper, silicon and tin being the most lucrative, particularly silver, which, despite its lower concentration, is valued 500 to 800 times more than tin and copper, making it a prime target for recycling. Silver content and processing volumes are key to the profitability of PV recycling: for panels with high silver concentration (0.2 percent), recycling is economically viable without fees at volumes above 18,000 tonnes per year; below this threshold, fees are necessary to cover up to 46 percent of costs (Granata *et al* 2022). Panels with only 0.05 percent silver require fees for profitability, unless processed volumes exceed 43,000 tonnes annually. Optimal returns on investment are tied to both the timing of investment and silver-market prices, with the best outcomes predicted for early investments at higher silver prices and substantial processing volumes.

Emerging recycling technologies aim to refine the separation process and enhance the recovery of glass, silicon and metals. These technologies can be generally divided into physical, thermal and chemical methods (Pereira *et al* 2023). Among these, the Advanced Photolife Process stands out, claiming over 80 percent material recovery through a combination of physical, thermal and chemical methods (Granata *et al* 2022).

purely for the sake of being European does not present clear advantages in terms of accelerated decarbonisation or increased economic growth.

Nor is the political focus on increasing economic resilience in this sector a valid justification for committing substantial public resources. Instead, more efficient strategies should be employed. Measures including accelerating solar deployment, stockpiling to ensure a buffer in a worst-case scenario and diversifying import sources offer more pragmatic approaches to mitigate threats to European economic security arising from solar PV imports. Manufacturing subsidies for the solar industry should prize innovation only. This criterion would ensure that funding would be directed toward technologies that offer genuine economic and climate benefits.

Finally, while a general over-reliance on imports from one country can be considered dangerous, the case of solar panels emphasises that an obsession with addressing this risk at individual product level is myopic. For the existing generation of mass-manufactured, energy-intensive solar panels, Europe will struggle to reclaim Chinese market share, and the case for trying is not well justified.

Europe can strengthen its economic resilience relative to China with an industrial policy that intervenes in sectors with greater potential to contribute to sustainable economic growth and alleviate decarbonisation bottlenecks. Examples include the manufacture of wind turbines or exploiting Europe's labour force and brand recognition for electric vehicles. Such an approach better leverages existing strengths and can contribute more effectively to the global push for clean energy. ■

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Endnotes

1. The EU currently has 110 GW coal-fired capacity, 180 GW natural gas fired capacity, and 105 GW nuclear capacity. Average hourly demand in 2022 was 320 GW.

2. See SolarPower Europe press release of 12 December 2023, 'New report: EU solar reaches record heights of 56 GW in 2023 but warns of clouds on the horizon'.

3. See Eurostat press release of 8 November 2023, 'International trade in products related to green energy'.

4. Agreement on the NZIA on 6 February 2024 requires ratification by the European Parliament and Council of the EU. See Council of the EU press release of 6 February 2024, 'Net-Zero Industry Act: Council and Parliament strike a deal to boost EU's green industry'.

5. Ivan Penn and Ana Swanson, 'Solar Company Says Audit Finds Forced Labor in Malaysian Factory', The New York Times, 15 August 2023.

6. Sandra Enkhardt, 'European solar manufacturers demand EU support', PV Magazine, 12 September 2023.

7. We discuss here the silicon manufacturing route, which is by far the most common today. Innovation in the sector may also see development of new supply chain routes, which we discuss in section 5.

8. Usha CV Haley and George T Haley, 'How Chinese Subsidies Changed the World', Harvard Business Review, 25 April 2013.

9. See European Commission memo of 4 June 2013, 'EU imposes provisional anti-dumping duties on Chinese solar panels'.

10. See European Commission press release of 2 December 2013, 'EU imposes definitive measures on Chinese solar panels, confirms undertaking with Chinese solar panel exporters'.

11. Jorge Valero, 'Commission scraps tariffs on Chinese solar panels', Euractiv, 31 August 2018.

12. See answer given by the European Commission to a European Parliament question on 'End of anti-dumping measures on imports of solar panels from China', 27 October 2018.

13. Levelised cost of energy (LCOE) refers to a calculation of the average cost per unit of electricity generated by a particular energy source, such as solar PV, over its operational lifetime. It takes into account all the costs associated with

the energy system – initial investment, operations, maintenance, the cost of fuel and the system's expected lifetime. The LCOE enables comparison of different energy technologies on a consistent basis. In this context, 'LCOE for solar PV' refers to the cost of generating electricity using solar PV technology.

14. See US Department of Commerce press release of 18 August 2023, 'Department of Commerce Issues Final Determination of Circumvention Inquiries of Solar Cells and Modules from China'.

15. Marco de Jonge Baas, 'Noorse waferfabrikant Norwegian Crystals failliet', Solar Magazine, 29 August 2023.

16. Valerie Thompson, 'Norsun announces temporary wafer production halt, layoffs', PV Magazine, 8 September 2023.

17. Kate Abnett, 'Europe's solar panel manufacturers ask EU for emergency support', Reuters, 30 January 2024.

18. Henning Jauernig, Benedikt Müller-Arnold, Stefan Schultz und Gerald Traufetter, 'Der deutsche Solarboom hängt an Chinas Tropf – kann das gut gehen?' Der Spiegel, 27 October 2023.

19. Trade measures would "would injure the EU solar sector to the detriment of the EU's own green energy transition at a critical moment in time". See SolarPower Europe statement of 29 November 2023.

20. See Rystad Energy press release of 20 July 2023, 'Europe hoarding Chinese solar panels as imports outpace installations; €7 billion sitting in warehouses'.

21. This is exactly what the EU is currently investigating Chinese electric vehicles for. An anti-dumping investigation is seeking to determine whether the Chinese state provides excessive support for automobile exports, leading to unfair competition with EU products. See European Commission press release of 4 October 2023, 'Commission launches investigation on subsidised electric cars from China'.

22. The suspension of the EU-China Comprehensive Agreement on Investment (CAI) serves as a pertinent example of how concerns over forced labour can impact trade flows between the two countries. The CAI negotiations, which started in 2014 and concluded in December 2020, faced significant challenges because of concerns over forced labour, particularly in Xinjiang. Following EU sanctions against Chinese officials for human-rights violations, China imposed retaliatory sanctions on EU entities and officials. In May 2021, the European Parliament voted to suspend the ratification of the CAI, as long as China's sanctions remain in place.

23. Much uncertainty surrounds this number. S&P Global reported industry estimates at 45 GW in August 2023; see Camilla Naschert, 'Glut of inexpensive solar panels in Europe boosts project economics', S&P Global, 21 August 2023. Rystad Energy made multiple estimates in 2023, ranging between 40 GW and 80 GW.
24. See IEA website: https://www.iea.org/reports/oil-security-policy.
25. 20 GW is an upper-bound estimate for three months EU deployment. The authors assume a typical solar panel of 1.5 square metres and 300 W capacity. They assume that the cost of storage is €50 per square metre, insurance costs are 1 percent of the value of stored panels, and overhead costs at 20 percent of storage and insurance cost. Finally, it is assumed that solar panels can be stacked 15 rows high in a warehouse. For estimates of the storage cost in Europe, see https://ecommercenews.eu/warehouse-storage/ and https://www.statista.com/statistics/527840/warehouse-primary-rent-cost-logistics-market-france-europe/.
26. With a subsidy rate of €0.10 per watt.
27. The EU Solar Strategy cites required 45 GW capacity, but this is given in AC terms. Assuming a conversion factor of 1.2 to account for the DC conversion, this figure translates to approximately 54 GW in DC terms.
28. See European Commission Global Gateway webpage.
29. See https://investeu.europa.eu/index_en.
30. See IEA, https://www.iea.org/data-and-statistics/charts/europe-solar-and-wind-forecast-by-policy-and-procurement-type-2023-2024.
31. See the European Commission Waste from Electrical and Electronic Equipment (WEEE) webpage.
32. See European Commission CORDIS webpage.
33. See EIT RawMaterials webpage.

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