THE ROAD TO

Net Zero

SUMMER 2023

PETROS FASSOULAS AND AIMÉE DUPRAT-MACABIES ARGUE FOR GREEN POLICIES TO BUILD A JUST ECONOMY

BERG *ET AL* SUGGEST A ROLE FOR FINANCIAL REGULATION IN THE TRANSITION TO A SUSTAINABLE FUTURE

CHRISTOPHER WALLER EXPLORES FINANCIAL RISKS ASSOCIATED WITH CLIMATE CHANGE

SUSTAINABLE DEVELOPMENT

Foreword

Welcome to the Summer 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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Navigating uncertainty

Petros Fassoulas and Aimée Duprat-Macabies stress the importance of social and green policies to build a just and resilient European economy

The pandemic health crisis, coupled with Russia's invasion of Ukraine, has cast a long shadow over European societies and economies. As the digital and green transitions reshape everything around us, it is imperative for the European Union to support its citizens in adapting to this changing reality.

This article emphasises the need for social and green policies that prioritise the wellbeing of individuals, address inequalities, and promote sustainable development. These recommendations align with the outcomes of the Conference on the Future of Europe, reflecting the collective voice of EU citizens, civil society, and social partners.

Economic challenges and labour market transformation

The EU is facing an uncertain economic outlook due to the side effects of the COVID-19 pandemic, the conflict in Ukraine, rising inflation, and a looming debt crisis. These crises have resulted in job losses, increased youth unemployment, and job insecurity. Despite positive productivity growth, real wages have stagnated or even declined in recent years.

To prevent this situation from leading to structural unemployment, it is crucial for the EU and national governments to provide short-term incentives that prevent long-lasting negative economic effects.

The EU must seize this opportunity to transition to a new model of growth that prioritises environmental sustainability and climate action. Redistributive measures, quality employment, robust social protection systems, and accessible quality services for all are vital components of this transition.

Replacing GDP as the sole indicator of prosperity with comprehensive metrics that encompass wellbeing, human rights, gender equality, and environmental protection is a crucial step in this direction.

The concept of the just transition should extend beyond specific regions and sectors, addressing the root causes of complex inequalities in Europe. Sectors most affected by the transition, such as mobility, transport, and construction, have predominantly male workforces, while sectors with predominantly female workforces are often overlooked.

The European Union stands at a critical juncture, grappling with the aftermaths of the health crisis, geopolitical tensions, and economic uncertainties. Urgent action is required to navigate these challenges and ensure a just and sustainable future

The EU should conduct a detailed analysis to identify other sectors that can contribute to a just transition, such as health, care, and education, which are already low-carbon and beneficial to society and nature.

Education and skills at the heart of the new model

The economic downturn has coincided with a growing number of unfilled job vacancies, potentially hindering key EU strategic priorities such as the European Green Deal. Reskilling programs and further education initiatives are essential for equipping workers, particularly those from vulnerable groups, with the necessary skills to adapt to the evolving labour market.

It is imperative to broaden the definition of 'frontline workers' to include sectors beyond the traditional ones and ensure their inclusion in relevant employment protections.

Education plays a vital role in fighting inequalities, promoting social mobility, and unlocking human potential. The EU should ensure that education aligns with the needs of the economy, facilitating job matching through adequate training programs.

Continued vocational education and training (VET) are essential in responding to structural changes in the labour market. Strengthening multistakeholder platforms like the European Alliance for Apprenticeship (EAfA) and increasing investments in vocational education will contribute to upskilling the workforce and fostering inclusivity.

To adapt to emerging opportunities in an evolving landscape, individuals need technical and transversal skills and the ability to continue learning throughout their careers. Dedicated funding should prioritise disadvantaged young people and ensure ongoing skills relevance and upskilling throughout their lifecycles.

Access to digital education programs, the teaching of digital skills, and awareness campaigns on the consequences of digitalisation and social media for democracy should also be enhanced.

The digital world must align with offline regulations

The shift to remote work during the pandemic has been significant and is likely to persist in the future. Consequently, we should adapt existing working rules and safeguards to encompass remote work conditions. This includes transposing non-remote working regulations into remote working frameworks to ensure equal protection for workers.

It is essential to consider the potential consequences of increased digitalisation, such as the deepening of the digital divide, invasion of privacy, and the blurring of work-life boundaries. In that regard, social partners are very important in shaping and implementing key digital rights, such as the right to disconnect, through collective bargaining.

Platform work has also rapidly gained prominence in recent years, particularly among younger workers, but often lacks adequate protection and rights compared to traditional employment.

We need clear criteria to differentiate between self-employment and false self-employment because all platform workers should have access to social rights and protection, while minimum standards should be set for those who may not qualify as employees.

Transparent algorithms, fair working conditions, and accessible redress mechanisms are essential components to safeguard the rights of platform workers.

Civil society and social partners have a key role to play

Ensuring robust social and civil dialogues at all levels of governance remains pivotal in shaping decisions related to employment, industrial relations, and social standards across industries and sectors within the European Union. The principle of non-discrimination and the universal right of association for workers, irrespective of their sector, must be upheld.

Key principles such as subsidiarity, proportionality, and the autonomy of social dialogue should be respected to protect EU social standards and workers' rights. Employers and trade unions, being intimately acquainted with labour market needs, should be equipped with the necessary means and tools to proactively anticipate changes and ensure the EU's central economic role while upholding the social acquis.

It is vital to safeguard fundamental rights and avoid any erosion of workplace standards or protections during emergency situations such as the COVID-19 pandemic and conflicts like the one in Ukraine.

While acknowledging the progress made in EU social and labour policies, it is crucial to extend support to vulnerable populations, including the long-term unemployed, Roma people, and migrants, who face multiple barriers to employment.

Civil dialogue, along with consistent consultation of civil society organisations representing marginalised groups, must be a core component of policy implementation. Efforts should focus on combatting discrimination in European labour markets, with labour and social legal instruments incorporating anti-discriminatory measures and affirmative actions.

Labour market policies should adopt a comprehensive, human rights-based, and person-centred approach. Commitment to the principle of co-determination in labour relations, facilitating collaboration between employers and employees in shaping working conditions, is essential.

Protecting and supporting the youth

The COVID-19 crisis has disproportionately affected young people, negatively impacting their employment prospects, income, educational outcomes, and mental health. Disturbingly, two-thirds of Europe's youth may now experience depression or anxiety, with marginalised youth facing the harshest consequences.

Policymakers must prioritise developing recovery plans that address the long-term impacts on young people, ensuring an intersectional approach to tackle the specific challenges faced by various youth groups.

Meaningful participation of young people and youth organisations is critical in shaping these plans. Enhancing the successful transition from education to employment, particularly for those graduating in the upcoming years, is imperative.

In addition, access to mental health and wellbeing support for young people should be expanded, recognising the relationship between socio-economic factors and mental health outcomes.

The EU should strengthen job creation schemes that offer quality employment opportunities for young people and contribute to their overall wellbeing.

Implementing dedicated quality standards at the European level will be instrumental in ensuring the success of programs such as the EU Youth Guarantee, while advocating for a ban on unpaid internships should be pursued.

Conclusion

The European Union stands at a critical juncture, grappling with the aftermaths of the health crisis, geopolitical tensions, and economic uncertainties. Urgent action is required to navigate these challenges and ensure a just and sustainable future.

It is imperative for the EU to prioritise the wellbeing of its citizens and the planet through the implementation of social and green policies.

Moreover, the EU must recognise the crucial role of civil society, social partners, and youth organisations in shaping policies and decisions. Genuine dialogue and collaboration are essential to build consensus and ensure that recovery measures leave no one behind.

EU policymakers, senior executives, and policy players should heed these recommendations and make the necessary commitments to drive transformative change.

Together, let us forge a path towards a fair and inclusive Europe, where prosperity, sustainability, and social justice go hand in hand. Only by working together can we build a resilient future for all. ■

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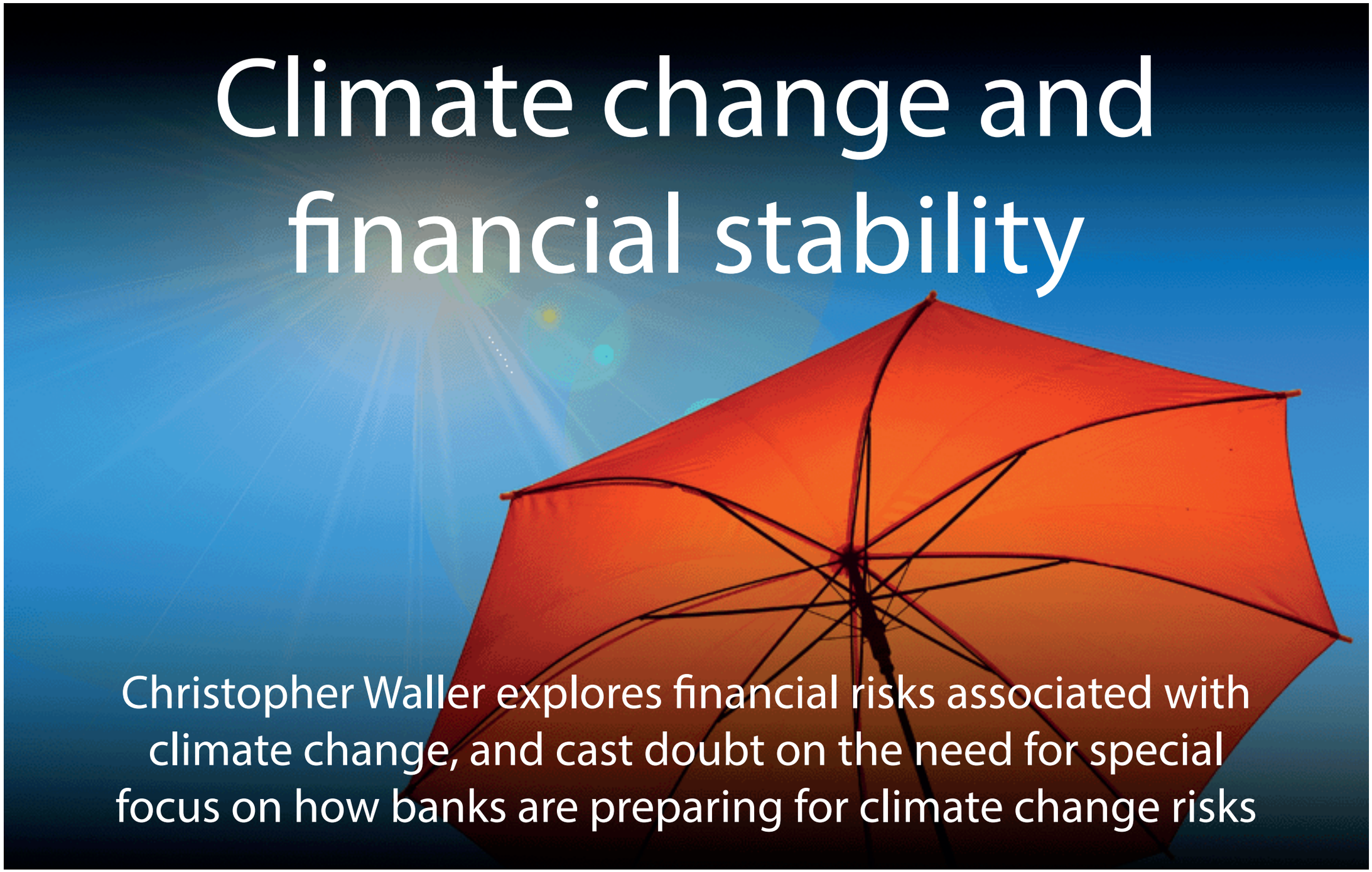
Climate change and financial stability



Christopher Waller explores financial risks associated with climate change, and cast doubt on the need for special focus on how banks are preparing for climate change risks

Climate change is real, but I do not believe it poses a serious risk to the safety and soundness of large banks or the financial stability of the United States[1]. Risks are risks. There is no need for us to focus on one set of risks in a way that crowds out our focus on others. My job is to make sure that the financial system is resilient to a range of risks. And I believe risks posed by climate change are not sufficiently unique or material to merit special treatment relative to others[2]. Nevertheless, I think it's important to continue doing high-quality academic research regarding the role that climate plays in economic outcomes.

In what follows, I want to be careful not to conflate my views on climate change itself with my views on how we should deal with financial risks associated with climate change. I believe the scientific community has rigorously established that our climate is changing. But my role is not to be a climate policymaker.

Consistent with the Fed's mandates, I must focus on financial risks, and the questions I'm exploring are about whether the financial risks associated with climate change are different enough from other financial stability risks to merit special treatment. But before getting to those questions, I'd like to briefly explain how we think about financial stability at the Federal Reserve.

Financial stability is at the core of the Federal Reserve and our mission. The Federal Reserve was created in 1913, following the Banking Panic of 1907, with the goal of promoting financial stability and avoiding banking panics. Responsibilities have evolved over the years.

In the aftermath of the 2007-09 financial crisis, Congress assigned the Fed additional responsibilities related to promoting financial stability, and the Board of Governors significantly increased the resources dedicated to that purpose.

Events in recent years, including the pandemic, emerging geopolitical risks, and recent stress in the banking sector have only highlighted the important role central banks have in understanding and addressing financial stability risks.

The Federal Reserve's goal in financial stability is to help ensure that financial institutions and financial markets remain able to provide critical services to households and businesses so that they can continue to support a well-functioning economy through the business cycle.

I believe that placing an outsized focus on climate-related risks is not needed, and the Federal Reserve should focus on more near-term and material risks in keeping with our mandate

Much of how we think about and monitor financial stability at the Federal Reserve is informed by our understanding of how shocks can propagate across financial markets and affect the economy. Economists have studied the role of debt in the macroeconomy dating all the way back to Irving Fisher in the 1930s, and in the past 40 years it has been well established that financial disruptions can reduce the efficiency of credit allocation and have real effects on the broader economy[3].

When borrowers' financial conditions deteriorate, lenders tend to charge higher rates on loans. That, in turn, can lead to less overall lending and negatively affect the broader economy[4]. And in the wake of the 2007-09 financial crisis, we've learned more about the important roles credit growth and asset price growth play in 'boom-bust' cycles[5].

Fundamentally, financial stress emerges when someone is owed something and doesn't get paid back or becomes worried they won't be paid back. If I take out a loan from you and can't repay it, you take a loss. Similarly, if I take out a mortgage from a bank and I can't repay it, the bank could take a loss. And if the bank hasn't built sufficient ability to absorb those losses, it may not be able to pay its depositors back.

These dynamics can have knock-on effects on asset prices. For example, when people default on their home mortgage loans, banks foreclose and seek to sell the homes, often at steep discounts. Those foreclosure sales can have contagion effects on nearby house prices[6].

When a lot of households and businesses take such losses around the same time, it can have real effects on the economy as consumption and investment spending take a hit and overall trust in financial institutions wanes. The same process works when market participants fear they won't be paid back or be able to sell their assets. Those fears themselves can drive instability.

The implication is that risks to financial stability have a couple of features. First, the risks must have relatively near-term effects, such that the risk manifesting could result in outstanding contracts being breached. Second, the risks must be material enough to create losses large enough to affect the real economy.

These insights about vulnerabilities across the financial system inform how we think about monitoring financial stability at the Federal Reserve. We identify risks and prioritize resources around those that are most threatening to the US financial system. We distinguish between shocks, which are inherently difficult to predict, and vulnerabilities of the financial system, which can be monitored through the ebb and flow of the economic cycle.

If you think about it, there is a huge set of shocks that could hit at any given time. Some of those shocks do hit, but most do not. Our approach promotes general resiliency, recognizing that we can't predict, prioritize, and tailor specific policy around each and every shock that could occur[7].

Instead, we focus on monitoring broad groups of vulnerabilities, such as overvalued assets, liquidity risk in the financial system, and the amount of debt held by households and businesses, including banks. This approach implies that we are somewhat agnostic to the particular sources of shocks that may hit the economy at any point in time.

Risks are risks, and from a policymaking perspective, the source of a particular shock isn't as important as building a financial system that is resilient to the range of risks we face. For example, it is plausible that shocks could stem from things ranging from increasing dependence on computer systems and digital technologies to a shrinking labour force to geopolitical risk.

Our focus on fundamental vulnerabilities like asset overvaluation, excessive leverage, and liquidity risk in part reflects our humility about our ability to identify the probabilities of each and every potential shock to our system in real time.

Let me provide a tangible example from our capital stress test for the largest banks. We use that stress test to ensure banks have sufficient capital to withstand the types of severe credit-driven recessions we've experienced in the United States since World War II[8].

We use a design framework for the hypothetical scenarios that results in sharp declines in asset prices coupled with a steep rise in the unemployment rate, but we don't detail the specific shocks that cause the recession because it isn't necessary. What is important is that banks have enough capital to absorb losses associated with those highly adverse conditions.

And the losses implied by a scenario like that are huge: last year's scenario resulted in hypothetical losses of more than $600 billion for the largest banks. This resulted in a decline in their aggregate common equity capital ratio from 12.4 percent to 9.7 percent, which is still more than double the minimum requirement.

That brings us back to my original question: Are the financial risks stemming from climate change somehow different or more material such that we should give them special treatment? Or should our focus remain on monitoring and mitigating general financial system vulnerabilities, which can be affected by climate change over the long-term just like any number of other sources of risk? Before I answer, let me offer some definitions to make sure we're all talking about the same things.

Climate-related financial risks are generally separated into two groups: physical risks and transition risks. Physical risks include the potential higher frequency and severity of acute events, such as fires, heatwaves, and hurricanes, as well as slower moving events like rising sea levels.

Transition risks refer to those risks associated with an economy and society in transition to one that produces less greenhouse gases. These can owe to government policy changes, changes in consumer preferences, and technology transitions.

The question is not whether these risks could result in losses for individuals or companies. The question is whether these risks are unique enough to merit special treatment in our financial stability framework.

Let's start with physical risks. Unfortunately, like every year, it is possible we will experience forest fires, hurricanes, and other natural disasters in the coming months. These events, of course, are devastating to local communities. But they are not material enough to pose an outsized risk to the overall US economy.

Broadly speaking, physical risks could affect the financial system through two related channels. First, physical risks can have a direct impact on property values. Hurricanes, fires, and rising sea levels can all drive down the values of properties. That in turn could put stress on financial institutions that lend against those properties, which could lead them to curb their lending, and suppress economic growth.

The losses that individual property owners can realize might be devastating, but evidence I've seen so far suggests that these sorts of events don't have much of an effect on bank performance[9]. That may be in part attributable to banks and other investors effectively pricing physical risks from climate change into loan contracts.

For example, recently researchers have found that heat stress—a climate physical risk that is likely to affect the economy—has been priced into bond spreads and stock returns since around 2013[10]. In addition, while it is difficult to isolate the effects of weather events on the broader economy, there is evidence to suggest severe weather events like hurricanes do not likely have an outsized effect on growth rates in countries like the United States[11].

Over time, it is possible some of these physical risks could contribute to an exodus of people from certain cities or regions. For example, some worry that rising sea levels could significantly change coastal regions.

While the cause may be different, the experience of broad property value declines is not a new one. We have had entire American cities that have experienced significant declines in population and property values over time.

Take, for example, Detroit. In 1950, Detroit was the fifth largest city in the United States, but now it isn't even in the top 20, after losing two-thirds of its population. I'm thrilled to see that Detroit has made a comeback in recent years, but the relocation of the automobile industry took a serious toll on the city and its people.

Yet the decline in Detroit's population, and commensurate decline in property values, did not pose a financial stability risk to the United States. What makes the potential future risk of a population decline in coastal cities different?

Second, and a more compelling concern, is the notion that property value declines could occur more-or-less instantaneously and on a large scale when, say, property insurers leave a region en masse. That sort of rapid decline in property values, which serve as collateral on loans, could certainly result in losses for banks and other financial intermediaries.

But there is a growing body of literature that suggests economic agents are already adjusting behaviour to account for risks associated with climate change[12]. That should mitigate the risk of these potential 'Minsky moments'[13].

For the sake of argument though, suppose a great repricing does occur; would those losses be big enough to spill over into the broader financial system? Just as a point of comparison, let's turn back to the stress tests I mentioned earlier.

Each year the Federal Reserve stresses the largest banks against a hypothetical severe macroeconomic scenario. The stress tests don't cover all risks, of course, but that scenario typically assumes broad real estate price declines of more than 25 percent across the United States.

In last year's stress test, the largest banks were able to absorb nearly $100 billion in losses on loans collateralized by real estate, in addition to another half a trillion dollars of losses on other positions[14].

What about transition risks? Transition risks are generally neither near-term nor likely to be material given their slow-moving nature and the ability of economic agents to price transition costs into contracts. There seems to be a consensus that orderly transitions will not pose a risk to financial stability[15]. In that case, changes would be gradual and predictable.

Households and businesses are generally well prepared to adjust to slow-moving and predicable changes. As are banks. For example, if banks know that certain industries will gradually become less profitable or assets pledged as collateral will become stranded, they will account for that in their loan pricing, loan duration, and risk assessments.

And, because assets held by banks in the United States reprice in less than five years on average, there is ample time to adjust to all but the most abrupt of transitions[16].

But what if the transition is disorderly? One argument is that uncertainty associated with a disorderly transition will make it difficult for households and businesses to plan. It is certainly plausible that there could be swings in policy, and those swings could lead to changes in earnings expectations for companies, property values, and the value of commodities.

But policy development is often disorderly and subject to the uncertainty of changing economic realities. In the United States, we have a long history of sweeping policy changes ranging from revisions to the tax code to things like changes in healthcare coverage and environmental policies. While these policy changes can certainly affect the composition of industries, the connection to broader financial stability is far less clear.

And when policies are found to have large and damaging consequences, policymakers always have, and frequently make use of, the option to adjust course to limit those disruptions.

There are also concerns that technology development associated with climate change will be disorderly. Much technology development is disorderly. That is why innovators are often referred to as 'disruptors'.

So, what makes climate-related innovations more disruptive or less predictable than other innovations? Like the innovations of the automobile and the cell phone, I'd expect those stemming from the development of cleaner fuels and more efficient machines to be welfare-increasing on net.

So where does that leave us? I don't see a need for special treatment for climate-related risks in our financial stability monitoring and policies. As policymakers, we must balance the broad set of risks we face, and we have a responsibility to prioritize using evidence and analysis.

Based on what I've seen so far, I believe that placing an outsized focus on climate-related risks is not needed, and the Federal Reserve should focus on more near-term and material risks in keeping with our mandate. ■

Christopher J Waller is a member of the Board of Governors of the Federal Reserve System

Endnotes

1. The views expressed here are my own and are not necessarily those of my colleagues on the Federal Reserve Board.

2. While the actions the Federal Reserve has taken to date are mostly in an exploratory spirit, they could lead to the perception that we intend to give climate change special treatment in the future. For example, recent actions include the organization of a Supervision Climate Committee and a Financial Stability Climate Committee, the issuance of Principles for Climate-Related Financial Risk Management for Large Financial Institutions in December 2022, and the pilot Climate Scenario Analysis exercise initiated with the issuance of scenarios in January 2023.

3. For example, Bernanke (1983) showed how financial disruptions can reduce the availability of credit and reduce aggregate demand, and Diamond and Dybvig (1983) showed how bank runs can affect the real economy.

4. In their articulation of the financial accelerator, Bernanke, Gertler, and Gilchrist (1999) demonstrate concepts like this. Return to text

5. For example, see Schularick and Taylor (2012); Jorda, Schularick, and Taylor (2013); and Kiley (2021).

6. For example, Harding, Rosenblatt, and Yao (2009) identify a contagion discount on properties close to foreclosed properties.

7. There are also unanticipated risks, which makes it all the more important to be comprehensive and effective in mitigating known risks.

8. The conditions characterized by severe post-war recessions with steep rises in unemployment rates and declining asset prices tend to put significant stress on the balance sheets of the largest banks, making them well suited for a capital stress test.

9. Blickle, Hamerling, and Morgan (2021) study FEMA disasters and find that they have an insignificant or small effect on U.S. banks' performance.

10. See Acharya, Johnson, Sundaresan, and Tomunen (2022).

11. See Linder, Peach, and Stein (2013) for a study of the effect of Hurricane Sandy on the economy.

12. For example, in addition to the previously mentioned Acharya et al paper, in a recent paper Meisenzahl (2023) shows that banks have reduced lending in areas more affected by climate change.
13. Based on the work of economist Hyman Minsky, this is the sudden onset of a market crash when sentiment shifts following a period of rapid speculative growth.
14. Total losses were $612 billion, of which losses on first-lien mortgages, home equity, and commercial real estate loans were $98.8 billion. See https://www.federalreserve.gov/publications/files/2022-dfast-results-20220623.pdf
15. In their reports on climate-related risks to the financial system, both the Financial Stability Board (2020) and the Financial Stability Oversight Council (2021) indicate that risks to the financial system associated with an orderly transition are most likely contained.
16. Drechsler, Savov, and Schnabl (2021) estimated the average asset repricing maturity between 1997 and 2013 was 4.23 years

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This article is based on a speech delivered at the IE University – Banco de España – Federal Reserve Bank of St. Louis Conference 'Current Challenges in Economics and Finance', Madrid, Spain, May 11, 2023.

Climate regulation and financial risk

Berg *et al* argue that it would be welfare-enhancing if policy changes were to follow a predictable longer-term path, and suggest a role for financial regulation in the transition

Climate risk has become a major concern for financial institutions and financial markets. Yet, climate policy is still in its infancy and contributes to increased uncertainty. For example, the lack of a sufficiently high carbon price and the variety of definitions for green activities lower the value of existing and new capital, and complicate risk management.

This column argues that it would be welfare-enhancing if policy changes were to follow a predictable longer-term path. Accordingly, the authors suggest a role for financial regulation in the transition.

Transitioning to a carbon-neutral economy requires structural changes. Fossil fuel-based energy needs to be replaced by renewable alternatives (eg. wind and solar), and high-carbon activities such as heating need to be transformed (IEA 2021).

Public debate and academic contributions have been focusing on ways to implement the low-carbon transition (NGFS 2019), on the financial costs of a late transition (Alogouskofis *et al* 2021), and on the benefits of early action (Gourdel *et al* 2022). The debate is increasingly relevant for financial stability analysis and risk management (BIS 2021).

For example, to inform climate stress tests, the Network for Greening the Financial System (NGFS) has developed climate scenarios showing higher costs and risks for high-carbon activities, in particular in a late or disorderly transition (NGFS 2021).

While these scenarios take carbon taxation into account, they fail to consider how changes in financial regulation, both over time and across constituencies, affect financial valuations and investment levels.

Absent a coherent climate regulatory strategy, financial institutions and markets may not perform efficiently, as their role in reallocating funds and managing risks may be severely impaired.

This should not be seen as a surprise: policy uncertainty adds risks, increasing the cost of capital for green investments and thus the value of postponing adjustments (Castellini *et al* 2021).

Absent a coherent climate regulatory strategy, financial institutions and markets may not perform efficiently, as their role in reallocating funds and managing risks may be severely impaired

Regulatory uncertainty and risk assessment

A set of climate policies such as a carbon tax and environmental and financial regulation, preferably coordinated globally, is needed to send the right signals to investors and elicit an effective response (Stiglitz *et al* 2017). However, these are slow in the coming. Drivers of this policy uncertainty and limited coordination include:

- Swinging perception of climate risks by policymakers, also due to swings in public opinion (eg. the gilet jaunes demonstrations in France, presidential succession in the US)
- New climate-related information reflecting availability of new data and improved methodologies, as well as the availability of new technologies that alter economic and policy trade-offs
- The global dimension of climate policy and the difficulties to reach consensus[1]
- Exogenous shocks, such as the current energy price crisis, which may inadvertently increase the attractiveness of regenerative energy sources or, by contrast, divert policies from formerly envisaged path of transition
- Poor quality of corporate carbon risk disclosure leading to unfair competitive advantage and greenwashing possibilities[2], as well as different disclosure coverage at the regional and global level, contributing to contradictory and ambiguous information to investors[3]

Implications of policy uncertainty for investments and risk management

As argued above, policy uncertainty tends to increase the cost of capital as far as the transition is concerned, negatively affecting the willingness (but also the ability) of investors to fund low-carbon activities in a variety of ways.

First, policy uncertainty has direct consequences for investment valuation as it bears negatively on net present values. The more volatile green policy measures, the lower their impact on investment decisions – and the lower the green investment levels in the economy.

Second, by fostering uncertainty throughout, delays in climate policy decisions contribute to a scarcity of green assets, so that a sudden swing in demand may trigger commensurate green asset price increases (Demekas and Grippa 2021).

Once the transition occurs, and green assets are more plentiful with technology at scale, a decrease in green asset prices might follow. Hence, uncertain climate policies may induce destabilizing swings in the prices of green assets over time.

As uncertainty contributes to delay the transition towards low-carbon real activities, market pressure to move towards greener technologies will remain limited. If a transition occurs unexpectedly, high-carbon firms will have stranded assets on their balance sheet (Mercure *et al* 2018) and losses in the P&L statement. This, in turn, may translate into credit risk for financial institutions funding them (Battiston *et al* 2017).

Third, policy uncertainty affects risk assessment at the level of financial institutions, which therefore may:

- Assume that others, including governments, will do what is needed in the public interest – so there is no need to act on their side

- Underestimate the systemic spillovers from joint or concentrated exposures to, or fire-sales of, stranded assets

- Ignore – or even encourage – the migration of activities to less-regulated parts of the world and financial markets

The upshot is that policy uncertainty may result not only in a slower-than-necessary green transition, but also in higher risk of financial instability.

A secondary effect operates via a reduced willingness of financial institutions to fund the low-carbon transition, generating a negative feedback loop as the delay in the transition may raise financial instability (Battiston *et al* 2021).

Conclusions: the need for policymakers to act now

Is there a way to lower policy uncertainties so that greening investment decisions can take place rapidly and with large impact? What role should financial regulators and supervisors play?

We argue that these actors, and in general all relevant policymakers, should devote sufficient resources to assessing the implications of policy uncertainty for individual and systemic financial risk, and reflect on the implications of such uncertainty on the financial system.

There is surprisingly little discussion about the role of policy uncertainty as a potential source of idiosyncratic and systemic risk for financial markets. This is where supervisory institutions and central banks should play a more active role.

A systematic analysis of how various policy decisions (eg. carbon tax, banking regulation, subsidies, environmental regulation) – and in particular their variability over time – influence corporate investment decisions and bank

lending conditions could better inform policymakers about the costs of discretionary climate actions and policy volatility, and the related trade-offs.

In particular, policymakers that regulate financial markets and intermediaries could reduce transition risk by following a few basic principles:

- They should strive to render climate-related rules impactful, by making them stable over time, credible in implementation, and predictable in evolution. For the sake of price stability, policy changes should be predictable and not easily reversable.

  For credibility, policy changes should be impactful rather than cosmetic. For predictability, rule changes should follow a particular direction, say, increasing the carbon price steadily. To this aim, benchmarking for all three characteristics (stability, credibility, predictability) should be used.

- Rule setting by policymakers and regulators should explicitly consider the impact new rules and regulations could have on (a) existing capital in place, and (b) new investments in high- and low-carbon activities. The asset price effects of rule setting are the driving force of corporate adjustment towards a net zero economy, and an explicit consideration of opportunity costs can help to improve the effectiveness of rule setting.

- Finally, to enhance the effectiveness of climate policymaking, policymakers should take into account expectation formation by financial industry participants, via transparency about (a) climate-related impact of investment (eg. by supporting data standardization, comprehensive collection, full disclosure), and (b)

the longer-term policy agenda (e.g. rule changes), encompassing the international/global dimension of this agenda. ■

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Endnotes

1. An example is the UNFCCC COP27 conference held in Sharm-el-Sheik in 2022.

2. For instance, in the transport sector, Scope 3 emissions represent more than 90% of total emissions but are rarely reported, or when reported the quality varies greatly from firm to firm with differences of also 30 times in values across companies (Bressan et al 2022).

3. For instance, while the SEC is eager to leave Scope 3 emissions out of firms' disclosure efforts, both the European Financial Reporting Advisory Group (EFRAG) in charge of updating the European Sustainability Reporting Standards (ESRS), and the International Sustainability Standards Board (ISSB), require Scope 3 emissions disclosure in accordance with the GHG emissions Protocol. Scope 3 emissions cover emissions through corporate's upstream and downstream value chain (eg. suppliers and distributors), business travel, leased assets, and financial exposures through financial contracts (equity and debt).

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Climate action: approaching a tipping point?

Sarah Breeden reflects that we haven't yet reached the tipping point in an unavoidably uncertain transition. Governments, business, finance and central banks all have unique roles to play to get us there

I am going to reflect on our collective progress in the transition to net zero. It is timely to do so. The latest IPCC synthesis report provides yet another stark warning of the impact that climate change will have on our planet. We are now a third of the way through the decisive decade; a decade where we will need to cut global emissions by over 40%, if we hope to limit warming to 1.5C[1]. And yet global CO_2 emissions continue to rise[2].

For us to meet this challenge we need to collaborate and to take individual responsibility for the role we each play.

For the Government, it is to set out the pathway to net zero. For each of you – and the firms you represent – it is to apply those pathways in boardroom decisions; decisions that will not only help facilitate an orderly transition, but also help ensure the long-term relevance and value of the companies you lead.

For the finance sector, it is to support and enable that transition. And for the Bank of England, it is to work within its objectives to ensure the financial system is resilient to the risks from climate change and supportive of the transition to net zero.

With that in mind, I wanted to reflect on a speech I delivered in 2020 on how to move beyond rhetoric to make climate action a reality.

I had split our journey into three phases. Firstly, recognising and identifying the financial risks climate changes poses. Secondly, building capabilities to enable us to turn aspiration into action. And thirdly, making business decisions to advance the transition.

With almost three years passed, I want now to evaluate our progress, identify the barriers we have encountered, and consider what else is needed if we are to progress.

Back in 2020, I suggested that we had probably achieved the first phase of our journey to net zero. Conversations with leaders in the financial sector made it increasingly clear that climate change is central to the future of their businesses, not just the confines of Corporate Social Responsibility departments.

It is difficult, but essential, for real economy and financial firms to make transition-driven business decisions in the absence of complete clarity on our pathway to net zero

I suggested we had entered the difficult second phase of turning aspiration into action, across the financial sector and the real economy. This phase involves a lot of hard work: the collection of data and the building of new tools that better enable climate considerations to be embedded in strategy and risk management.

And I finished with a hope that we were fast approaching the third and final phase – with these tools actively used in financial and business decisions to progress an orderly transition to net zero.

Since then, a global pandemic, a war and the fastest tightening in financial conditions in thirty years have meant that things have not panned out as we might have expected. Let's take stock of where that has left us.

Taking stock

My prism on this is as a central banker and regulator, where we have good sight of how the UK's banks and insurers are building their approaches to climate risks. These firms sit at the centre of the economy, and their responses matter.

I have seen a step-change in their approach. They are making more serious investments in developing effective capabilities – both to manage climate-related financial risks and to identify opportunities. But are they enough?

Let me explore this across four core dimensions: scenario analysis: firm risk management capabilities; disclosure; and green finance.

Learning from scenario analysis

I'll start first with scenario analysis - an essential tool for understanding the size and pathways of unprecedented and uncertain future climate risks.

The Bank has delivered its first climate scenarios exercise, the CBES. In my view this was transformative, both in shining a light on otherwise opaque risks and in building capabilities.

Importantly, the exercise required firms to understand how their real economy customers were both exposed to these risks and the actions they would take to manage them. This was one of the most challenging aspects of the work – as it revealed gaps in real economy firms' understanding of what climate transition means for them. A gap I will return to.

The CBES also showed that costs were lowest, and opportunities greatest, with an early and well managed transition. That underlines that while governments set public climate policy, banks and insurers have a collective interest in managing climate-related financial risks in a way that supports that transition over time.

Managing climate related financial risks

Second, interactions with banks and insurers had revealed them to be in the early stages of developing their climate risk management capabilities. To address this, we set the world's first supervisory expectations for climate risks in 2019 – expectations that became part of the PRA's core supervisory processes last year.

Our reviews and observations – including the CBES – have shown significant progress. However, a distance remains to the endpoint and all firms need to invest to make further progress.

We have given firms a huge amount of homework to do, as set out in our latest Dear CEO letter and in direct supervisory feedback. I can assure you we will be marking that homework.

Progress on climate related disclosures

Third, in 2020, the quantity and quality of climate disclosures was in its infancy. We had recognised the need for it to move from the static to the strategic, for it to be forward-looking and for it to be comparable across firms.

Now, mandatory disclosures for large corporates under the TCFD are a reality in the UK and are driving the right conversations around board tables.

Here at the Bank we are soon to publish our fourth TCFD-aligned report, overcoming challenges with each new report.

And internationally the ISSB is due to build on the work of the TCFD by publishing its first global standards on climate later this year – in a fraction of the time usually taken.

I have very little doubt that in the future we will look back at the ISSB's work as a fundamental building block of comparable global green markets.

The growth of green finance

Fourth, we have seen and continue to see growth in the green finance market. The share of green finance in total finance has steadily increased, reflecting burgeoning investor demand and the financial system's ability to innovate[3]. That poses new challenges, including greenwashing, and markets regulators like the FCA are responding accordingly.

But it's not only green products we need to see growth in. More fundamentally, we need to see an increase in transition finance projects that help business deliver long-term emissions reductions – greening our future economy, not just investing in the currently green.

To that end, I welcome the Government's 2023 Green Finance Strategy. It includes a huge number of measures, but I was especially pleased to see commitments that will create the required cross-economy infrastructure for financing – including sector investment plans, an industry-led Transition Finance Market Review, and a Net Zero Business and Investment Group to advise government on the needs of the private sector to mobilise capital.

Turning aspiration into action

The reason I have spent some time on these four areas is not just because a lot has happened. It is because it is important to recognise the progress we have seen.

But have we reached a tipping point where firms' capabilities and understanding of the opportunities and risks from transition are driving strategic decision-making? Well here is the reality check. The shift I had hoped to see in stronger linkages between climate change and strategic decision making across the economy have proved harder to deliver in practice.

Why is that? Undoubtedly, those headwinds of the last three years and for which we have no recent precedent have reduced our collective ability to take action. This is undeniably unfortunate – but it is a legitimate rationale.

Indeed, against this backdrop we have perhaps seen more progress than might have been expected. But we cannot get away from the fact that regardless of this legitimacy, climate risks continue to build and still need to be addressed.

Beyond these unexpected headwinds, the key challenges have come from foreseeable sources. I am conscious I have adopted a number of lists – but bear with me for one final one as I set out four key challenges we will need to overcome if we are to turn aspiration into action that advances the transition. And in the spirit of being solutions focused, not just a naysayer, I will also provide views on how to overcome each of the challenges.

Challenges to advancing the transition

The first challenge is that filling capability gaps in the transition finance infrastructure takes time, so we need to continue to take urgent steps now.

Collectively we need to equip the financial sector with forward-looking information from the real economy to allocate capital effectively and mobilise finance at scale.

That means the rapid implementation of ISSB standards, finalising the Transition Plan Taskforce's framework for transition plans, and the adoption of innovations that reduce greenwashing such as product labels.

The Government's 2023 Green Finance Strategy sets out further detail on the timeline for Sustainability Disclosure Requirements and commits to reflect developments in international standards. It also commits to consult on the requirements for the UK's largest companies to disclose their transition plans.

But, the responsibility for driving forward the transition to net zero is not only for governments and the authorities in building the frameworks. As NEDs, it includes all of your firms in using those frameworks. And you can, and must, make progress now whilst policy is developing – ahead of regulation and to support the development of best practice.

A necessary foundation for that is investing in education to increase your staff's understanding of climate issues. Without that, none of this can happen.

Transition plans are fundamental to driving the right transition. They allow financiers both to manage their risks and to allocate capital to support real economy decarbonisation. And by highlighting where there is clarity about the way forward and where gaps remain, they compel the right conversations. I encourage you all to engage in them now.

The second challenge is that the world does not stand still. We have seen unexpected political and economic headwinds and it seems prudent to assume more will come.

With unexpected headwinds and limited bandwidth, longer-term issues can end up deprioritised. Issues do not though go away – quite the opposite, they build in the background. So we all need to be nimble and adaptable in our responses to the near-term whilst continuing to make progress on the long-term.

We must also learn lessons as we go. Russia's illegal invasion of Ukraine, for example, was a shock to our transition pathway and highlighted the sorts of disorderly transition risks we have been worried about. We saw first-hand the economy-wide costs of a necessary reduction in (Russian-imported) fossil fuels before alternative energy sources were in place - a reminder of the costs of disorderly transition.

But we cannot ignore the broader challenges. The fallout of this crisis and the near-term imperative to tackle energy security issues has reduced bandwidth to address other issues. This is a good segue to my third challenge.

The third challenge is that it is difficult, but essential, for real economy and financial firms to make transition-driven business decisions in the absence of complete clarity on our pathway to net zero.

It is easy for me to stand here and tell you that you should be making decisions now that stretch many years into the future, to manage the risks and seize the opportunities of net zero, without full clarity on the policy path to get there. But we need to recognise that setting clear and comprehensive policy will take time, likely years. The recent Green Finance Strategy takes us forward in a significant way, but the extent of policy making is formidable.

We should also not be in any doubt that the transition is already building, creating opportunities and crystallising risks, and that its speed will only accelerate. Within the UK, policies on energy efficiency in buildings are driving changes now[4]. And transition policies elsewhere such as the US Inflation Reduction Act will have onshored impacts for the UK.

So firms cannot, and should not, delay taking action to better understand how transition might impact their businesses.

As I mentioned earlier, the CBES revealed a significant gap in the understanding of real economy firms on what the transition to net zero means for them. Whilst I recognise there is uncertainty, I urge firms to explore how different scenarios are relevant to their strategy, to test their specific vulnerabilities and to identify opportunities.

Here at the Bank, we have helped create tools to support such analysis[5]. And they continue to be enhanced. They include carbon prices consistent with different pathways to net zero to help you identify robust strategies. I encourage you to use them.

And the fourth challenge is that system wide change is complex as the actions of one are dependent on actions of others, so it is important to coordinate action throughout the supply chain.

Each firm should be stretching its horizons – building capabilities now that enable action to drive long-term reductions in emissions through their value chain. That does not mean immediately ceasing to deal with high emission counterparties and suppliers. That does not necessarily remove emissions, perhaps chasing them into the shadows instead.

Rather, economy-wide emissions reductions will come through proactive engagement with counterparties and suppliers, and decisions aligned to the transition over time. This means understanding the needs of firms up and down the supply chain and having difficult discussions about steps to reduce emissions.

And smaller corporates will need help from larger corporates and their financiers to develop their climate expertise. The collaboration between GARP and Chapter Zero shows how effective that can be in driving faster progress.

I truly believe that transformation can come from constructive and systematic engagement with your value chain. I therefore urge you to convene your opposite numbers in and around the real economy. Chapter Zero is a great network.

Conclusion

We know the costs of transition to a net zero economy are lowest with early and well-managed action. And we are making good progress in supporting that transition, arguably more than we might have expected given the shocks we have faced.

But there is still much more to do. We have not yet reached the tipping point where we have built the capabilities and the transition finance infrastructure that will support the right strategic decisions in an unavoidably uncertain transition.

We all have a role to play in driving progress. Governments globally have the key role in developing the policy paths and infrastructure that deliver the transition and draw us closer to this tipping point. Central banks and regulators can operate within their objectives to catalyse, complement and amplify those policies.

And, business and finance can – indeed in order to manage their future risks will need to – make progress whilst policy is developing, ahead of clarity on sectoral paths and regulatory practice. Be assured that the difficult conversations that follow are a sign of success on our pathway to net zero, not a sign of failure.

Waiting for certainty and perfect information creates an excuse to go slowly. But this is a collective action problem where seemingly rational individual inaction makes our collective future problems much bigger. So we must not let perfection be the enemy of progress. And after all, managing uncertainty is what you do all the time. Be brave here too.

I will leave you with an encouragement (again) to each play your role, and to make the most of this important network. ■

Sarah Breeden is Executive Director, Financial Stability Strategy and Risk, at the Bank of England

Endnotes

1. In pathways that limit warming to 1.5°C with no or limited overshoot, net global GHG emissions are projected to fall by 43% below 2019 levels by 2030. See IPCC (2023), 'AR6 Synthesis Report: Climate Change 2023'.

2. World Economic Forum (2022), 'Analysis: Global CO_2 emissions from fossil fuels hits record high in 2022'.

3. From around 0.1% in 2012 to above 4% in 2021. See The City UK (2022), 'Green finance: a quantitative assessment of market trends'.

4. 40% of homes in England now have an EPC rating of B and C or better. See Department for Business, Energy & Industrial Strategy (2022), 'Energy efficiency: what you need to know'.

5. See CFRF (2022), 'Climate Financial Risk Forum Guide 2022: Scenario Analysis in Financial Firms', NGFS (2023), 'Scenarios Portal', Bank of England (2021), 'Guidance for participants of the 201 Biennial Exploratory Scenario: Financial risks from climate change'.

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Mobilising transition finance

Many jurisdictions now require companies to demonstrate ‘climate alignment’. Alexander Lehmann says investors need tools to evaluate whether transition plans are credible

One aim of sustainable finance regulation is to push companies towards activities that will be compatible with the target to limit global warming to 1.5 degrees Celsius above pre-industrial levels. This type of regulation – for example setting out classifications of what economic activities count as 'green'[1] – seeks to encourage financing for activities and technologies that are clearly carbon neutral.

But financial markets now increasingly focus on transition finance as a component of the broader sustainable finance asset class. Transition finance refers, for example, to financing for emission reductions and low-carbon technologies in industries such as cement or steel, where no purely green technologies are readily available. Transition financing is also needed for energy companies in the process of switching to renewables and phasing out their fossil-fuel assets.

From 'cheap talk' to credible climate plans

Some observers have argued that transition finance requires a new classification that would set out intermediate technologies and 'shades of green' deployed on the path to a net zero world – in other words, technologies that are not, in a strict sense, sustainable, but which are needed to get to sustainability.

Shipping, for instance, is a typically 'hard-to-abate' sector. Gas, rather than oil-powered, vessels may reduce emissions initially while not offering the ultimate net zero technology, such as green hydrogen. In the European Union, a technical expert group has proposed such a separate transition classification (Platform on Sustainable Finance 2022), but EU legislation on this right now does not seem likely.

That is no grave loss. A static classification of activities is neither sufficient nor necessary for transition finance to take off. Transition finance relies inherently on forward-looking climate commitments by companies.

Only on the basis of well-defined transition plans will investors be in a position to understand the residual climate risks to which companies are exposed, while bond and loan markets will increasingly feature contracts that link financial terms to the achievement of climate outcomes.

Only on the basis of well-defined transition plans will investors be in a position to understand the residual climate risks to which companies are exposed, while bond and loan markets will increasingly feature contracts that link financial terms to the achievement of climate outcomes

This central role of corporate climate plans has been recognised in templates for transition plans developed by, for example, the Organisation for Economic Co-operation and Development (OECD, 2022) and the G20 Sustainable Finance Working Group (2022).

The sheer number of net zero targets companies have announced would suggest that this concept is well-established. In fact, transition plans are a much more complex aspect of corporate disclosure and strategy. They should, for instance, explain how emissions in the upstream and downstream value chain are captured.

They should also explain the incentives management has to deliver on the plan, for instance, by setting internal carbon prices or linking executive pay to climate outcomes.

Some companies have already adopted this relatively comprehensive concept, in part based on templates that the Financial Stability Board's Taskforce on Climate-Related Financial Disclosures (TCFD) first designed in 2016.

However, overall, the quality of corporate climate disclosures remains disappointing. In February 2023, the Climate Disclosure Project showed that only a small fraction of the 18,000 companies monitored globally met all key indicators of high-quality climate transition plans (CDP, 2023).

Only in a handful of EU countries do more than 10 percent of reporting companies define plans that meet most of the required indicators. According to the UK-based Transition Pathway Initiative, only one-quarter of about 400 large and listed global companies have made a strategic assessment of issues related to the climate transition. Major aspects of management quality were often inadequate[2].

New regulatory standards

Against this backdrop, a number of regulatory initiatives will now likely bring more clarity on the elements corporate transition plans should include:

- In the EU, the Corporate Sustainability Reporting Directive (CSRD, (EU) 2022/2464) will require roughly 50,000 companies to publish their climate transition plans, beginning in the 2024 accounting period. A 2022 European Commission proposal for a Corporate Due Diligence Directive[3] remains under negotiation but is likely to raise standards further by requiring considerable detail in such plans, including how they would be in line with the 1.5 degree warming scenario. The European Financial Reporting Advisory Group, the EU's accounting body, has published a draft standard that fleshes out these requirements (EFRAG, 2022).

- In parallel, the International Sustainability Standards Board (ISSB) is developing new disclosure rules, with a climate standard to take effect from 2024 (ISSB, 2022). This also requires companies to publish transition plans.

- Standards in the United Kingdom will also be important, given the close linkages to EU capital markets and London's possible role as a green finance hub for emerging markets, as envisaged in the UK government's 2023 green finance strategy (HM Government, 2023). Detailed standards for the transition plans of large or listed companies are expected in late 2023[4].

- In addition, there are now various guidelines and regulations on transition finance and related corporate disclosures in Japan[5] and other key Asian markets.

Much has been made of the EU's greater ambition in disclosure. The EU's 'double materiality' concept, which is embodied in the CSRD (reflecting sustainability risks to the firm as well as the firm's impact on the planet) will go well beyond the equivalent ISSB standards[6].

In terms of the format and content of corporate transition plans, the emerging EU, UK and international accounting standard templates are, in fact, very close. Unlike for green finance and the often-complex classifications of activities, regulatory equivalence, which could foster cross-border capital flows, seems a realistic prospect.

Fleshing out the fine print

Transition plans will quickly become an important tool in corporate strategy, and will be central to non-financial disclosures and reporting. But the high-level language in the EU directives and the new accounting standard will need to be fleshed out in further guidance and backed up in national legislation.

Three aspects should be addressed:

- The EFRAG (2022) standard should be clearer on how the pathways for emission reductions will be set. This involves tricky judgements on how the finite remaining budget for global greenhouse gas emissions is allocated to industrial sectors, and how EU and national targets are translated to each company.

  There also needs to be clearer guidance on emissions arising further down the value chain ('scope 3' – indirect emissions) and whether targets are to be set in relative (intensity) or absolute terms. The sheer variety of methodologies invites arbitrage towards lower standards.

- Sound transition plans will also need to be backed up by corporate governance and transparency rules. The EFRAG standard only requires companies to explain how the transition plan is embedded in the overall business strategy and that it has been approved by management bodies, which risks resulting in superficial language.

  An ongoing review of four related EU directives in this area (including the one on the harmonisation of transparency requirements)[7] should therefore be accelerated and should support the ambition for better sustainability disclosures.

  Corporate governance rules are largely in the competence of EU countries and are defined in a patchwork of national legislation, securities regulations and non-binding codes or guidance from central banks. Climate-related aspects should become more central, for instance by requiring a climate strategy review in annual shareholder meetings.

- Finally, investors' assessments of corporate transition plans will rely on certification and verification by assurance providers and other private companies. This industry is set to expand, with the audit profession playing a more prominent role. Verification providers should be free of conflicts of interest and should deploy transparent models. The EU could design a relatively light-touch system of accreditation, as is already planned in support of the EU's new green bond standard[8].

The potential of the EU's corporate bond market

If designed well, transition plans will underpin the further growth of green and transition finance. They will guide the design of bonds and loans that tie financial terms to climate outcomes.

In 2022, over 21 percent of European bond issuance was labelled as sustainable in some form. Within this total, sustainability-linked bonds, which reward issuers for achieving targets rather than spending on certain projects, have grown particularly strongly.

In 2022, about 200 EU companies issued such bonds for a total amount of €89 billion. Despite this rapid growth, the market for corporate bonds linked to climate outcomes is still quite immature. The European Securities and Markets Authority (ESMA, 2023) has shown that there has been a near-uniform bond contract structure and typically undemanding coupon step-up penalties, which were largely unrelated to the issuer's credit risk.

Many of the performance targets set in corporate bond issues seem to have been unambitious, or have failed to capture relevant emissions. As it operates currently, the EU's corporate bond market does not reward climate commitments sufficiently.

Once corporate transition plans become more transparent and credible, banks and bond investors will be in a position to fund companies that are committed to certain climate outcomes, and which can signal this commitment credibly. This will not only channel additional finance to those companies fully engaged in the climate challenge, but will also exert a more meaningful discipline over the private-sector low-carbon transition than has been possible so far. ■

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Endnotes

1. As in the European Union taxonomy for sustainable activities; see https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

2. See https://www.transitionpathwayinitiative.org/

3. See https://commission.europa.eu/business-economy-euro/doing-business-eu/corporate-sustainability-due-diligence_en

4. See https://transitiontaskforce.net/workplan/

5. See https://www.meti.go.jp/english/press/2021/0507_001.html

6. For a discussion, see https://www.bruegel.org/event/corporate-disclosure-sustainability-risks-reconciling-international-and-eu-approaches

7. See https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13128-Corporate-reporting-improving-its-quality-and-enforcement_en

8. See Council of the EU press release, 'Sustainable finance: Provisional agreement reached on European green bonds', 28 February 2023, https://www.consilium.europa.eu/en/press/press-releases/2023/02/28/sustainable-finance-provisional-agreement-reached-on-european-green-bonds/

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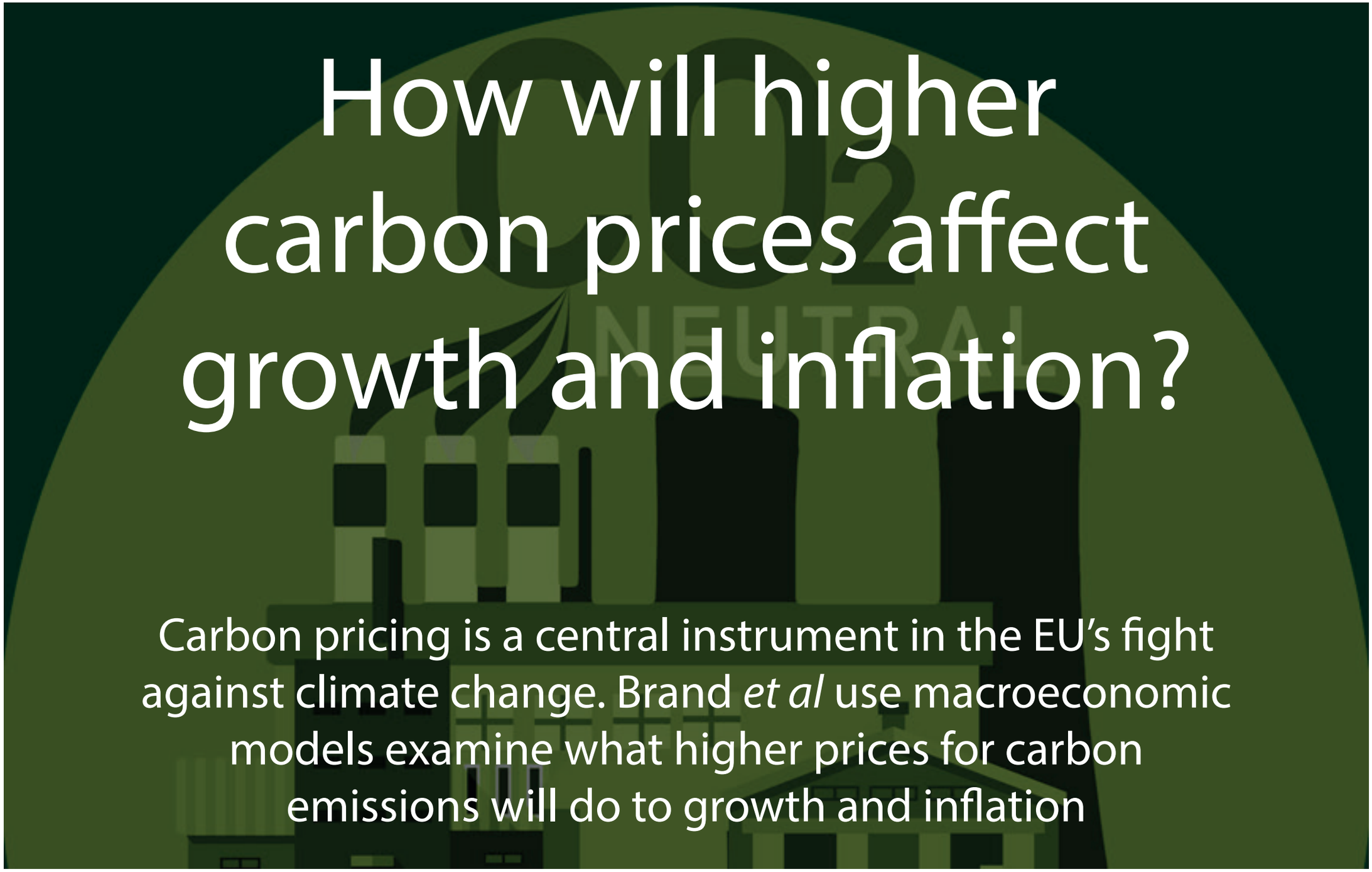
How will higher carbon prices affect growth and inflation?



Carbon pricing is a central instrument in the EU's fight against climate change. Brand *et al* use macroeconomic models examine what higher prices for carbon emissions will do to growth and inflation

Carbon pricing is a central instrument in the EU's fight against climate change, but it will also affect our economies. In this post on *The ECB Blog*, we use macroeconomic models to look at what higher prices for carbon emissions will do to growth and inflation.

Urgent action is needed to reduce greenhouse gas emissions and prevent the most disastrous effects of climate change. This is why the EU aims to reduce such emissions by 55% by 2030 (compared to 1990 levels), and to achieve net zero emissions by 2050.

The EU's Fit-for-55 package will use measures like carbon prices, regulation and green investment, all of which will affect the economy. But how, and with what economic consequences?

Carbon pricing and the economy

In this post we focus on carbon pricing. It is the most effective instrument to reduce emissions because it is targeted at the carbon footprint of the economy. It forces everyone to take the damage caused by emissions into account – for example when running a business, driving a car, or heating a home.

Carbon pricing usually takes the form of a tax imposed on emissions or an emission trading scheme in which companies can buy and sell the right to generate emissions (which *The ECB Blog* will look at in a dedicated post soon). All forms of carbon pricing provide incentives to reduce emissions. They do that by putting a price tag on the emissions from consumption and production.

For example, you might travel less often by plane as you see prices rising due to the fact that airlines have to buy carbon emissions allowances.

How does carbon pricing affect the economy and, eventually, growth and inflation? Carbon prices influence both supply and demand primarily via higher energy prices – either directly via their impact on consumer prices or indirectly via their impact on production costs.

Model-based estimates of carbon-price increases consistent with the International Energy Agency's net zero scenario in 2050 suggest a moderate impact on euro area GDP and inflation over the current decade

On the supply side, the increase in production costs drives up inflation and results in lower production. If the government sets out the future path of carbon price increases in a credible way, firms can anticipate and factor in those higher costs when they set their prices or decide on production volumes. The more firms do so today, the stronger the inflation impact will be upfront.

On the demand side, higher carbon prices hit household incomes and firm profits. This in turn reduces consumption and investment, eventually creating downward pressure on inflation. The more households and firms take into account future carbon price increases for their spending today, the more they will frontload this reduction in consumption and investment. So we have two forces moving inflation in opposite directions.

There are a number of factors affecting how strong these effects are, and in which direction they pull. Fiscal policy, for example, can redistribute the receipts from carbon taxes to low-income households. This would reduce the loss of real incomes and help sustain household consumption.

If countries around the world tax carbon emissions differently this will affect international competitiveness, the terms of trade (the amount of goods a country can purchase for a certain amount of exported goods), and the demand for export goods.

Quantifying the overall effect of carbon pricing on the economy is fraught with a high level of uncertainty, including model uncertainty. To deal with this uncertainty, we used six macroeconomic models to assess the impact of raising carbon prices in the euro area[1].

For the calculation we assumed a carbon price increase from €85 in 2021 to €140 per tonne of CO_2 emission by 2030[2]. For the rest of the world, we factored in a proportionate increase in carbon prices, albeit from lower levels.

What would be the quantitative impact of this increase in carbon prices on the euro area economy? The models suggest that it would moderately lower consumption and investment, with GDP falling 0.5-1.2% below baseline by 2030 (see Chart 1, top, where the baseline refers to a scenario with no changes in carbon prices).

Across all models, the median estimate for GDP translates into average annual growth dropping by roughly 0.1 percentage points. Likewise, the models suggest that the maximum impact on annual inflation would be modest at less than 0.2 percentage points per year in the period up to 2025, and falling gradually thereafter (see Chart 1, bottom).

Accordingly, the carbon price increase, as assumed for this simulation, would only have a rather limited economic impact on the euro area economy. That means monetary policy would face only a modest trade-off in terms of stabilising inflation relative to output.

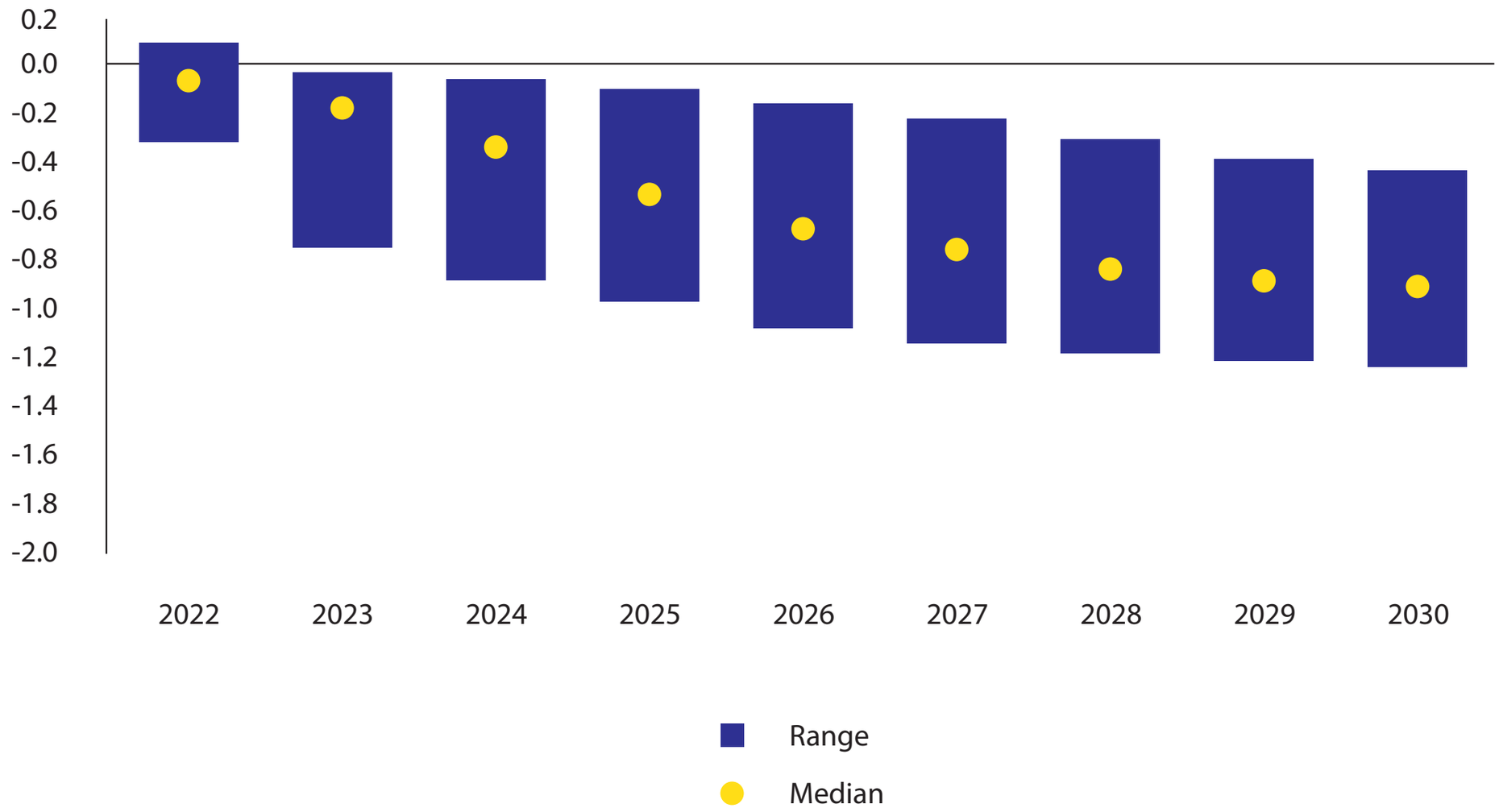
The size and, ultimately, the direction of the resulting response of policy interest rates depend on the model. Models emphasising the adverse supply-side effects of the scenario, with a larger impact on inflation, tend to prescribe a limited increase of policy interest rates. And models in which adverse demand effects dominate tend to show a small decline of policy rates.

Raising carbon prices is expected to support the transition to a low-carbon economy. But the carbon price increase in our scenario would reduce carbon emissions in the euro area by only around 11% by 2030. This is the median estimate of our six models (see Chart 2).

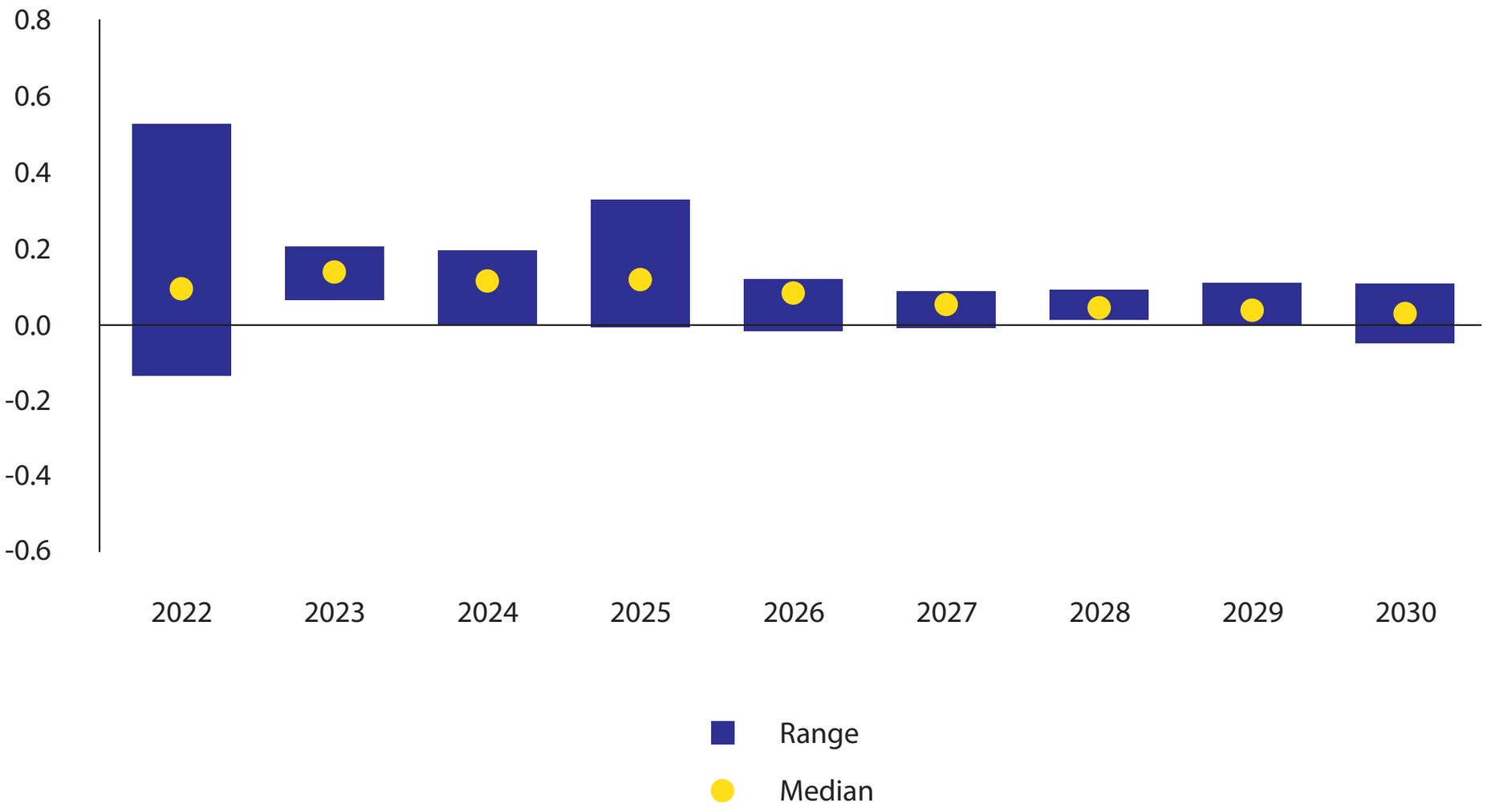
And that figure is far below the EU's intermediate goal of reducing emissions by 46% by 2030 (compared to 2021 levels). This shortfall highlights the need for a more ambitious carbon pricing policy, additional regulatory action, green investments, and technological adaptation and innovation.

Chart 1. Carbon pricing impact on real GDP (LHS) and inflation (RHS)

Percentage and percentage-point deviation from baseline paths

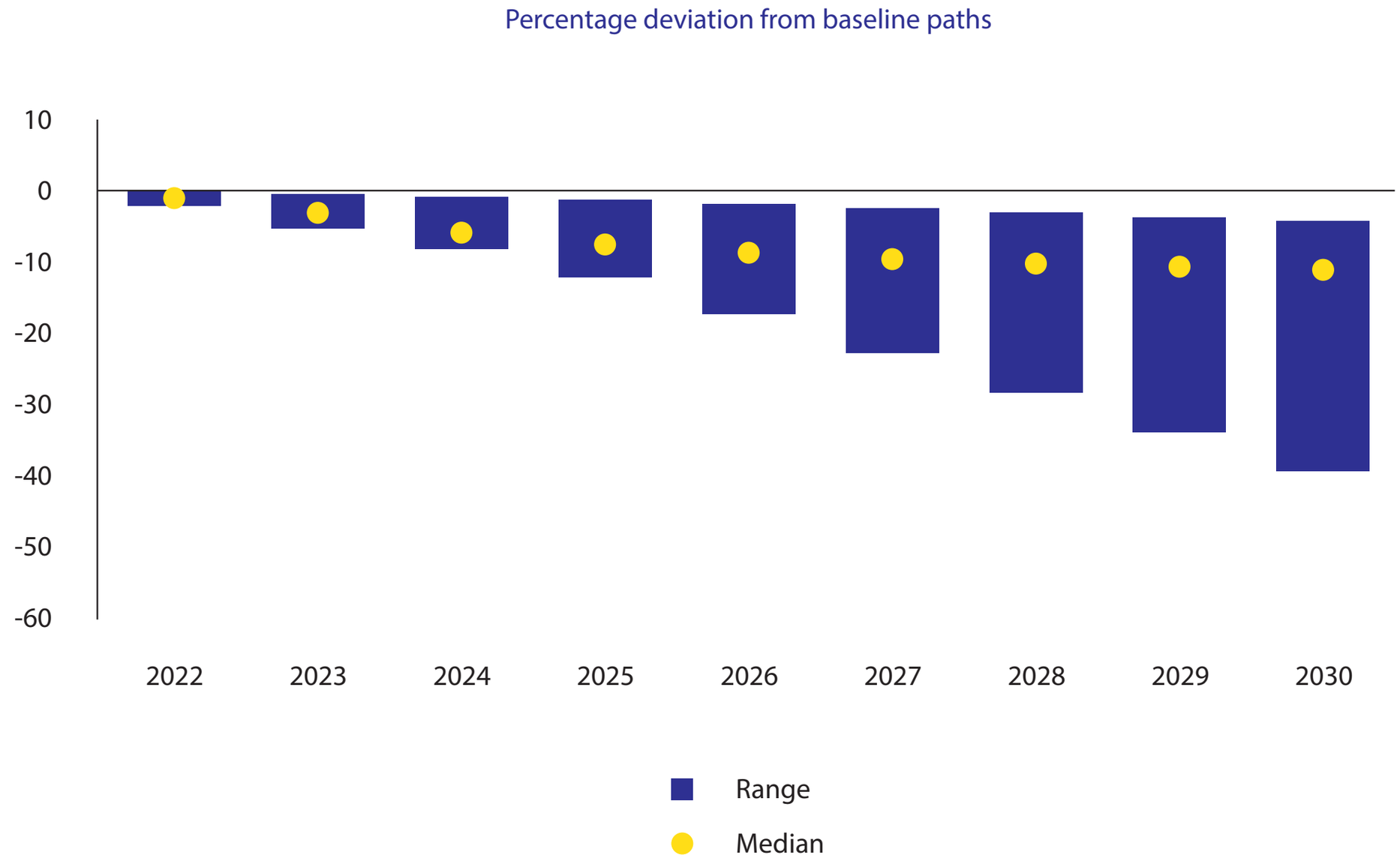


Percentage and percentage-point deviation from baseline paths



Note: The charts display the impact (range and median across models) of the assumed carbon price increase on euro area real GDP and inflation between 2022 and 2030.
Sources: NAWM-E, E-DSGE I + II, G-Cubed, NiGEM and Oxford.

Chart 2. Carbon pricing impact on carbon emissions



Note: The chart displays the impact (range and median across models) of the assumed carbon price increase on euro area carbon emissions between 2022 and 2030.
Sources: NAWM-E, E-DSGE I + II, G-Cubed, NiGEM and Oxford.

We have to put the estimated reductions in carbon emissions in the euro area into an international perspective. The euro area currently contributes a mere 5% of global carbon emissions. Achieving a substantial effect on global emissions would require a more ambitious increase in carbon prices in the rest of the world.

If these carbon prices were aligned with those for the euro area by 2030, the estimated reduction in global carbon emissions would be about three times greater than in our benchmark scenario. In this event, the euro area terms of trade would improve by more, while euro area foreign demand would weaken more strongly, doubling the estimated negative impact on euro area GDP.

How fast carbon emissions can be reduced depends on how quickly the economy adjusts to higher prices for carbon emissions. If capital and labour get reallocated more swiftly, if the economy adapts more rapidly to new technologies and if there is sufficient financial support, the process can go faster.

It would also help if green energy could replace fossil fuel generated energy more easily than assumed in the models. This would reduce emissions more strongly and also mitigate the impact on GDP and inflation. More green investments or major technological advances would also help in this regard.

To conclude, model-based estimates of carbon-price increases consistent with the International Energy Agency's net zero scenario in 2050 suggest a moderate impact on euro area GDP and inflation over the current decade, with modest inflation-output trade-offs for monetary policy as it seeks to preserve price stability.

But the estimated carbon emission reductions by 2030 are limited, equal to around one-fourth of the EU's intermediate goal. Achieving greater cuts in emissions with higher carbon prices would have a bigger impact on inflation and GDP, with more sizeable trade-offs for monetary policy.

Accordingly, reaching the EU's climate goals will require a mix of ambitious carbon emission pricing, additional regulatory action and technological innovation, as set out in the Fit-for-55 package. ■

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Endnotes

1. Three of these models were developed at the ECB in line with its climate change action plan: the New Area-Wide Model with a disaggregate energy sector (NAWM-E), as well as two smaller-scale environmental DSGE models with financial frictions and costly abatement, respectively (E-DSGE I + II). The three other models are commercial models that are widely used for climate change analysis: NiGEM, G-Cubed and the Oxford Economics model.

2. The starting value of €85/tCO_2 in 2021 corresponds to estimates of effective carbon rates by the Organisation for Economic Co-operation and Development. The terminal value of €140/tCO_2 by 2030 is aligned with the carbon price assumption in the International Energy Agency's net zero scenario for 2050, as set out in its 2022 World Energy Outlook.

This blog was prepared in liaison with Alina Bobasu, Kai Christoffel, Alistair Dieppe, Michael Dobrew, Marien Ferdinandusse, Alessandro Ferrari, Thaïs Massei, Romanos Priftis, Angela Torres Noblejas and Aurelian Vlad.

Fostering innovation for climate neutrality

The pace of innovation is not aligned with carbon neutrality. Mario Cervantes, Chiara Criscuolo, Antoine Dechezleprêtre and Dirk Pilat argue for policies to encourage the adoption of green innovation

Achieving climate neutrality will require cost reductions and the rapid diffusion of existing technologies, as well as innovation in new technologies. However, climate-related innovation has declined since 2012, while the deployment of existing technologies has grown, resulting from a policy emphasis on deployment rather than R&D.

This column argues that science and technology policies targeted at early-stage technologies most needed for net zero emissions are critical to accelerate innovation. Carbon pricing, the removal of fossil fuel subsidies and other demand-side instruments can encourage the adoption of technologies that are closer to the market.

Countries representing more than 90% of global GDP have now announced targets of climate neutrality by 2050 (Net Zero Stocktake 2022). Reaching these targets requires massive technological change (Van der Ploeg and Venables 2023). Further reducing the cost of mature technologies, such as renewables, will help make these fully competitive with carbon-based alternatives, allowing them to be deployed at scale.

However, many other technologies, such as green hydrogen, are still in their infancy and need further development. IEA estimates that half of the global reductions in energy-related CO_2 emissions through 2050 will have to come from technologies that are currently only at the prototype or demonstration phase (IEA 2021).

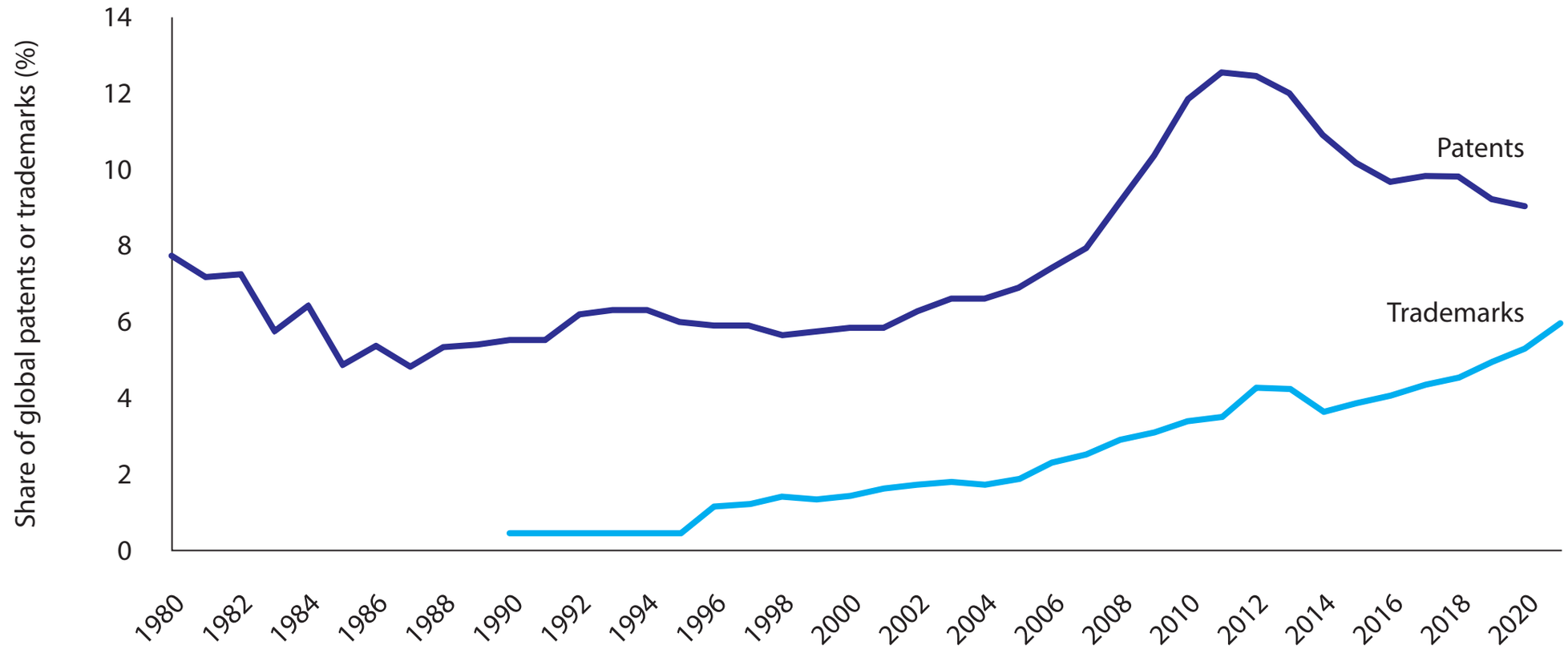
Low-carbon innovation is lagging and has moved from R&D to diffusion

Despite the urgency, the pace of innovation is not aligned with carbon neutrality (Cervantes *et al* 2023). Over the past decade, climate-related innovation, measured as the share of patent filings in climate related technologies relative to all technologies, has slowed down (Figure 1).

In contrast, the deployment of existing technologies, measured by the growth of trademark filings for climate-related goods and services, has risen. While venture capital (VC) investment in green start-ups has grown over the past decade, it has decreased since 2018 (Bioret *et al* forthcoming).

Governments urgently need to increase public R&D expenditures targeted at technologies that are still far from market, but necessary to reach carbon neutrality by 2050

Figure 1. Global low-carbon patenting has declined, but climate-related trademarks continue to rise



Note: Patent data refer to families of patent applications filed under the Patent Cooperation Treaty (PCT), by earliest filing date. Trademark filings are from the European Patent Office, the US Patent and Trademark Office and the Japan Patent Office.
Source: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, February 2023.

Moreover, VC investors appear focused on late-stage ventures, as opposed to seed investment into new ventures. Together, these trends suggest that the business sector is more focused on the diffusion and commercialisation of existing technologies than on the development of new innovations.

This results from a policy emphasis on deployment rather than R&D, notably a levelling-off of concrete climate policy measures across OECD countries between 2010 and 2020, particularly for innovation-related policies (Kruse *et al* 2022).

Public expenditures on R&D for low-carbon technologies have remained flat (as a percentage of GDP) over the last 30 years (Figure 2), despite pledges by many countries to double clean energy R&D funding between 2016 and 2021.

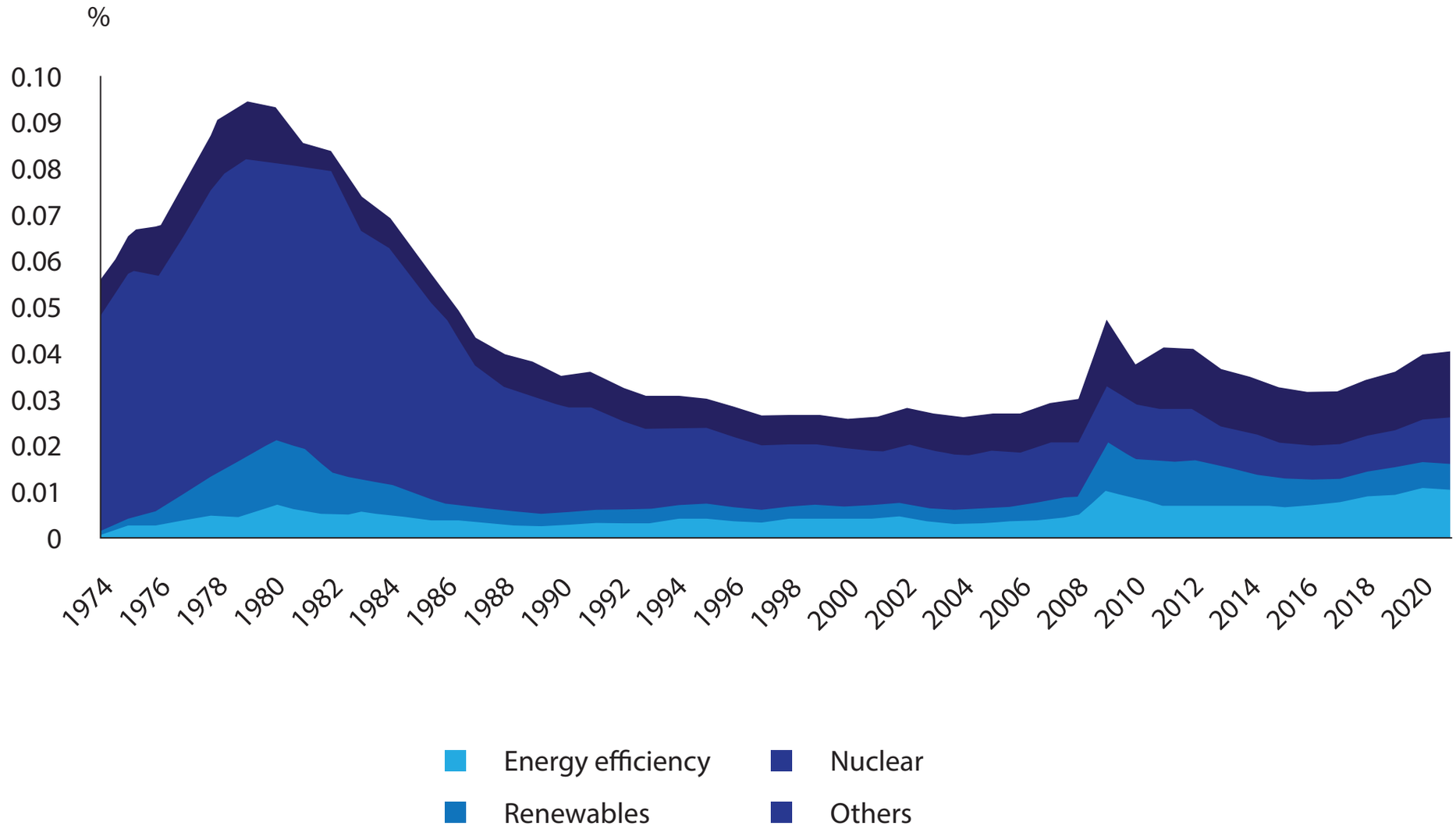
Recent policy actions such as the European Union member countries' Recovery and Resilience Plans and the US Inflation Reduction Act may give a renewed impetus to such R&D.

The contrast between government spending on R&D and support for deployment is striking. European countries spent €458 million in 2018 to support R&D in wind and solar power (Figure 3). The cost to society implied by subsidies for the deployment of wind and solar technologies that same year represented €78,400 million – 150 times more than public R&D. This ratio is smaller in the US and Japan, but there also the emphasis is clearly on support for deployment rather than R&D.

Net zero innovation policies are well justified

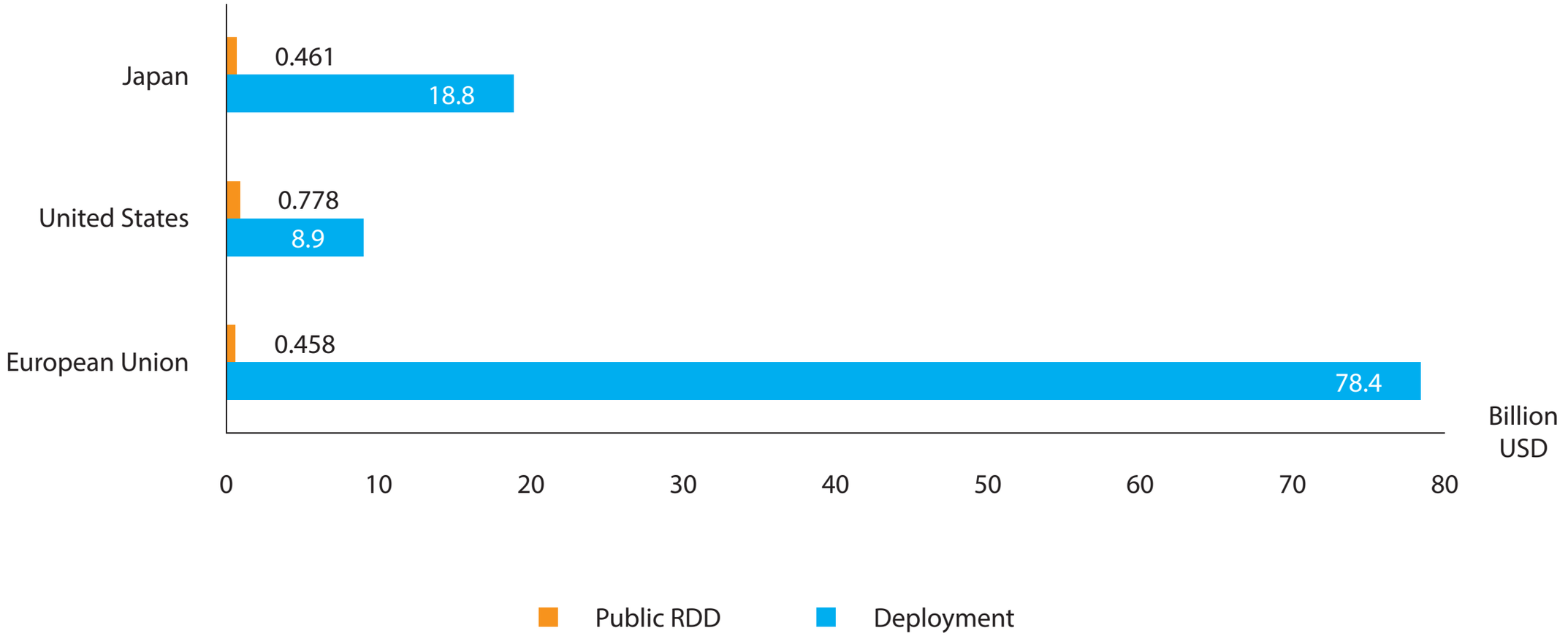
Given the range of barriers and market failures discouraging low-carbon innovation, the theoretical justifications for low-carbon innovation policies are well established.

Figure 2. Low-carbon public RD&D expenditures in GDP across IEA countries, 1974–2020



Note: The 'Others' category includes carbon capture and storage, hydrogen and fuel cells, other power and storage technologies, and other cross-cutting technologies and research.
See https://www.iea.org/data-and-statistics/data-product/energy-technology-rd-and-d-budget-database-2
Source: IEA Energy Technology RD&D Budgets database, December 2022.

Figure 3. Public RD&D and deployment support in renewable energy, 2018 (billion USD)



Source: IEA Energy Technology RD&D Budgets database, December 2022; Taylor, Michael (2020), Energy subsidies: Evolution in the global energy transformation to 2050, International Renewable Energy Agency, Abu Dhabi.

This includes the existence of significant social benefits from innovation in new technologies, which are particularly high for low-carbon technologies (Dechezleprêtre *et al* 2014), but also learning-by-doing (Grubb *et al* 2021).

In addition, carbon remains largely unpriced at the global level: 60% of carbon emissions are not priced at all and the average effective carbon price is only €16.7/tonne CO_2 (OECD 2022). This reduces the incentives to develop and adopt new low-carbon technologies.

Science, technology and innovation (STI) policies are critical because technological progress reduces the costs of emissions reduction policies, as demonstrated by the sharp decline in the costs of batteries and solar energy over the past decade (IPCC 2022).

By reducing the cost of technology, STI policies reduce the social and economic costs of reaching climate objectives. This increases the responsiveness of emissions to carbon prices, which implies much lower carbon prices to reach the same climate target.

Therefore, STI policies can partially substitute for low carbon prices, which is important as these are often difficult to implement politically. Voters strongly prefer subsidies to low-carbon technologies over other climate policies such as carbon pricing, bans or regulations (Stantcheva *et al* 2022).

What can policies do?

First, governments urgently need to increase public R&D expenditures targeted at technologies that are still far from market, but necessary to reach carbon neutrality by 2050. This implies making low-carbon R&D the highest priority in governments' research budgets and providing a long-term and stable perspective for such funding.

Governments should focus their support on technologies that are central to decarbonisation pathways and that are unlikely to be provided by the market. Carbon capture, utilisation and storage (CCUS), advanced high-energy density batteries, hydrogen electrolysers, direct air capture, and biofuels account for a large share of emissions reductions until 2050 in all climate models, but receive only around one-third of the level of public R&D funding of the more established low-carbon technologies (Cervantes *et al* 2023). In general, countries need to adopt a portfolio approach to diversify industrial and technology risks, thus avoiding lock-in and give all green technologies a fair chance.

Second, rebalance the use of R&D support instruments. R&D tax credits have positive effects on firms' innovation activities, but more on experimental development than on basic and applied research (Galindo-Rueda *et al* 2020). Conversely, grants have larger positive effects on the R&D stage.

Horizontal R&D support has advantages, but by construction mainly benefits technologies that have the highest short-run returns. Tax credits are therefore not the right policy tool to promote new technologies that are not close to the market, such as hydrogen, justifying a stronger focus on targeted instruments.

Third, close the funding gap for large-scale demonstration projects of technologies that still have a low technology readiness level. For example, CCS demonstration projects currently cost around $1 billion (OECD 2021). The recent announcement by 16 countries at the September 2022 Clean Energy Forum to commit U$94 billion for clean energy demonstration is an important step in the right direction.

Fourth, while R&D support policies by nature target domestic firms only, deployment subsidies also benefit foreign firms. Deployment policies should therefore be designed with a clear understanding of the supply side so that they do not face constraints in the domestic economy, such as skill shortages and lack of infrastructure.

Provisions limiting the foreign content of goods and services risk slowing down the climate transition, especially in the presence of shortages in the domestic economy.

Fifth, barriers to external funding should be reduced to help high-risk companies raise funds. Favourable tax schemes, low-interest or subsidised loans for young firms, and a greater mobilisation of government venture capital toward the green transition can help.

Sixth, collaboration in low-carbon innovation should be strengthened. There is ample room for improvement in collaborative R&D, between firms, between firms and public research institutions and between countries, to capitalise on complementary skills and resources at the domestic and international levels.

Coordinated action can accelerate innovation, enhance economies of scale, strengthen incentives for investment, and foster a level playing field where needed.

Finally, low-carbon innovation policies need to be embedded in a broader package. Carbon pricing and the removal of fossil fuel subsidies are necessary to encourage the adoption of clean technologies that are closer to market and help 'redirect' innovation toward low-carbon activities.

For example, the introduction of the European carbon market (EU ETS) led to a large and rapid increase in low-carbon innovation among regulated companies (Calel and Dechezleprêtre 2016).

The low-carbon transition will involve a massive structural transformation that will require the alignment of policy frameworks beyond STI and climate policies. Competition and entrepreneurship policies play a critical role in encouraging business dynamism and the reallocation of resources.

Education and skills policies can help develop skills for the transformation and helps workers adjust to structural change. An efficient and cost-effective shift to a low-carbon economy thus requires the engagement of many parts of government beyond those traditionally mobilised in the development of climate change policies. ■

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Business aviation's path toward a net zero CO_2 future

Ed Bolen discusses business aviation's focus and resolve toward a net zero CO_2 future that was showcased at EBACE2023

Business aviation has fully embraced the need to become more sustainable and achieve net zero carbon emissions by 2050. Our industry's multifaceted approach to these goals was recently showcased throughout the 2023 European Business Aviation Convention & Exhibition (EBACE2023) that took place 23-25 May at Geneva's Palexpo convention centre and adjoining Geneva Airport (GVA).

Co-hosted by the European Business Aviation Association (EBAA) and the National Business Aviation Association (NBAA), EBACE highlighted the game-changing technologies, ground-breaking solutions for sustainable flight and exciting market opportunities propelling our industry forward.

The show also featured engaging speakers – including a candid and inspiring keynote discussion with Formula One powerhouse duo Toto and Susie Wolff – along with a bustling exhibit hall, a sold-out aircraft display and packed sessions on the show floor. This year's edition of EBACE also hosted the unveiling of Textron Aviation's new Cessna Citation Ascend, and the EBACE debut of Airbus Corporate Jets' ACJ TwoTwenty, Bombardier's Challenger 3500 and Gulfstream's G800 aircraft.

Perhaps most importantly in this global moment, however, EBACE2023 presented a powerful embodiment of business aviation's commitment to environmental stewardship and the use of sustainable aviation fuel, or SAF. Made from renewable feedstocks instead of petroleum, these drop-in fuels are driving business aviation's net zero goal; in its purest form, SAF can cut total lifecycle emissions by as much as 80%.

Through partnership with Jet Aviation, SAF was made available at GVA throughout EBACE2023, allowing operators to reduce CO_2 emissions when departing the show. Avfuel Corporation also added its supply of Neste MY Sustainable Aviation Fuel to airports for Geneva-bound flights from airports in Arkansas, Kansas and Florida.

Additionally, 'book-and-claim' credits were made available at New York's White Plains Airport (HPN) through a partnership between Avfuel and Atlantic Aviation. Book-and-claim allows operators to purchase SAF to be used to fuel jets elsewhere at airports where SAF is available, allowing operators to claim the environmental benefits from SAF without actually using it directly.

Tools like book-and-claim are vital to sustainability, as the production, distribution and availability of SAF continue to be an issue in the business aviation sector. This has prompted business aviation operators in Europe to call for regulations mandating a SAF book-and-claim system.

Despite fevered protests against our industry, and concerning movements across Europe to ban business aircraft and short-haul flights, our industry's focus on sustainability remains steadfast

The three-day EBACE Sustainability Summit also examined other important tools available now to business aviation operators. One session examined the use of carbon offset credits, which allow operators to write off their CO_2 emissions through funding specific, approved projects that remove CO_2 from the atmosphere.

In fact, CO_2 emissions from all attendee travel to and from the show, and from the 22 hotels and the shuttle buses used for EBACE, were offset by such carbon credits through a partnership with 4AIR.

While another important tool toward achieving net zero, however, *"carbon offsetting is not a passport for business as usual,"* noted Maureen Gautier, Manager for Sustainability and Future Workforce at EBAA. *"We really have to reduce first."*

Business aviation continues to innovate in this regard. We are leading the way in designing lighter and more efficient airframes, cleaner-burning engines and utilizing direct routing to reduce travel times and fuel burn.

"Technology leads to sustainability," said Michael Amalfitano, President and CEO of Embraer Executive Jets, in an EBACE newsmakers panel discussion featuring leaders of six leading business aircraft OEMs. *"As we continue to advance our products and our services to support those advancements, it's a really strong commitment by all the OEMs to continue to create a more efficient aircraft and a more efficient manufacturing operation."*

Advancing the future

EBACE also highlighted the technologies leading our industry beyond petroleum-based propulsion, with ongoing development of electric-powered advanced air mobility (AAM) aircraft tracking toward commercial introduction as soon as two years from now.

With leaders promising certification and the first commercial flights by 2024 – and several AAM aircraft displayed on the show floor – EBACE affirmed this new mode of air transport will soon become a reality. *"We are fully on track for a type certification before the end of 2025 in Europe,"* said Daniel Wiegand, Co-Founder and Chief Engineer for innovation and future programs at Lilium.

These certified AAM will be usable vehicles. Mark Henning, Managing Director for AutoFlight, noted the company recently set a world record flying its full-scale prototype a distance of 250 km (155 miles.) *"It was important to show to the world out there that eVTOL [electric vertical takeoff and landing] isn't science fiction anymore,"* he said.

In fact, commercial operations for battery-powered eVTOL are expected to begin next summer, with Germany's Volocopter offering commercial AAM passenger flights during the 2024 Paris Olympics. *"We want first of all to bring advanced air mobility and a sustainable network to everyone,"* said company CEO Dirk Hoke. *"And we will not do it only for the Olympics, we will be there then for the years to come in Paris."*

The message from EBACE2023 was clear: despite fevered protests against our industry, and concerning movements across Europe to ban business aircraft and short-haul flights, our industry's focus on sustainability remains steadfast. I invite readers of *World Commerce Review* to continue following these and other exciting developments guiding us toward business aviation's bright, innovative and sustainable future. ■

Ed Bolen is President and CEO of the National Business Aviation Association (NBAA)

Climate risks and global value chains

Extreme weather events will become more frequent as global temperatures rise. Rikard Forslid and Mark Sanctuary analyse the impact of the 2011 Thailand flood on Swedish firms

Extreme weather events will become more frequent as global temperatures rise. This is a challenge for companies that depend on complex international supply chains. There is an academic literature that analyses the impact of natural disaster shocks at the firm level (eg. Barrot and Sauvagnat 2016, Boem *et al* 2019, Carvalho *et al* 2021, Todo *et al* 2015, Zhu *et al* 2016, Kashiwagi *et al* 2021).

These studies focus on the Great East Japan Earthquake or on natural disasters in the US and find significant domestic effects as well as spillovers between Japan and the US. For example, Boehm *et al* (2019) find that the Great East Japan Earthquake caused the output of subsidiaries of Japanese firms in the US to fall roughly one-for-one with the decline in imports.

In a recent study (Forslid and Sanctuary 2022), we provide evidence of the impact of extreme weather events on two small countries located far from one another in the impact of the catastrophic 2011 Thai flood on Swedish importing firms. Both Sweden and Thailand are small countries located far from one another.

A priori, it would seem that Thai imports could be easily substituted by imports from countries closer to Sweden. Instead, the evidence points to very large effects. Production falls by an average of 8% among the affected Swedish firms, and the multipliers are very large, with a fall in production almost 30 times larger than the fall in imports.

The Thai flood of 2011 began in July of that year and inundated 9.1% of the total land area of the country, affecting close to 13 million people, with 728 deaths. Damages were estimated at $46.5 billion, dispersed across 69 provinces in every region of the country, and Bangkok and its vicinity were paralysed for two months (Poapongsakorn and Meethom 2013).

The flood hit the manufacturing sector especially hard. METI (2012) report, for instance, production losses of 84% in transport machinery, 77% in office equipment, and 73% in information and communication equipment. The time to recover differed between sectors, but also among individual firms depending on their location.

The fact that Sweden is a small economy far away from Thailand seems to have aggravated the effects of the shock. Multipliers are much higher than in other studies on large countries

In the automotive industry Toyota required 42 days to partly resume operations, while Honda required 174 days. Thailand produced approximately 43% of the world's hard disk drives in 2011, and recovery was somewhat slower than in the automobile sector. Many companies had facilities in Ayutthaya, where industrial parks were heavily inundated (Haraguchi and Lall 2015).

Overall, however, Thai industry recovered within months and had made important progress within six months. Production in March 2012 was 10% lower than that in March 2011, which may be compared to the maximal loss of 77% in November 2011 (METI 2012).

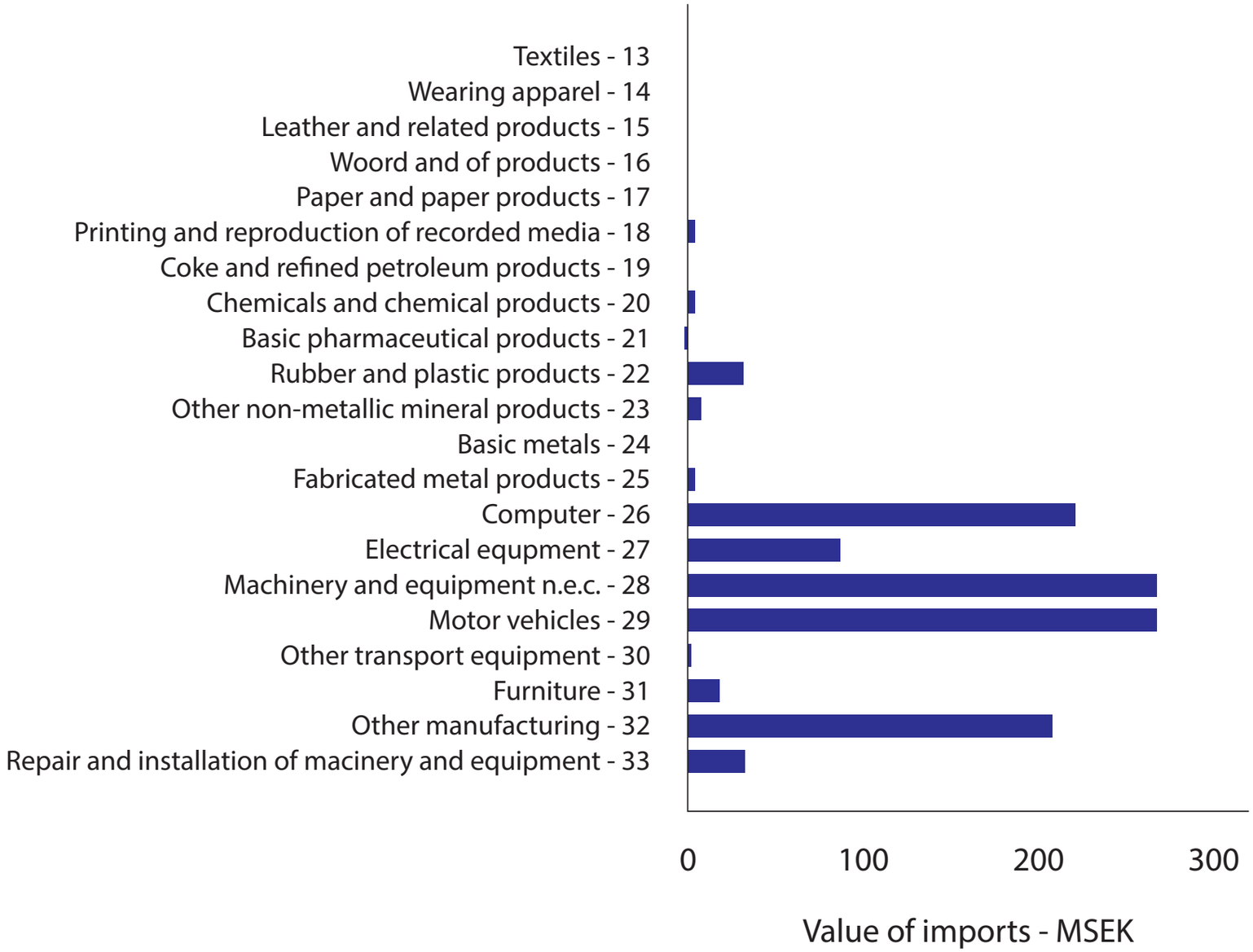
Swedish manufacturing imports from Thailand was concentrated in machinery and equipment (Sector 28) and computer and electronic products (sector 26) both in terms of value and number of importing business, shown in Figure 1.

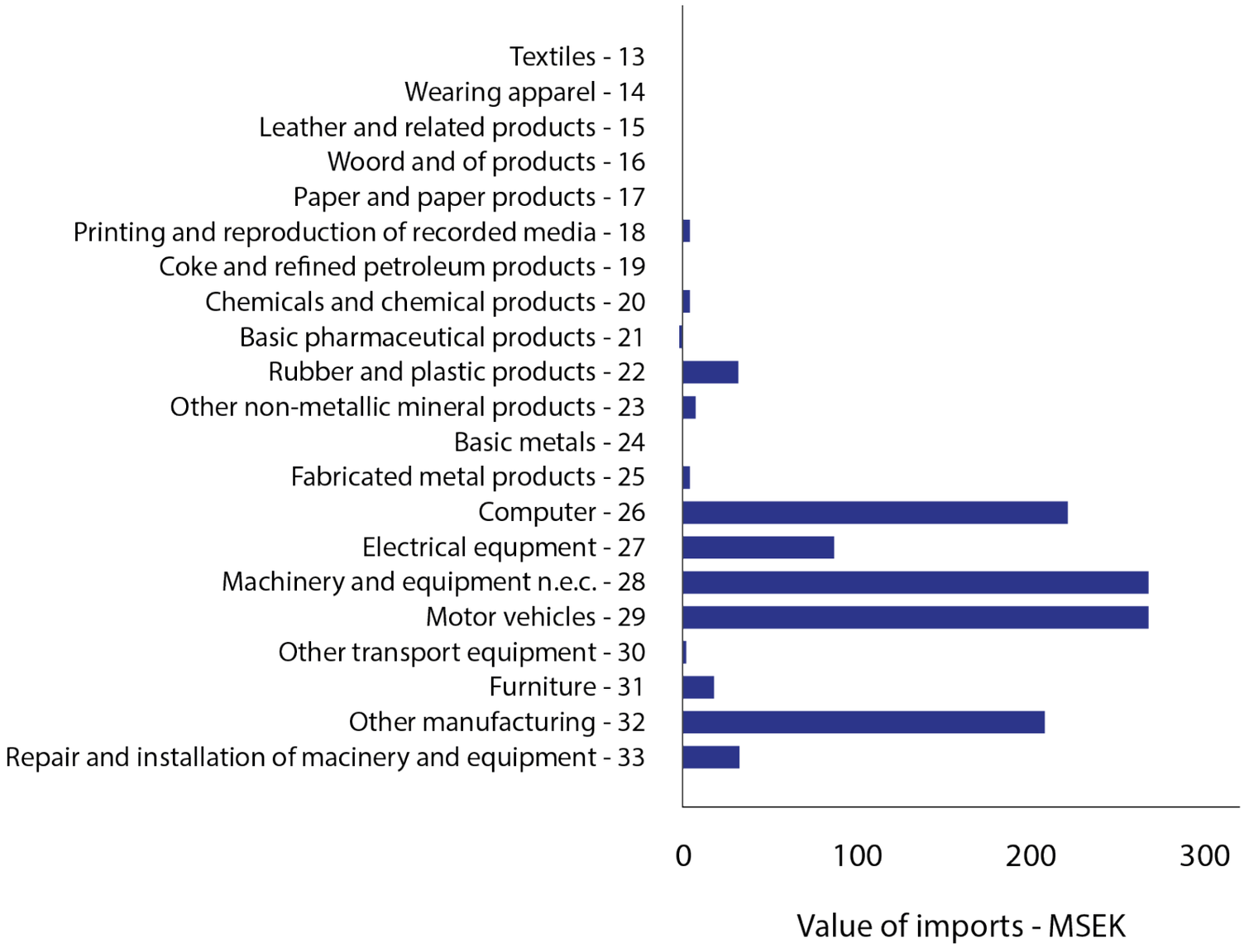
Estimating the impact of the flood on Swedish businesses requires careful study design. For our Thai flood study, we use firm-level data, including the products each business imports, and the countries from which these imports come from, over the period from 2006-2013.

Swedish businesses with an average of at least some (greater than zero) imports from Thailand in the two years prior to the flood (2009 and 2010) are assigned to the treated group, while all other Swedish firms that import during this period are assigned to the control group.

Figure 2 illustrates the divergence in imports between the treated and control groups of firms, the magnitude of the flood's impact is clear. Thai imports by Swedish businesses fell by around 90%: Swedish imports from Thailand were around €100 million lower in 2012, the year following the flood.

Figure 1. The pattern of Swedish imports from Thailand





Source: Statistics Sweden

Moreover, sales by exposed Swedish firms dropped 8% drop in 2012. This suggests the Thai flood caused a drop of about €3 billion in sales by Swedish business, a 30-fold amplification.

Interestingly, the adverse impacts to Swedish businesses persisted for two years through to 2013, even though Thai production had largely recovered within six months of the flood waters receding. This indicates that fixed costs in establishing links in supply networks may be substantial, and once severed, supplier-buyer relationships may be costly to re-establish (eg. Antras and Chor 2021).

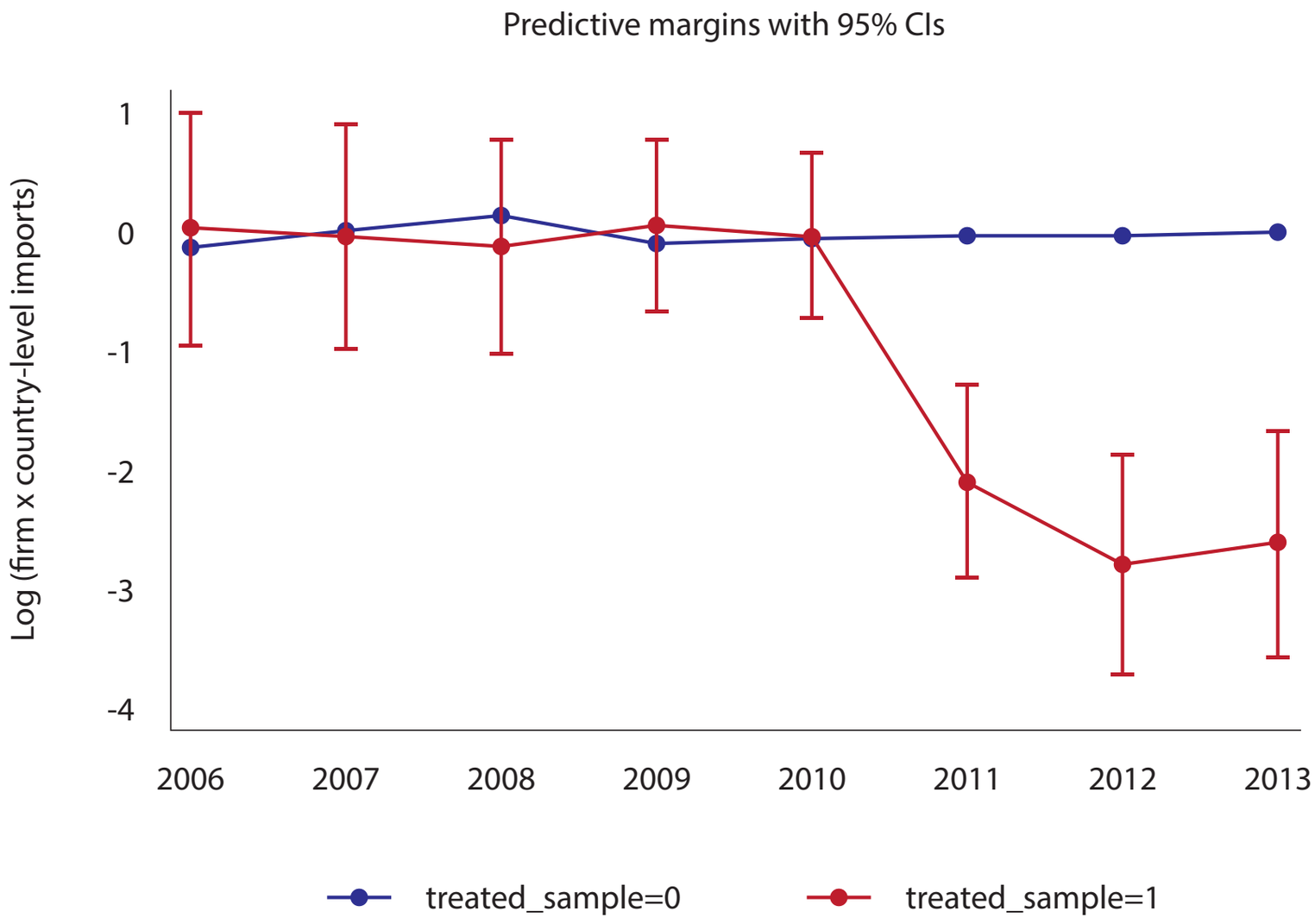
Swedish importers predominantly switched to other Asian suppliers, and there is weak evidence of reshoring (where Swedish businesses sourced alternative inputs from EU countries). Larger businesses were better at handling the shock, facing a smaller drop in the value of imports from Thailand than smaller businesses.

Geographical diversification of suppliers is also important in determining how well Swedish businesses weathered the shock. Exposed businesses that import a product from more than one country are almost completely shielded from the disruptions caused by the flood; it was easier for these firms to substitute to similar inputs from non-Thai countries of origin.

In contrast, businesses that imported a product from Thailand only were unable to source alternative suppliers of the goods affected by the flood. There were also strong negative horizontal effects. Swedish businesses cancelled orders of goods that were complementary to the goods they were unable to obtain from Thailand – imports of other goods from other countries fell by around 80%.

Overall, these new insights suggest that firms were poorly prepared to manage the disruptions arising from the flood, even though some firms hedged their operations with multiple sources of critical inputs.

Figure 2. The impact of the 2011 Thai flood



Source: Forslid and Sanctuary (2022).

Moreover, imports from Thailand were slow to recover as Swedish businesses turned to other countries to meet their needs for critical inputs that Thailand had been unable to supply. The fact that Sweden is a small economy far away from Thailand seems to have aggravated the effects of the shock. Multipliers are much higher than in other studies on large countries.

Similarly, we find that small businesses are worse hit by the shock than large firms, possible due to weaker negotiating power. These microeconomic insights help clarify aggregate effects of foreign extreme weather events on the home economy.

While individual firms may suffer significant losses from events like the Thai flood (Xu and Monteiro 2022), and the aggregate effects were non-negligible, securing alternative sources for critical inputs can help support better economic resilience to extreme weather at home. ■

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Fostering a sustainable digital transformation

Abeliansky *et al* discuss the two side effects of automation – increased inequality and a rise in carbon emissions – and propose a policy response to deal with both problems

Automation and digitalisation are progressing rapidly worldwide, auguring improved productivity and living standards but also the prospect of genuine social harm. This column discusses two side effects of automation – increased inequality and a rise in carbon emissions – and proposes a policy response to deal with both problems simultaneously.

By imposing a higher tax on automation-driven emissions and redistributing the proceeds so as to mitigate increased inequality through education and re-training, such a policy could reduce resistance to new technologies, increase skill levels, and foster the transition to cleaner electricity production.

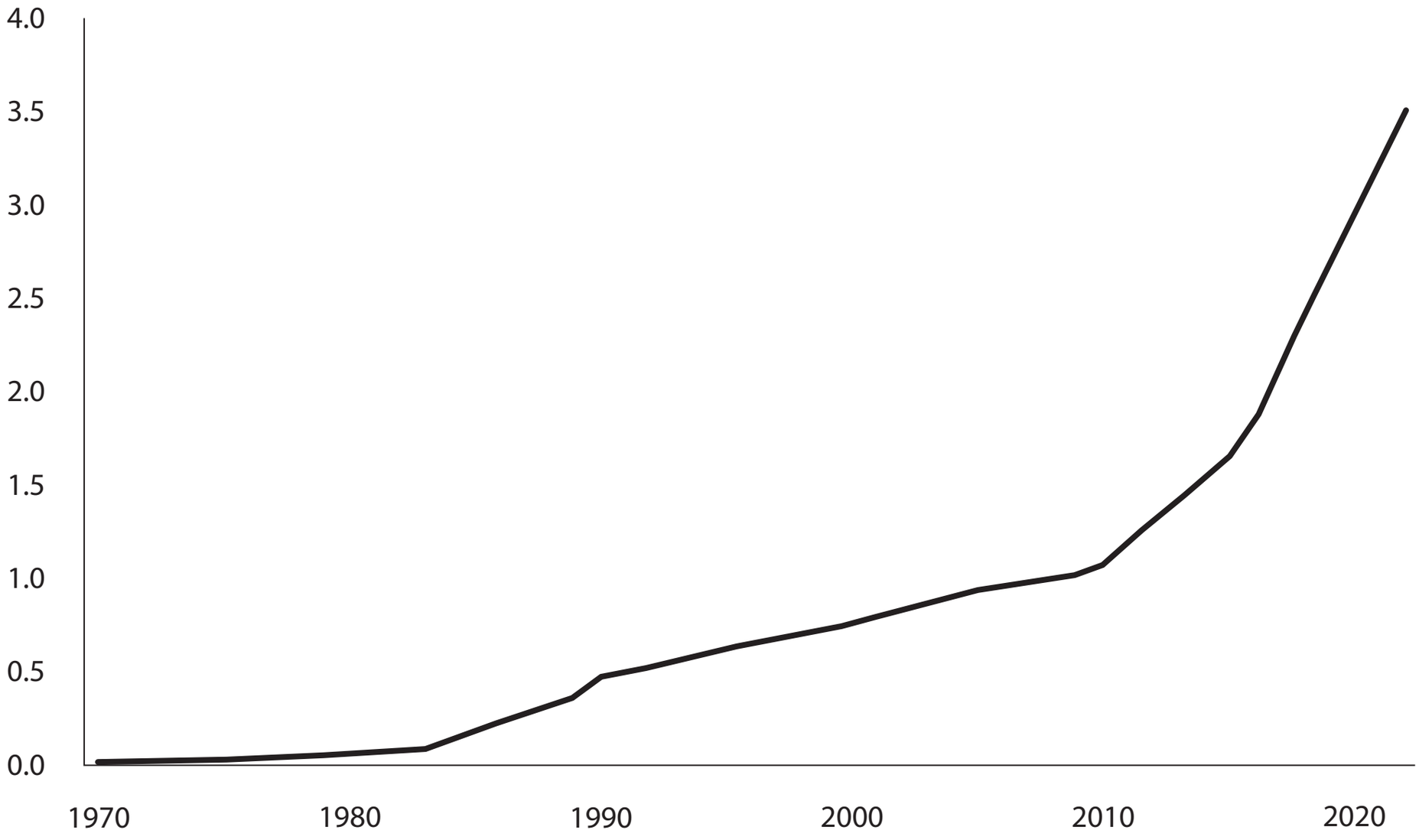
Automation, digitalisation, and artificial intelligence (AI) are progressing rapidly worldwide: robots increasingly substitute for humans in many assembly line tasks; 3D printers are used in the production of customised parts and medical implants; and AI-based models and devices are used to quickly diagnose disease, develop medical remedies, write reports, code, and generate inspiring ideas (*The Economist* 2014, Ford 2015, Brynjolfsson and McAfee 2016, Hu 2023).

Figure 1 illustrates the growth in automation based on one frequently used data source: the International Federation of Robotics (2016, 2017, 2018, 2022). The number of industrial robots[1] worldwide was negligible until the early 1990s, but has since increased steeply, by a factor of eight.

After the global financial crisis of 2007–2009, the growth rate of the number of robots increased markedly to about 10–15% per year (International Federation of Robotics 2022).

Most recently, the number of users of AI-based models has skyrocketed. ChatGPT, for example, surpassed 100 million active monthly users in January 2023, just two months after its launch (Hu 2023).

Figure 1. Worldwide stock of industrial robots (in millions of units)



Notes: International Federation of Robotics (2016, 2017, 2018, 2022) with authors' interpolations for the years lacking data.

While automation, digitalisation, and AI tend to raise productivity and per capita income (Graetz and Michaels 2018), they also raise several concerns. The first apprehension has to do with the potential for automation technologies and AI to replace human labour, and the associated fears of technological unemployment (Arntz *et al* 2017, Frey and Osborne 2017, Abeliansky *et al* 2020).

Policymakers might instead consider an automation tax, which would only be paid by a firm if and when it automated the production of a task and replaced a worker with a robot

A second concern relates to the role of automation and digitalisation in raising inequality levels. Because the corresponding technologies typically complement high-skilled workers but substitute for low-skilled workers, upward pressure is placed on the wages of the former and downward pressure on the wages of the latter, leading to greater wage inequality (Acemoglu and Restrepo 2018, Lankisch *et al* 2019).

Recent research suggests that AI increases the productivity of low-skill workers proportionately more than the productivity of high-skill workers (Brynjolfsson *et al* 2023) in terms of comparable tasks. Nevertheless, AI is used predominantly for tasks that are on average more skill-intensive (see eg. Marr 2023) such as coding and debugging, language translation, and summarising research results.

Humans are, as yet, not perfectly substitutable in these tasks, but are still required for appropriate and effective prompting, and for revising the output produced by AI. This stands in contrast to the use of industrial robots and 3D printers, which are able to perfectly substitute for (predominantly low-skilled) workers.

As a consequence, even if AI reduces the performance gap within given tasks, it could still increase inequality at the aggregate economic level.

The third concern has to do with the negative impact of robots, 3D printers, and AI on the labour share of income and its corresponding positive impact on the capital share (Eden and Gaggl 2018, Prettner 2019, Guimarães and Gil 2022a). This is because robots, 3D printers, and AI have properties resembling labour in the production process, and capital in terms of ownership.

Thus, their use transfers income from workers to capital owners and thereby reduces the labour income share. A final concern relates to the high electricity requirement of automation – in particular of AI. Because most countries

still use fossil fuels intensively in electricity production, this implies a potentially negative impact of automation, digitalisation, and (especially) AI on the efforts to mitigate climate change (Creutzig *et al* 2022).

Recent estimates by Patterson *et al* (2021) and Luccioni *et al* (2022) suggest that the training of the large language model GPT-3 required close to 1,300 megawatt-hours of electricity and led to more than 500 tonnes of carbon dioxide equivalent emissions.

These potentially negative aspects have led to calls for the implementation of 'robot taxes' (Dill 2017, Guerreiro *et al* 2022, Gasteiger and Prettner 2022). In this context, however, several drawbacks of such a tax should be considered.

Most immediate is the issue of what defines a robot and should therefore be used to delineate the tax base. The definition of an industrial robot, which replaces human labour alongside an assembly line, may be clear – but it is definitely unclear for algorithms that replace human labour in targeting ads to customers, in writing texts, or in coding.

In addition, because the use of robots, 3D printers, and AI raises productivity, a robot tax that impedes their general adoption would be associated with a loss of per capita income and a reduction in living standards (Prettner and Strulik 2020).

Policymakers might instead consider an automation tax, which would only be paid by a firm if and when it automated the production of a task and replaced a worker with a robot (ie. the automation tax is not paid by firms investing in robots upon entry).

Results suggest that a robot tax may have a much more negative impact on employment and wages than an automation tax (Guimarães and Gil 2022b), yet machines are usually not able to replace workers in all tasks, making the assessment of the replacement of workers by machines blurry in practice.

Moreover, it might be difficult to distinguish an automation-related job separation from other sorts of separations. This murkiness raises questions as to whether potential alternatives to a robot (or an automation) tax exist that could achieve similar outcomes without such drawbacks – or would at least minimise them.

In the following section, we propose a tax-subsidy scheme that may help alleviate automation-driven inequality and automation-driven emissions by linking them through one consistent policy response.

Solving two problems using one tax

One potential way to ensure a sustainable digital transformation is to link the negative economic and environmental consequences of automation and digitalisation by imposing a higher tax on carbon dioxide emissions and using some of the proceeds thereof to fund schemes for those who suffer negative consequences during the transition.

Such schemes could include:

(1) retraining those who lose their jobs because their skills become obsolete;

(2) ensuring more generally that the education system does not leave any children behind with inadequate skills for contemporary labour market success;

(3) providing (possibly temporary) public employment for displaced workers who struggle to find new jobs (eg. Kasy and Lehner 2023, who evaluate such a guaranteed job programme implemented in the Austrian municipality of Gramatneusiedl); and

(4) providing social security benefits in terms of unemployment insurance and health insurance for those who cannot get retrained or re-employed for various reasons (see Prettner and Bloom 2020 for an overview on the effects of different policy responses to automation).

If the proceeds are used to reduce distortionary taxes, the effects of such a policy may resemble the double dividend of environmental taxes (Goulder 1995, Bovenberg 1999).

The difference is that, in this case, the proceeds of the tax would be used to mitigate increases in inequality – thereby reducing resistance to the adoption of new technologies – and to foster the skill level of the population through education and re-training (eg. Peralta and Gil 2021, who show that a direct subsidy to low-skilled workers displaced by automation is roughly neutral in terms of economic growth). Both the tax and the subsidy are expected to be beneficial to long-run economic growth.

To summarise, the crucial advantages of a tax-subsidy scheme that links the negative environmental externalities of automation and digitalisation with the undesired inequality effects are as follows:

- The negative pollution externalities of the increasing use of robots and AI could be internalised.
- Those who suffer due to automation and digitalisation during the transition could be compensated (at least partly) by the proceeds of such a tax, which should help contain a further rise in inequality.

- The problem of defining a robot to designate what is being taxed – and all associated bureaucratic complications in executing robot taxation – do not occur.

- The resistance to new technologies that are beneficial on average and at the aggregate level could be reduced, with corresponding long-run benefits for economic growth and development.

- As a consequence of all the previous items, overall living standards could be raised.

- In addition, and in contrast to a pure robot tax, a higher emissions tax would provide an additional incentive to switch from polluting sources of electricity generation to cleaner technologies, thereby fostering their adoption and innovation.

Overall, a tax-subsidy scheme along the lines proposed here could be an important instrument to ensuring a sustainable digital transformation that keeps both emissions and inequality in check.

Conclusions

Automation and digitalisation improve productivity and living standards, but tend to have negative social side effects by creating 'losers' from the transformation and negative environmental side effects by increasing emissions due to higher electricity demand.

To compensate the losers, robot taxes have been proposed. Even if these taxes could be implemented from a practical perspective, which is highly uncertain, they reduce efficiency and living standards by slowing the adoption of technologies that rely on automation and digitalisation.

To overcome this problem and foster a sustainable digital transformation, we propose a policy response that links its two negative side effects – increasing inequality and higher emissions.

The environmental externalities from the transition to automation and digitalisation could be internalised by a higher tax on emissions, while the proceeds of this tax could be redistributed to compensate the losers from the transition.

Implementing such a scheme would also be helpful for reducing resistance to the new technologies, increasing the skill level of the population, and fostering a transition to cleaner electricity production. All these effects would be in line with the goal of ensuring a sustainable digital transformation.

Thus, it is important to start this discussion and to evaluate the effects of such a proposed tax-subsidy scheme quantitatively. Of particular significance is the question of the appropriate size of such a tax and its fiscal impact. ■

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Endnote

1. The International Organization for Standardization (ISO) defines an industrial robot as an "automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or fixed to a mobile platform for use in automation applications in an industrial environment."

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