

## Abstract

This study addresses the transition to a carbon-neutral economy necessary to curtail climate change impacts, focusing on three potential transition pathways with varying emissions reduction rates. It evaluates associated economic costs, investment needs and financial risks for corporates, households, and financial institutions within the euro area. Innovations in the research include short-term transition scenarios, granular sector dynamics, and energy-specific country factors. The study employs a diverse dataset that includes climate, energy, and financial information for millions of firms within the euro area credit register and securities database, and country-level data on households. Results indicate immediate and decisive actions towards carbon neutrality provide significant benefits for the euro area economy and financial system, minimizing financial risks without causing financial stability concerns, provided firms and households finance their green investments orderly. However, specific sectors and credit exposures require careful monitoring during the transition.

## Non- technical summary

Climate change presents critical threats to natural, human, and economic systems, calling for a prompt transition towards carbon neutrality by 2050. So far, climate assessments, including the ECB's climate stress test, have demonstrated the significance of an immediate shift to reduce long-term physical risks. However, achieving a maximum temperature rise of 1.5°C by the end of the century seems currently unattainable. The Russian-Ukraine conflict underlines the risks of high fossil fuel dependency, paving the way for a faster transition, or a potential stagnation due to the current economic and energy situation. This paper evaluates three potential transition pathways up to 2030. Firstly, the accelerated transition scenario suggests that the ongoing energy crisis could spur an immediate green shift. Secondly, the late-push transition scenario involves a green shift from 2025 due to recent macroeconomic challenges, leading to the same emission reductions by 2030 but at a higher cost. Lastly, the delayed transition scenario expects a slower transition, less costly but only compatible with a temperature rise of approximately +2.5°C at the century's end. The study enhances the ECB climate stress test framework by detailing the current European energy environment and its future evolution and building three short-term scenarios. It analyses the effect of the green transition and energy dynamics on non-financial corporates and households within these scenarios. It also describes the impact of the three scenarios on euro area financial institutions up to 2030, without accounting for the benefits of emissions reductions. The study reveals that an immediate and decisive transition (accelerated transition) would be most beneficial, limiting climate change effects and reducing energy costs significantly. Delayed transitions increase financial risks and fail to meet the desired emission reduction targets.

## 1 Introduction

The imminent threat posed by climate change has prompted a global response to mitigate its damaging effects. Governments worldwide agreed to the 2015 Paris Agreement, which entailed limiting global temperatures to below 2°C above pre-industrial levels and, ideally, keeping the increase to 1.5°C. This agreement, supplemented by a transition to a net-zero economy, aims to counter climate change while sustaining economic growth and preserving the environment. The European Central Bank's economy-wide climate stress test showed short-term costs incurred through the transition to green energy, but these were compensated by long-term benefits. The stress test also revealed that corporations and banks faced notable

risks with consequences for financial stability if they did not adjust. Turning the European Union into a sustainable economy is a complex task demanding significant investment and transformation in European energy landscapes. Despite having reduced emissions by 30% since 1990 and tripling the share of renewable energy—the path ahead remains steep. Despite the challenges, a green transition is being deemed essential. There exists a growing interest in charting out how to achieve a net-zero economy and its impact on the economy as well as the financial system amongst policy makers and industry experts. The challenges of transitioning towards a green economy also bring along certain risks. As a result, energy costs per company would rise as brown energy sources would become more expensive due to carbon taxes and supply-side bottlenecks. Furthermore, companies would need to invest more to transition from brown energy to renewable energy and become more energy efficient. The recent geopolitical developments, such as the Russian war in Ukraine, have altered the macroeconomic and energy environment, making the transition more challenging. This geopolitical event has resulted in reduced gas availability in Europe and led to a significant increase in electricity and gas prices, caused by energy supply shortages and inflationary pressures. In response to these changes, three potential transition paths have been considered: accelerated transition, late-push transition, and delayed transition. The scenarios considered show that an earlier transition leads to smaller financial risk, which consequently requires less policy support to offset the costs. An accelerated transition is preferable to a late-push transition, as the latter might lead to energy price shocks and adversely impact the profitability of energy-intensive firms. In conclusion, irrespective of the scenario, firms in mining, manufacturing and utility industries would be most affected. Banks would see an increase in expected losses and provisioning needs in the short term, although the impact would depend on the portfolio size.

## **2 The European energy context**

The European Union's (EU) energy consumption primarily stemmed from oil products and natural gas, contributing to 65% of their total energy usage in 2021. Although reliance on such carbon-intensive sources remains high, the consumption of renewable energy has tripled over the past 30 years, now accounting for nearly 20% of overall consumption. Around 56% of the available energy in the EU in 2021 was imported from non-European Union (EU) countries, predominantly Russia. However, political developments in recent years, including Russia's invasion of Ukraine in 2022, have caused significant hikes in energy prices and reduced gas supplies to EU nations. Despite the negative impacts of climate change becoming increasingly evident, limited action has been undertaken to transition towards a net-zero economy. As of 2021, EU greenhouse gas emissions had rebounded following a dip during the COVID-19 pandemic. Geopolitical events recently have impeded green transition efforts, prompting various EU governments to enter long-term energy contracts with third countries. Despite the implementation of the 'Fit for 55' package and the European Green Deal, current measures fall short of the required progress towards the Paris Agreement's +1.5°C target.

## **3 Scenario narrative**

In this text, the importance of timely and accurate scenario design is highlighted in order to gain insight into the different potential pathways to a carbon-neutral economy. Recent geopolitical events, such as the energy crisis triggered by the Russian war in Ukraine, have significant implications for the economy and net-zero transition pathways. As a result, scenario design needs to reflect these developments. This exercise focuses on three plausible transition pathways to a net-zero economy by 2030. The scenarios differ in terms of

transition timeliness and emissions reductions. The first scenario is an accelerated transition, driven by high fossil fuel prices and funding flows. The second scenario is a late-push transition, where measures to alleviate the energy crisis only result in minor decreases in carbon intensity. The third scenario is a delayed transition, starting when the economy has recovered from the shock, but not achieving the emissions reduction targets required to limit the temperature increase by the end of the century. The scenarios incorporate factors such as sectoral dynamics, GHG emissions pathways, decarbonization of energy consumption, and the impact on energy prices. Investment in green technologies, including carbon mitigation activities and renewable energy capacity, is an essential component of the scenarios. The economic impact, captured by sectoral gross value added (GVA), varies across the scenarios. Under the accelerated transition, GVA experiences significant growth, while the late-push and delayed transitions show slower growth. The analysis presented in this text provides a comprehensive and granular understanding of the potential pathways to a carbon-neutral economy.

## **4 Impact on corporates**

The analysis in this section used the framework established for the first European Central Bank (ECB) top-down climate stress test and refined models for firms to assess the impact of three transition pathways on their balance sheets and probability of default. Energy-related and sectoral dynamics were accounted for and models were recalibrated based on more recent data with extended coverage. Firm-level models estimated the impact of transition risk on firms' energy expenses, green investments, and energy-sector revenues, which were used to estimate firm-level probabilities of default based on changes in profitability and leverage. In the short term, transition risk could impact firms' profitability through a supply-side, and partially carbon-tax-induced, energy price shock. Firms would invest in carbon mitigation activities, funded mainly through loans, resulting in increased indebtedness and interest rate expenses. The transition to a net-zero emissions economy would lead to the gradual phasing out of coal and gas production, creating winners and losers. The impact of transition risk would largely be heterogeneous across sectors, with the strongest increases in credit risk seen in the electricity, mining, and manufacturing sectors.

## **5 Impact on households**

The green transition would financially impact households and lead to spill overs into the financial sector due to households and non-financial corporations (NFCs) contributing to around 40% and 37% respectively of euro area banks' total loan exposures. Banks may face significant implications from transition risks as the household sector represents a major portion of their counterparty. Among ECB top-down climate stress tests, one focused on evaluating the impact of climate risk on NFCs and banks' corporate portfolios. In the green transition, households will be affected through their energy consumption and building energy efficiency. According to the International Energy Agency, about 8% of global greenhouse gas (GHG) emissions could be cut through behavioural changes, such as using energy-efficient appliances or choosing greener transport options. The European Commission mandates ambitious energy efficiency standards for buildings under the "Fit for 55" package. Changes in energy efficiency requirements could adversely impact the value of homeowners' properties and their home equity. Furthermore, improving the energy efficiency of buildings could force homeowners to take on debt, potentially impacting their solvency. The household credit risk would be directly affected by household energy expenses. More ambitious emission reductions under accelerated and late-push scenarios would require households to make

higher investments.

## 6 Transmission to the financial system

The last module of this assessment focuses on the transmission of transition risk to the financial system through credit risk and market risk channels, using a static balance sheet assumption. The impact on euro area banks and non-bank financial institutions is examined. For banks, the exposure to energy-intensive sectors makes them vulnerable to transition risk, with a substantial share of corporate loan portfolios directed towards these sectors. Large banks are more exposed to potential losses due to their less collateralized loan exposures. The transmission of transition risk from households to banks is assessed based on the projected deterioration in the credit quality of banks' household loan portfolios. Banks' credit risk would increase with transition risk, with the highest increase among banks in the upper risk quartile. The best trade-off between credit and transition risks would be achieved under an accelerated transition scenario. The market risk channel affects banks' corporate bond portfolios, with potential losses ranging from 3% to 10% of portfolio fair value across different scenarios. Non-bank financial institutions also face substantial market risk impact, with losses varying across sectors and countries. Insurance corporations and pension funds have a higher exposure to the electricity, gas, and steam sector. Future analysis could consider non-euro area firms, sovereign bonds, non-linear pricing models, and dynamic portfolio adjustments.

## 7 Conclusions

The paper discusses the development of a climate stress test by the European Central Bank (ECB), which seeks to understand the euro-area economy's vulnerability to varying potential transition scenarios to a net-zero emissions economy. To frame the climate stress test, the ECB enhanced the original framework by: considering euro-area macroeconomic trends, examining sector-level dynamics, and assessing impacts of differing transition timings on real economy and financial institutions. The study did not cover feedback loops between the real economy and the financial sector and thus suggested this as an area for further research. Three scenarios were designed: 'accelerated transition', 'late-push transition', and 'delayed transition', differing primarily in timing and intensity of emissions reductions. The study finds that an accelerated transition offers significant benefits to firms, households, and the financial system, despite leading to short-term costs due to rapid increases in energy prices. Conversely, a late transition might increase physical risk exposure for firms and households due to increased energy prices and less renewable energy capacity. Impacts would be highly heterogeneous across sectors; firms in mining, manufacturing, and utility industries would be most affected by transition risks. While transitions are expected to increase banks' expected losses in the short-medium term, it does not raise concerns for the euro area's financial stability. The stress test findings align with previous exercises conducted by Financial Stability Board and NGFS member institutions.

## References

This is a list of references for a publication related to the financial impacts of climate change. Some notable works cited include a staff report led by Acharya et al. (2023) from the Federal Reserve Bank of New York on "Climate Stress Testing," a working paper by Adrian, T., et al. (2022) from the International Monetary Fund on "The Great Carbon Arbitrage," and a paper by

Alogoskoufis, S., et al. (2021) on the methodology and results of an "ECB economy-wide climate stress test." Also included are reports from organizations such as the Bank of Canada, Bank of England, and the International Energy Agency, publications from ECB Banking Supervision and the European Commission on climate-related financial stability and transition strategies, and journal articles on diverse aspects of the topic. Other sources include technical reports from the International Renewable Energy Agency and policy documents like the Paris Agreement (2015). Some research topics include renewable energy market updates, climate change impacts and adaptation, financial stability risks related to household inequality, and green energy transition risk stress tests.

## **Annex**

This is a list of references for a publication related to the financial impacts of climate change. Some notable works cited include a staff report led by Acharya et al. (2023) from the Federal Reserve Bank of New York on "Climate Stress Testing," a working paper by Adrian, T., et al. (2022) from the International Monetary Fund on "The Great Carbon Arbitrage," and a paper by Alogoskoufis, S., et al. (2021) on the methodology and results of an "ECB economy-wide climate stress test." Also included are reports from organizations such as the Bank of Canada, Bank of England, and the International Energy Agency, publications from ECB Banking Supervision and the European Commission on climate-related financial stability and transition strategies, and journal articles on diverse aspects of the topic. Other sources include technical reports from the International Renewable Energy Agency and policy documents like the Paris Agreement (2015). Some research topics include renewable energy market updates, climate change impacts and adaptation, financial stability risks related to household inequality, and green energy transition risk stress tests.