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The double materiality of climate physical and transition risks in the euro area*

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Keywords: double materiality, NGFS scenarios, climate sentiments, climate policy credibility, EIRIN Stock-Flow Consistent model.

Our research investigates the double materiality of climate physical and transition risks in the euro area economy and banking sector. First, by tailoring the EIRIN Stock-Flow Consistent model, we provide a dynamic balance sheet assessment of the Network for Greening the Financial System scenarios. We find that an orderly transition achieves early co-benefits by reducing carbon emissions (12% less in 2040 than in 2020) while supporting growth in economic output. In contrast, a disorderly transition worsens the euro area economic performance and financial stability, while high physical risks can make real GDP to shrink by 12,5% in 2050, in comparison with an orderly transition. Second, by extending the concept of climate sentiments, we analyse how firms' expectations about climate policy credibility affect their investment decision in high or low-carbon goods, and the impact on economic decarbonization. We find that firms that trust an orderly policy introduction and anticipate carbon price scenarios, switch earlier to low-carbon investments. This, in turn, contributes to decrease the risk of stranded assets for the economy and for the banking sector. Our results highlight the crucial role of early and credible climate policies to signal investors in the low-carbon transition.

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Introduction

Central banks and financial supervisors have recognised the importance to analyse climate-related financial risks and many of them joined the Network for Greening the Financial System (NGFS). In partnership with an expert group of climate scientists and economists, the NGFS has developed climate scenarios (NGFS 2020) that develop trajectories for economic activities and energy technologies (e.g. fossil fuel or renewable based), conditioned to an early and credible introduction of carbon pricing (the orderly scenarios), or a late and sudden policy introduction (the disorderly scenario), or to current policy (the hot house world). The NGFS scenarios provide a common reference for understanding how climate change and climate policy could evolve and are used by both financial authorities and investors in their climate stress test exercises (see e.g. Allen et al. 2020, Clerc et al. 2021). For instance, the European Central Bank (ECB) economy-wide climate stress test, published in September 2021, has used the first vintage of NGFS scenarios to assess the implications of transition and physical risk on a set of approximately 4 million companies and 1,600 consolidated banking groups in the euro area (Alogoskoufis et al. 2021). Similarly, the second vintage of NGFS scenarios has been used by ECB Banking Supervision to perform the 2022 climate stress test published in July this year, to assess climate stress test capabilities for 104 participating banks (ECB 2022a). Furthermore, the ECB/ESRB report on the macroprudential challenge of climate change, published in July 2022, also leverages the NGFS scenarios to build short-term impact assessments on corporates and financial institutions (ECB 2022b).

These studies contributed to assess and communicate the impact of NGFS scenarios with climate transition and physical risks on the economy and finance. Thus, investors looking at these scenarios may form expectations about the future profitability of high-carbon and low-carbon activities and adjust their investment decisions accordingly. For instance, if banks deem the transition policies credible, they could revise their financial risk assessment for high and low-carbon firms, by respectively increasing and decreasing the cost of capital. This, in turn, can influence firms' investments. Similarly, if firms deem such scenarios credible, they can anticipate the impact of the carbon tax in their Net Present Value (NPV) and switch earlier from high-carbon to low-carbon investments. The importance of analysing feedback from investors' expectations about climate scenarios and their adjustment in investments in the economy has been recently recognized (Battiston et al. 2021, Krieblieh et al. 2022). Assessing this feedback loop is important to study the double materiality of climate risks (European Commission 2019, Boissinot et al. 2022), from the point of view of investors and firms, and to understand the costs and the feasibility of the transition.

In Gourdel et al. (2022) we address this gap. By tailoring the EIRIN Stock-Flow Consistent (SFC) model (Monasterolo and Raberto 2018, Dunz et al. 2021a) we first provide an assessment of the impact of the NGFS scenarios of physical and transition risks in the euro area economy and banking sector. We focus on the credit and bonds markets, and on commercial banks and the ECB as financial actors. Then, we extend the concept of climate sentiments (Dunz et al. 2021b) to firms. We assess how firms' expectations about climate policy credibility affect their investment in high or low-carbon goods, and we analyse the impact on economic decarbonization. Building on the results, we discuss implications for climate financial policies aimed to tame climate risks.

The double materiality of climate physical and transition risks

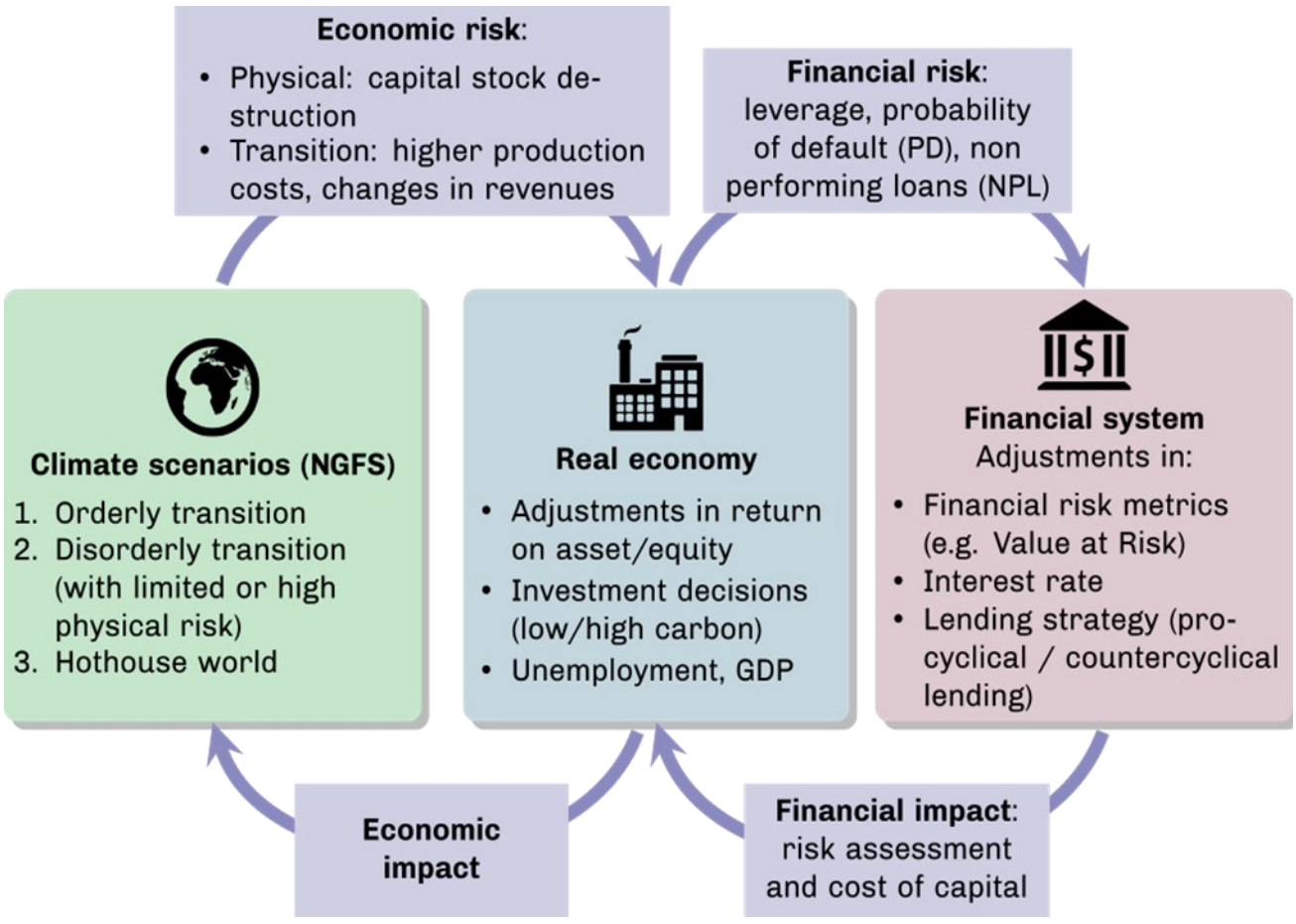
Capturing the finance-economy-climate feedback is fundamental to assess the double materiality of climate risks. It enables us to translate investors' expectations about climate change and policy scenarios into a revision of their risk assessment and cost of capital, which in turn affects the feasibility of transition scenarios (Battiston et al. 2021).

Figure 1 represents the double materiality feedbacks and how they are implemented in the EIRIN model. The first feedback generates from the NGFS scenarios and moves to the economy and finance (top of the figure). Climate physical and transition risks impact firms' performance, leading to adjustments in firms' profitability, investment decisions and economic performance more broadly (GDP, unemployment, inflation, etc). Financial actors (e.g. banks), which are have invested in firms (e.g. via securities and/or loans) that will be affected by climate risks, experience adjustments in probability of default (PD), non-performing loans (NPL) and in portfolio risk metrics, e.g. the Value at Risk (VaR).

The second feedback originates from investors' adjustment in expectations about climate physical and transition risks and impacts the economy and the realization of the climate scenarios. Investors that look at the impact of NGFS climate scenarios on firms and on the economy, and trust them, may adjust their climate-financial risk assessment, leading to adjustments in the cost of capital for firms, based on firms' energy technology and climate risk exposure. Further, firms that find the carbon tax scenarios credible would adjust their investment decisions and switch earlier from high-carbon to low-carbon activities. This, in turn, fosters a structural change in the economy and affects the realisation of climate transition and physical risk scenarios.

Nevertheless, an approach to assess the double materiality of climate risks in the economy and finance is still missing. This, in turn, limits the understanding by central banks and financial supervisors of the potential policy response.

Figure 1: The double materiality of climate physical and transition risks in the economy and finance



Sources: Gourdel et al. (2022).

Methodology

EIRIN is a Stock-Flow Consistent (SFC) model of an open economy composed by heterogeneous and interacting agents of the real economy and financial system. Agents are heterogeneous in terms of source of income and wealth, contribution to greenhouse gas (GHG) emissions, energy technology profile, and preferences. The EIRIN economy include wage and capital-income earning households, energy firms, capital good producers, consumption goods and service firms, a bank, the government, the central bank (which mimics the ECB), and a foreign sector. Agents interact through a set of real markets (consumption goods and services, energy, labour, and the raw materials market), and financial markets (sovereign bonds and equity). EIRIN's agents are represented as a network of interconnected balance sheets calibrated on real data[1] in order to trace a direct correspondence between stocks and flows and increase the relevance of results. This rigorous accounting framework displays the dynamics of agents' balance sheets, and to analyse the direct impact of shocks on agents, at the level of balance sheet entry; *the indirect impact of shocks* on macroeconomic variables (e.g. GDP, interest rate) and financial variables, e.g. banks' probability of default (PD) and non-performing loans (NPL); *the reinforcing feedbacks* in the financial sector that could amplify the shocks, leading to cascading losses. EIRIN is a behavioural model, meaning that agents' decisions are informed by behavioural rules and heuristics. In particular, EIRIN's agents are endowed with adaptive expectations about the future and can internalise policy changes, which feed into their intertemporal cost-benefit calculation for investment decisions. The departure from traditional forward-looking expectations allows us to consider the impact of climate uncertainty, lack of market coordination and potential mispricing. In addition, this feature contributes to understand the drivers of out-of-equilibrium states in the economy and the potential amplification effects on investors' balance sheets.

NGFS scenarios of physical and transition risks: economic and financial transmission channels

Climate transition and physical risks are obtained from the trajectories of the NGFS scenarios[2] of orderly and disorderly transitions, and hot house world. Climate transition risk is related to the way (either orderly or disorderly) in which the carbon tax is introduced, leading to different trajectories of carbon pricing (in US$2010/t CO2) across scenarios. The orderly transition scenario assumes an immediate and gradual increase in carbon prices in the case of the orderly scenario, thus facilitating the transition to a low-carbon economy. In contrast, the disorderly scenario assumes a later and sudden increase in carbon prices, thus triggering sharper emission reductions to meet the Paris Agreement. The hot house scenario considers the current policies in use, i.e. a low carbon tax in place (about 13 USD/ton of carbon).

In EIRIN, climate transition risk originates as a demand shock to the euro area economy. The introduction of a carbon tax (consistent with the NGFS scenarios) and other climate policies such as green subsidies, negatively affect the demand for fossil fuels-based energy and for high-carbon goods, and the cost of production of high-carbon firms. Conversely, climate policies positively affect the demand and value of green assets. Due to lower demand and higher costs, high-carbon firms start to lay-off workers, leading to indirect effects in the economy on investments, unemployment, households' consumption and GDP growth. Adjustments in economic performance, in turn, affect banks' financial indicators, i.e. NPL, PD, leverage, and overall the banks' financial stability. Economic and financial shocks affect government's fiscal revenues, budget balance, and contribute to the building up of sovereign risk.

[1] We use publicly available socioeconomic and financial information, as well as supervisory data when provided.

[2] We used the NGFS 2020 scenarios for comparability with ECB's climate stress test results 2021.

Climate physical risk (e.g. floods) enters the economy by destroying productive capital and infrastructures, which in turn impact on firms' production capacity (direct impact) via shocks on production factors (e.g. capital, labour, energy). Floods represent a supply shock that limits firms' ability to serve demand. In the short run, firms cannot easily substitute input factors, and start to lay-off workers. Unemployment increases and lowers households' income, indirectly weakening workers' wage bargaining power, thus lowering households' consumption and real GDP. Shocks on firms' performance translate into shocks on the financial performance of banks, altering their financial risk metrics and financial stability. The shock can then affect sovereign risk via lower tax revenues (due to lower economic activity in the aftermath of the disaster) and higher fiscal and sovereign debt (due to fiscal spending and potential debt issuance to support reconstruction).

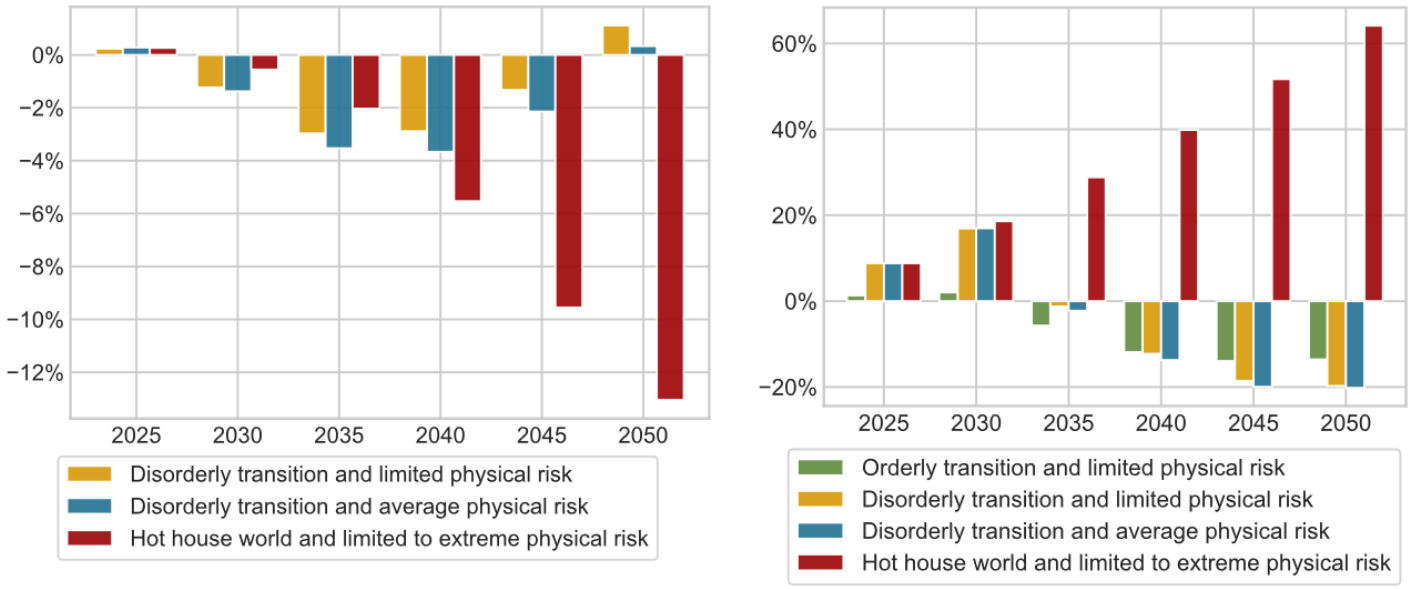
An orderly transition fosters euro area GHG emissions reduction, economic and financial stability

Results show that orderly, disorderly and hot house world scenarios have very different implications on GHG emissions and GDP growth in the euro area (Figure 2). Figure 2 (left) shows that the orderly transition scenario implies short-term, yet limited, costs to economic growth (0.3% less than the other scenarios in 2025). However, an orderly transition achieves important, and early, co-benefits in terms of lower carbon emissions (-12% in 2040 relative to 2020) and strengthened financial stability. After performing slightly worse in the short-term, GDP in the orderly transition outperforms the disorderly and hot house world scenarios already in 2030. In contrast, a disorderly transition scenario leads to a negative impact on real GDP (-2.8%) by 2035 compared to the orderly scenario. This negative GDP impact is amplified when physical risks are more severe (-3.3% in 2035). Finally, the scenario with current policies, i.e. the hot house world, results in a more significant negative GPD growth impact of -4.7% by 2040 compared to the orderly transition scenario, due to high physical risks.

Note that our shock results are large in magnitude, and larger than the ones obtained in previous supervisory exercises (see e.g. Alogoskoufis et al. 2021, Allen et al. 2020). However, the shocks should be considered as a lower bound and thus conservative, since the NGFS scenarios do not model sufficiently the acute physical risks, nor their potential compounding with other risks and could therefore underestimate the economic and financial impacts of climate risks (Ranger et al. 2022).

Figure 2 (right) shows large differences in GHG emissions across NGFS scenarios. GHG emissions increase considerably in the hot house world scenario compared to 2020 levels, while the orderly transition scenario shows the earliest emission decrease, due to decoupling of emissions from GDP growth. An orderly transition leads to the most effective GHG emissions reduction, while in the disorderly transition scenarios policies are implemented later, leading to emission reduction only after 2030. While emission levels converge between the orderly and disorderly transition scenarios by design of NGFS scenarios, their cumulative difference over the entire simulation remains sizeable. The large emission reduction stems from the change in energy production. In the orderly scenario, the increase in renewable energy is gradual, leading to smaller financial impacts. In contrast, in the disorderly scenario, the increase is sudden and materializes later, leading to abrupt cost adjustments in the other economic sectors.

Figure 2: Euro area real GDP, percentage deviation from the orderly transition scenario (%, left panel) and additional GHG emissions in different scenarios (% change in comparison to 2020, right panel).

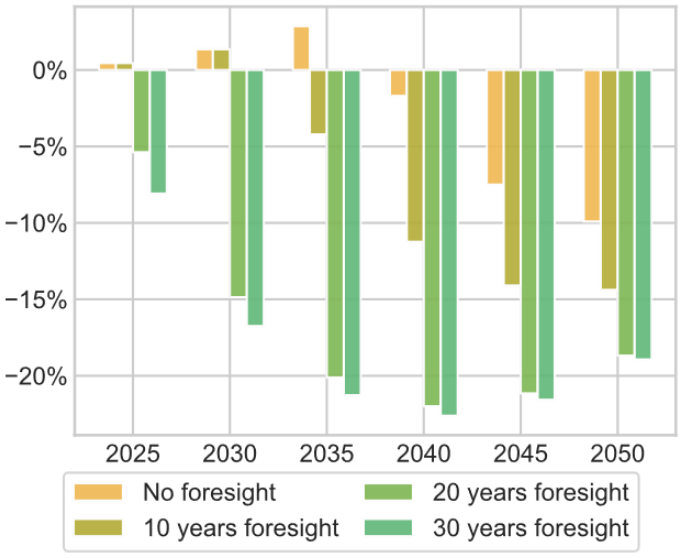


Note: Values displayed are for one year, given for a subset of years only, indicated by the x-axis.

Firms' climate sentiments play a main role to support an orderly low-carbon transition

In Figure 3 we consider the role of firms' expectations about climate impacts and climate policies, i.e. the "climate sentiment" (Dunz et al. 2021b) in the transition. Two important results emerge. First, if firms believe in the early introduction of an ambitious carbon tax and start to internalize the scenarios of carbon prices in their NPV assessment, an earlier energy transition could occur, promoting economic decarbonization. This effect is particularly pronounced when firms extend their policy anticipation up to 20 years for their NPV assessment, resulting in 20% less emissions from 2035 onwards compared to a case with no anticipation. Changes become more limited beyond that horizon, because the carbon price path stabilises then. The impacts of firms' climate sentiments on growth and unemployment are very contained, meaning that there is no trade-off in encouraging this anticipation.

Figure 3: Impact of firms' climate sentiments on economic decarbonization.



Note: The figure shows the change in euro area GHG emissions for selected years (as a percentage deviation from the 2020 level) as a result of firms' anticipation of orderly carbon tax introduction (the NGFS orderly transition scenarios) and consequent adjustment in investment decisions in high and low-carbon activities.

Second, the longer the investment horizon of firms, the higher the credit in the initial phase of the simulation. This is because the price of green capital is still comparatively high, and because in the short term, investment decisions would be less profitable. Thus, the benefits from lowering its carbon tax payments appear when the carbon price does reach the levels that were anticipated.

Policy implications

Our analysis not only confirms the importance of the double materiality principle for a more comprehensive assessment of economic and financial impacts of climate scenarios, but also supports the calibration of prudential measures and instruments to account for and internalise such principle. On the one hand, our results show the relevance for policymakers to credibly commit to a carbon price path, in order to foster firms' climate sentiments and the low-carbon transition, with very limited – and temporary – costs for the economy. On the other hand, our results show the importance of firms and banks' internalization of climate scenarios in their investment decisions, in order to ensure an orderly low-carbon transition and limit climate physical risks. Implications for central banks and financial supervisors include the importance of assessing the double materiality of climate risks in their climate stress tests exercises. In particular, regulators' models should account for the interplay between the economy and the financial sector, including the expectations and reactions of the main actors, in order to correctly weight the costs, opportunities and likelihood of a green transition. Indeed, our results show that firms' climate sentiments can play a main role in the realization of climate transition, with important implications for future physical risks. In this regard, it should be noted that the specific forward-looking nature of climate risks requires an appropriate policy calibration. This means considering future costs and benefits of the policy not only depending on possible future climate scenarios, but also on firms and banks' behaviours, which can ultimately affect the realization of climate scenarios and in turn affect their own risk profiles.

Finally, our analysis confirms the current limitations of the NGFS scenarios for risk assessment (Ranger et al. 2022), suggesting the importance to include asset-level physical risk (Bressan et al. 2022) and compound physical risk (Dunz et al. 2021b) in supervisory climate stress tests. The current lack of climate sentiments alongside a deep understanding of acute physical risk underestimate the future impact of climate risk and mask the additional benefits that would derive from an orderly transition. In this regard, a modelling framework that fully accounts for the consequences of no policy action on GDP shocks, combined with the contribution of investors to the realization (or not) of the transition, via their expectations and investment decisions, is essential for strengthening climate stress tests.

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