GENERALI ASSET MANAGEMENT

# CORE MATTERS

## Climate change: quantifying the costs of acting too late

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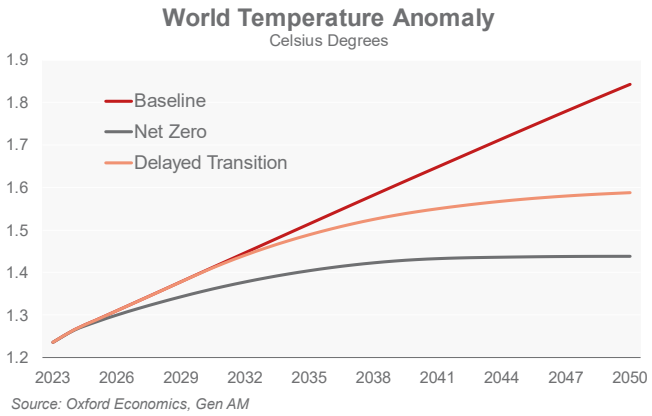
### Our Core Matters series provides thematic research on macro, investment, and insurance topics

- Last December's COP28 ended with a global pledge to reduce to zero the net emission of Greenhouse Gas (GHG) by 2050. Yet the lack of precise and binding measures casts doubts about its full implementation.
- It is becoming more likely that countries will at best stick to their current commitments, which fall short of what is needed to prevent a sharp increase in climate-related natural catastrophes. But avoiding the large, frontloaded costs related to an effective GHG reduction will increase the likelihood of large, backloaded costs to prevent or repair damages from climate change. These may become so big that countries may be forced into much harsher curbs to the consumption of fossil fuels at a later stage.



*Source: Oxford Economics, Gen AM*

- We seek to quantify the economic and financial market impact of delaying the necessary transition versus that of proceeding early and in an orderly way by means of a climate scenario. A continued rise in temperatures will have ultimately a significantly negative impact on long term growth, which our modelling is likely to underestimate as it does not consider in full the impact of the rise in the number and strength extreme climate events. Starting late with rushed and uncoordinated measures would yield subpar results in terms of temperature increase. A sudden spike in uncertainty and the need of forceful measures would first harm confidence and risk asset returns. Second, by suddenly raising the price of fuel to rapidly reduce usage it may create a persistent stagflationary environment.
- In this report we sketch the possible implications for a wide range of asset classes, acknowledging the huge uncertainty that surrounds this kind of exercise. We find that a late implementation of effective climate policies leads to a sharp decline in activity compared with an orderly transition. Unlike other studies we try to account for the uncertainty related to the sudden and uncoordinated introduction of these policies. We find that this could trigger double digit equity losses in the quarters immediately following the introduction of these measures, with prolonged weakness and a >100 bps increase in Euro area HY spreads in the first year, which would remain some 70bps above baseline in the long run.

## 1 The uncertain path to emission reduction

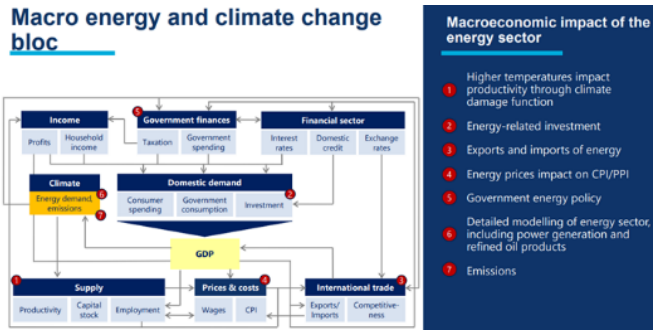
The COP28 conference that ended in December 2023 has delivered a mixed outcome. First, and most importantly, countries eventually acknowledged the link between fossil fuel usage and climate change and called to “transitioning away” from fossil fuels in energy systems, in a just, orderly, and equitable manner. That said, no binding pledges or a timeline were provided. Secondly, about 116 countries signed the Global Renewables and Energy Efficiency Pledge agreeing to triple renewable energy capacity to at least 11k gigawatts by 2030 and to improve energy efficiency. However, China and India did not sign it.

If anything, the conference showed once again that bringing to zero net GHG emissions by 2050 looks increasingly unrealistic. Moreover, the recent elections in Europe and several political parties’ platforms (such as the US Republicans) show that the backlash against green policies is growing stronger. This implies that the pledges already announced by several countries, which would still leave global temperature increasing by nearly 3°C by 2100, looks at risk.

Therefore, market participants will have to revise what are their most likely scenarios and assess the implications for their investment portfolio. In this report, we firstly, briefly recap the methodology that we follow and secondly, describe our baseline scenario to 2050 and the impact on the main asset classes. Finally, we introduce what we deem an increasingly likely risk scenario: a situation in which fast rising climate-related natural catastrophes lead world policymakers to take very forceful measures in 2030 to limit climate change.

## 2. Quantifying the choices using scenarios

The evolution of GHG emissions, the implied climate change and its economic impact is very hard to model, especially given the lack of any historical precedent. Therefore, it is customary to assess and quantify the policy trade-offs with scenarios. Scenarios are not forecasts. Instead, they map out a range of plausible future outcomes, based on a quantitative modelling on the relationship between fuel costs, fuel usage, GHG emissions, temperature increase and its impact on growth. On the policy side, models provide a way to assess the costs, in terms of inflation and growth, of reducing fossil fuels by increasing their prices compared to greener sources of energy. They are typically constituted of two blocks: a **climate model** linking fuels, emission temperatures and its impact on productivity, added on top of a **standard econometric model** routinely used to produce forecasts or assess the impact of fiscal and monetary policy. The chart below schematises the tool that we use, a commercial model produced by Oxford Economics. It combines a standard model used to




Source: Oxford Economics

macroeconomic forecasts and policy simulation with an Integrated Assessment Model (IAM) which provides a quantification on the two-way linkage between climate change and economic conditions.

The consumption of fossil fuels is reduced by the imposition of taxes or quantity restrictions. In most models, they are all put together into an estimate of the shadow cost (i.e. the effective economic costs), which is proportional to the GHG intensity of each fuel. Therefore, in the models, this shadow prices is approximated by an actual tax that affects the domestic price of fuels: the reduction in fossil fuel consumption is achieved by raising this tax. This restriction is modelled by means of an exogeneous increase in the shadow price.

The widely used example of this approach is the work produced by the Network for Greening the Financial System (NGFS), a network of central banks which produces publicly available climate scenarios, used by regulators and the financial industry. In July 2023 NGFS published a new vintage of scenarios. In this work we take a similar approach and compare a Current Policies baseline, which would underdeliver in terms of temperature increase, but imply minimal policy-induced economic and financial impact over the next few years, with two alternatives: the increasingly implausible **Net Zero 2050 scenario**, in which the increase in shadow prices needed to cap temperature rise is implemented as early as this year in a coordinated way across countries (and is complemented by massive investment in decarbonisation), and a second one (**Delayed Transition**), in which strong measures are taken only from 2031.

## 3. Current commitments are not enough

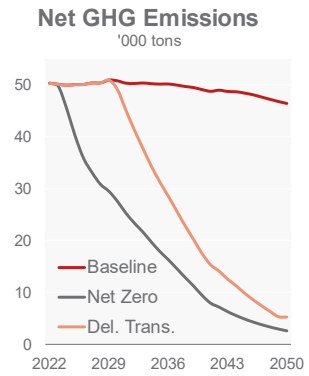
Our baseline scenario assumes the implementation of the already stated policies. This is consistent with the International Energy Agency's (IEA) "Stated Policies Scenario" (STEPS), which is based on a country-by-country and sectoral assessment of the energy-related policies in place. STEPS is more pessimistic than the IEA's "Announced Pledged Scenario (APS)", which includes all climate commitments made by governments and industries. We state the differences for the US, EU and China in the following table. The **base-line scenario** projects average global temperature to rise by 1.9°C above pre-industrial levels by 2050 (3°C by 2100).

The scenario sees global emissions peaking by 2030 and slowing further by 2050 but remaining well above the net zero goal. In this scenario, the development of electrification and greener sources of power is capped also by insufficient investment. Despite falling oil and coal demand, the global energy mix will still rely on these dirtier fuels. Electricity will cover only a relatively small share of global energy consumption (32% by 2050, compared with 21% in 2022), with the largest expansion in road transport with EV.

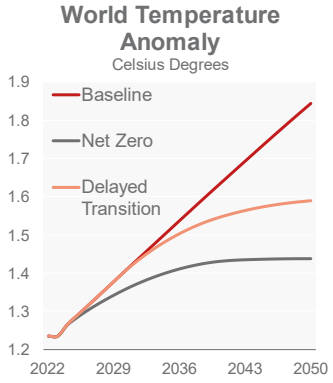
**Announced (APS) vs implemented (STEPS) measures**

| Scenario | Assumptions |
|---|---|
| | **United States** |
| STEPS | * Energy provisions according to inflation Reduction Act (2022), Consolidate Appropriations Act (2021) and Infrastructure Investment and Jobs Act (2021). |
| | * Defence Production Act deployment supporting domestic production of heat pumps, building insulation equipment, solar panel components, transformers and batteries. |
| | * US Methan Emissions Reduction Action Plan |
| APS | * Update NDC aiming to reduce GHG emissions by 50-52% by 2023 (from 2005 levels) and national target to reachnet zero GHG emissions by 2050 |
| | * 2021 US Methane Emissions Reduction Action Plan. Commitment to the Flobal Methane Pledge. |
| | **European Union** |
| STEPS | * Energy spending provisions in the European Green Deal and national recovery plans elaborated within the framework of the EU RRF |
| APS | * Full implementation of the decarbonisation targets in the Fit for 55 package. |
| | * Net zero emissions target by 2050 embedded in the 2021 European Climate Law. |
| | * EU member country-level targets for carbon or climate neutrality before 2050: Finland (2035), Austria (2040), Germany, Portugal and Sweden (2045). |
| | * Green Deal Industrial Plan targets enhancing the competitiveness of EU net zero industry. |
| | * Targets in the EU Hydrogen Strategy for a Climate Neutral Europe. |
| | * Partial implementatioin of the targets set in the REPowerEU Plan, eliminate the import of Russian natural gas supply to the EU well before 2030. |
| | * 19 EU member states commitment to the Global Methane Pledge. |
| | **China** |
| STEPS | * Made in China 2025 transition from heavy industry to higher value-added manufacturing. |
| | * 14th Five-Year Plan:<br>- Reduce CO2 intensity of the economy by 18% from 2021 to 2025<br>- Reduce energy intensity of the economy by 13.5% from 2021-2025<br>- 20% non-fossil share of the energy mix by 2025, 25% by 2030. |
| | * Updated NDC and Action Plan for CO2 to peak before 2030:<br>- Aim to peak CO2 emissions before 2030<br>- Lower CO2 emissioons per unit of GDP by over 65% from 2005 levels by 2030. |
| APS | * Carbon neutraliyt target by 2060. |

*Source: International Energy Agency,GenAM*




*Source: IEA, Ox. Econ. GenAM*




*Source: Oxford Economics, Gen AM*

The "Net Zero" scenario constitutes an important benchmark as it details what would be needed to reduce global warming. In line with the NGFS assumption**,** the global emission weighted carbon shadow prices would reach about $710 per CO2 tonne at 2010 prices (instead of around $70 in the Baseline scenarios). Investment in cleaner technology rises to around US$ 3tn per year by 2050. Global warming would not surpass 1.4 °C by 2050, before stabilising.

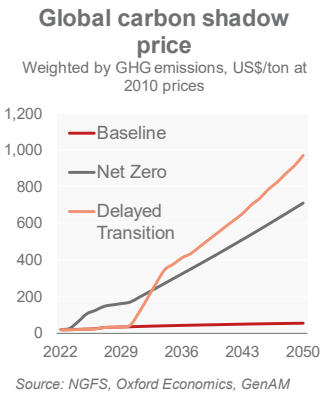
However, higher carbon prices achieved via taxes amid inelastic energy demand would raise inflationary pressures: in our simulation, global inflation increases by as much as 1.5pp above baseline two years after the introduction of a carbon tax. By 2050, carbon taxes would stop increasing in real terms (as the goal would be achieved), so that the inflation impact returns to baseline. In terms of real GDP, higher inflation eats into real incomes. Initially, GDP falls short of the baseline. But in the latter half of the 2050 period, much has already been achieved and the price channel starts to fade. Productivity advances will benefit from slower temperature increases that are materialising. The GDP loss varies among countries in line with their energy intensity of GDP. Thus, China is more exposed to relative losses than the US. Countries with large service sectors, instead of heavy industries and manufacturing, are better placed. As a carbon tax works like a negative

supply shock, lowering growth and raising inflation, we assume that central banks are ready to tolerate a temporary overshooting of price growth from target. This would cushion the adverse impact of carbon tax on growth but at the cost of keeping inflation high for longer.

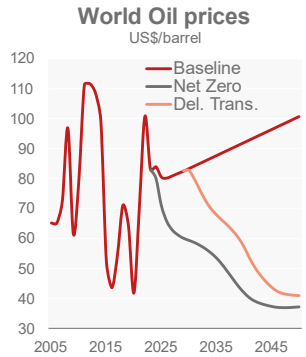
## 4. Acting late: likely and costly

### 4.1. Disorderly transition is a likely outcome

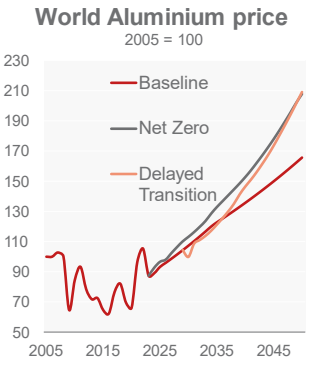
Global carbon emissions from fossil fuels hit a record in 2023, still growing by 1.1% vs. 2022. Emissions must fall by almost half in the next seven years to not lose sight of meeting the 1.5°C target. The UN Production Gap Report 2023 finds that despite their promises, the top fossil producing countries plan to produce by 2030 around 110% of the level of fossil fuels consistent with limiting warming to 1.5°C. In its assessment of the COP28 results the NGFS finds that climate policies need to raise ambition levels beyond that of current pledges and commitments and be coordinated between public and private actors in developing and advanced economies.



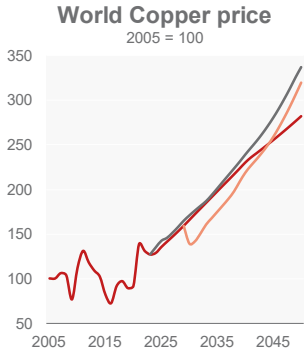

Source: NGFS, Oxford Economics, GenAM




Source: Oxford Economics, GenAM




Source: Oxford Economics, GenAM




Source: Oxford Economics, GenAM

Climate change is already having an increasing impact on livelihoods and calls for an overhaul of our pattern of energy production and consumption are growing louder. Yet, as they promise long term damage reduction but higher costs short term, action is not very palatable politically. It is true that clean energy has become far cheaper in recent years, "reaching the point of being cheaper than adding new dirty energy" (World Bank), but effective efforts at reducing fossil fuel consumption and emissions would remain inflationary. Moreover, as the examples of the *Gilets Jaunes* in France and the farmers in Holland show, policies like carbon taxes are likely to hurt more specific constituencies, often already under pressures from the adverse effect of globalisation. Climate denial or, more broadly, opposition to climate policies has already become a key item of the political agenda of several parties which are likely to extend their gains, for example at the June election for the EU parliament, not to mention the US Republican party which may be back in power by the end of 2024. All this decreased the likelihood of the emergence of a large cohesive majority that is indispensable to back a smooth but effective implementation of the measures needed to achieve net zero. At the same time, the recurrence of heatwaves and floods will likely increase over the coming years, putting pressures on policymakers to act.

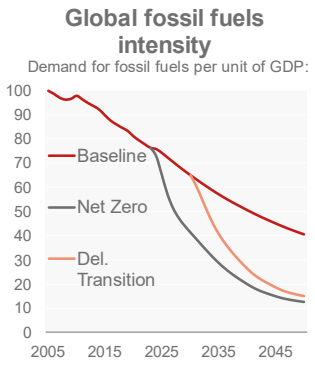
> *Stiff political resistance against climate policy measures*

Therefore, a delayed transition scenario remains likely. Compared with an ideal net zero scenario, it exhibits a smaller reduction in temperature, and consequently higher disruption on economic activity from climate change. Moreover, the measures are taken more abruptly and entail large economic costs in terms of inflation and growth.

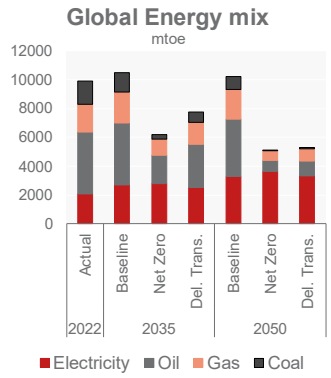
In this scenario, consistent with a similar exercise made by NGFS, we assume a delayed, but much steeper implementation of carbon prices, starting in 2030. Let's recall that the carbon prices is an umbrella for a set of policies only a part of which (around 50%, we assume) bring revenues to governments. We assume that most of these revenues are channelled into energy investment. The size of the capex for climate mitigation is, in cumulative terms, similar to what the NGFS assumes in the Net Zero scenario but implemented in a shorter time period. Therefore, it would be less effective in terms of growth and decarbonisation.

The carbon tax drives a wedge between the domestic price of fossil fuels (which increase) and the global ones, which at some point decreases due to lower demand. The flip side is an increase in the demand for raw materials needed for the climate transition, especially metals like copper.

Even if implemented late, the policies assumed in our delayed transition scenario bring about a sizeable change in the world energy mix: in that scenario, not only efficiency reduces the demand for energy, but also the share of brown fuels decreases strongly. Given the short transition period, it turns out less clean than in the net zero case, especially as the decline in energy intensity is less pronounced.

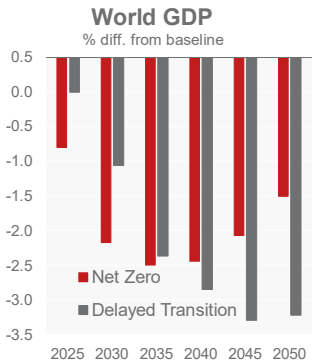


Source: IEA, Oxford Economics, GenAM

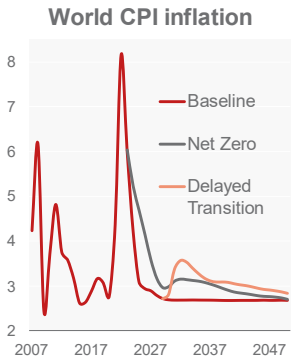


Source: IEA, Oxford Economics, GenAM

As stated previously, the increase in the shadow price of fossil fuels works like an adverse supply shock, raising inflation and depressing activity. The impact is clearly more harmful if, as in the Delayed Transition scenario the reduction in fossil fuels consumption must be reached in a shorter period.

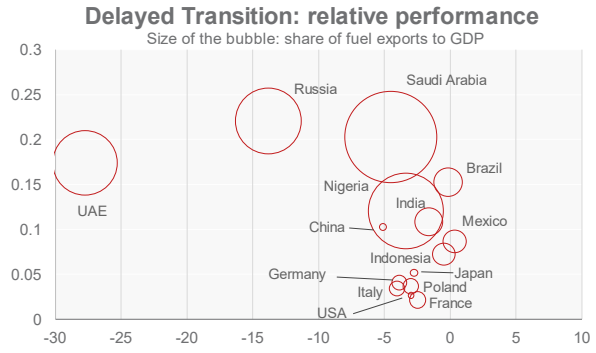


Source: Ox. Econ., GenAM



Source: Oxford Economics, GenAM

The interplay between the degree of technological development, which drives the fossil fuel intensity of production, and the reliance on exports determines which countries are the main losers from climate policies. In every scenario including restriction on brown fuel usages (even more so when they are implemented very rapidly) oil producers are clearly worse off, but within them, those with low extraction costs like Saudi Arabia, can cushion the impact as they will continue to export oil. Others, like Mexico, can benefit from diversification away from fossil fuel income.



Source: IEA, Oxford Economics, GenAM

## 4.2. Uncertainty has a strongly negative effect on risky assets

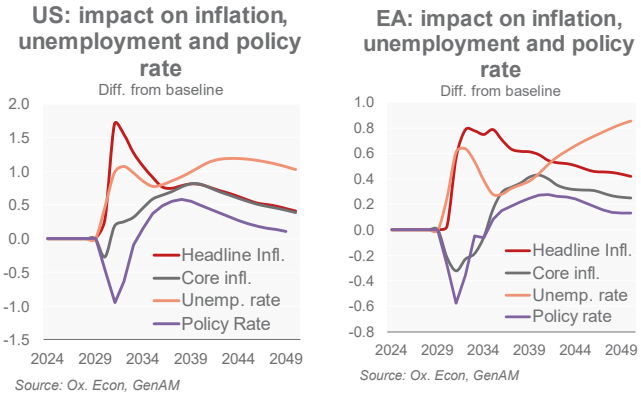
The short-term impact on asset prices is shaped by two factors. First, unlike in the NGFS Delayed Transition scenario, the decision to steeply step up efforts to fight climate change is taken abruptly and with poor coordination[1]. Therefore, instead of the smooth response predicted by NGFS, uncertainty depresses valuations and the drop in confidence impacts consumption and investment. Risker assets are affected by the so called "green swan" phenomenon, i.e. a sudden and unforeseen repricing due to the unexpected worsening of the prospects for fossil fuels demand. Of course, it is hard to quantify with confidence how "shocking" the introduction of policies would be. In setting the shock we used evidence from similar exercises carried out by Moody's and NGFS[2]. We implemented it via a shock on VIX which, in our model has global repercussions on private agents' confidence. In our scenario we suddenly increase VIX to 40 in 2030 and let it drop back to the long-term average of around 17 within one year. As a reference, it reached 59 in Q4 2008 and 35 in Q2 2020. Another important difference to the NGFS Delayed Transition scenario is the behaviour of the central banks.

1 The Appendix shows how results for the main asset class differ with respect to the original NGFS Delayed Transition scenario.

2 Moody's tries to assess the "green swan effect", by discounting the total value losses over the scenario horizon and frontload them into the equity prices. A clear drawback is that this assumes perfect foresight by investors, which is hardly credible given the huge uncertainties related to climate scenarios. Yet the approach is valuable as it seeks to consider the forward-looking element of asset prices which is hard to consider in a standard macro-based pricing model. NGFS published in October a note on how to adjust the initial part of the climate scenarios by considering the impact of the policy changes on private agents' confidence.

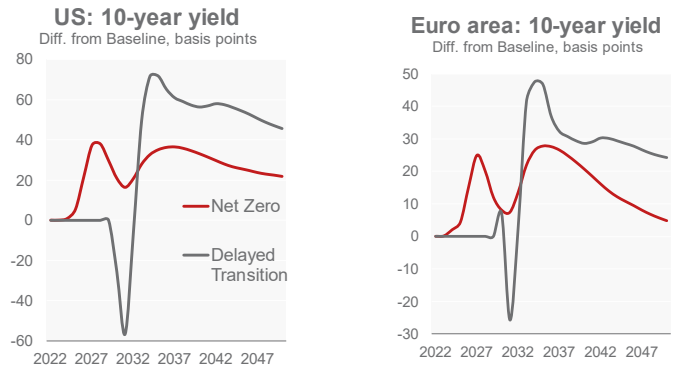
NGFS assumes that monetary policy reacts to fuel-price-related inflation by raising rates.

Such an assumption is questionable, in our view, for at least two reasons. Firstly, climate policies act clearly as an adverse supply shock, as they both raise headline inflation and lower growth. The impact on employment is negative, and that on core inflation is positive, which should lead the central banks to react to the policy driven shock to inflation to a lesser extent than a standard policy rule would prescribe. Secondly, the ECB and other central banks have put helping the transition towards greener fuels among their priorities. Stifling it via higher rates looks a bit of a contradiction. For this reason, we let monetary policy react to according to standard reaction functions. Therefore, the Fed and, to a lesser extent the ECB cut rates in the aftermath of the policy announcement, and afterwards they raise it slightly above baseline to stem the second-round impact of higher energy costs on core inflation, in order to prevent it from drifting too much above target.



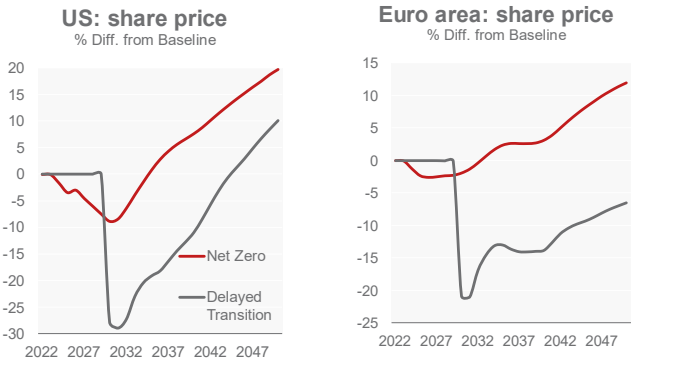
Source: Ox. Econ, GenAM

This, and the policy-induced recession create a momentary decrease in long-term rates, which recover fast to catch up with higher inflation.



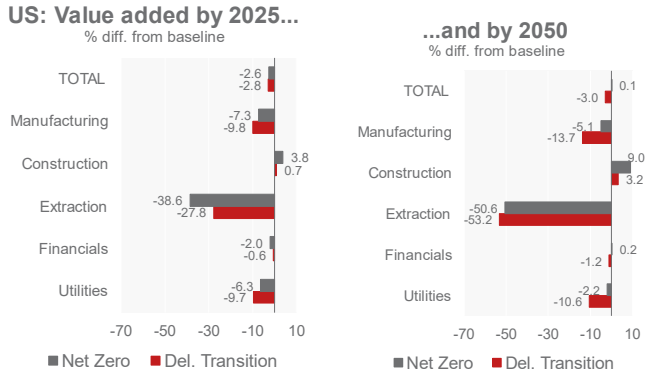
Source: Ox. Economics, GenAM

Equity prices are hit first by the rise in uncertainty, then by the recession and the prospects of a rise in stranded assets. *The higher carbon intensity of the US economy requires more punitive measures in the short term, but the assumed higher investment has a more beneficial long-term impact[3].



Source: Ox. Economics, GenAM

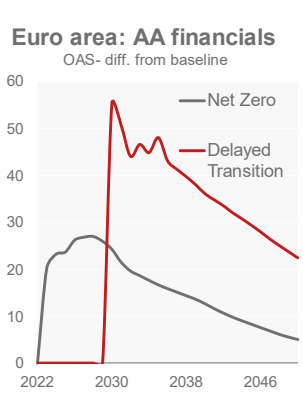
The impact of policy is wider across sectors, depending chiefly on the carbon content of their production processes and in some cases by the reduction in demand (fossil fuels).



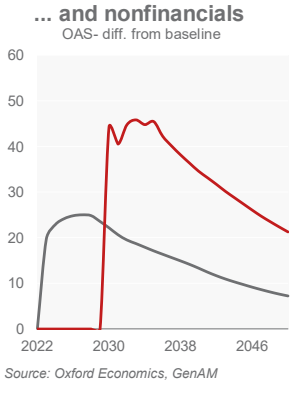
Source: Oxford Economics, GenAM

Sectoral differences play a big role in the evolution of credit spread. We simulate that using our proprietary credit model, which derives spreads as a function of financial conditions and the evolution of sectoral value added. The simulations show that the large uncertainty following the hasty announcement of climate policies lead spreads to jump by as much as 120 basis points compared with a no policy change scenario. A worse economic outlook keeps spreads permanently higher than the baseline until the end of the scenario horizon.

[3] A more detailed analysis on the equity impact of climate scenarios can be found in this Core Matter. where a smoother approach is considered (i.e., no "green swan")




Source: Oxford Economics, GenAM

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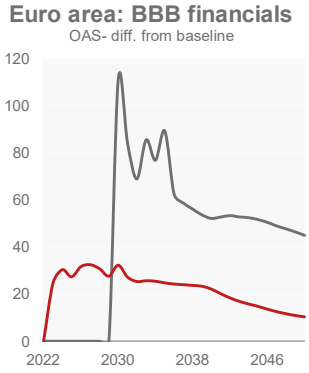


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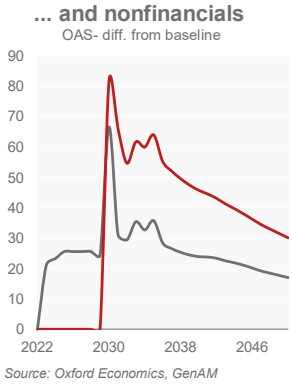


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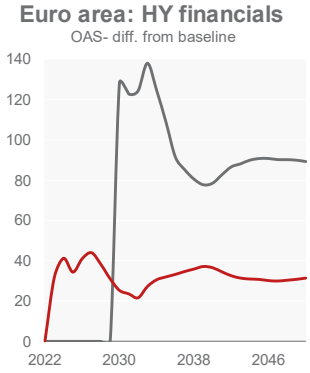


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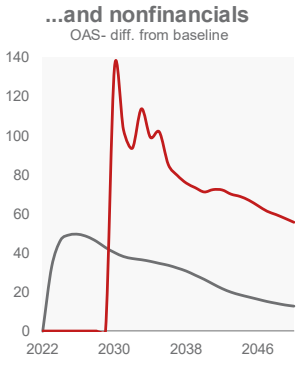



Source: Oxford Economics, GenAM

## 5. Conclusion

Once the commitments spelled out in COP28 become more detailed, we will likely see an improvement from the current-policy scenario, but the measures will most likely fall short of what is required. On the other hand, waiting is costly. Global warming is already leading to serious climate-related economic losses, which are likely to become more severe. The possible escalation of natural catastrophes could force governments to act quickly but reducing GHG in a short period of time imposes very large adaption costs to the economy. We provided a quantification of the possible economic and financial costs of waiting too long before rushing into action.

We are aware of the limitations of this type of exercise and the false sense of centrality provided by a precise estimation of something inherently very uncertain. Climate change policies are assumed to affect the economy via standard macroeconomic channels, under the assumption that the structure of the economy does not change much. The uncertainty surrounding the results is therefore very large: this is relevant not just for the point estimates, but also for the reaction of economic agents: much stronger confidence shocks can be envisaged, with much graver implications for the economy and financial markets.

Moreover, our model is likely to underestimate physical risk. In our simulation, by 2050 potential GDP in developed economy is some 2.5% lower than in the Net Zero scenario, due largely to the impact of chronic climate risk, i.e. the negative impact higher temperatures have on productivity.

The temperature/productivity link is modelled by linking potential growth with a quadradic function of temperatures. Alternative models have been tested[4] showing that a 2°C temperature increase (roughly what we get in a delayed transition scenario), can reduce global GDP by anywhere between 0 and 5%, so our estimates are somewhere in the middle. Secondly, the model does not include acute physical risks like floods, heatwaves, cyclones, droughts. They are much more difficult to assess. And while the economic wealth impact is clearly negative, that on GDP is much more unclear if the damages can be repaired and thus lead to higher demand. In its latest release, the NGFS estimates that, in the Current Policy Scenario, climate-related hazards cause losses worth 8% of global GDP by 2050.

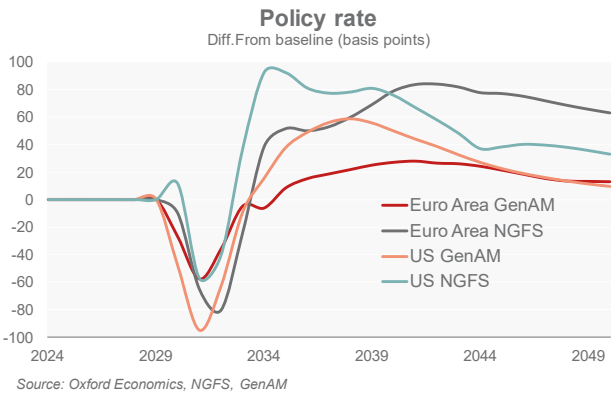
Summing up, the quantitative results of this kind of exercise must be considered with caution, but the simulation makes clear which asset classes are more at risk from a delayed and hasty climate transition, whose likelihood has increased after the at best mixed outcome of the COP28 Conference.

[4] See for example Howard, H. P., and T. Sterner (2017): "Few and Not So Far Between: A Meta-Analysis of Climate Damage Estimates," Environmental and Resource Economics, 68(1), 197–225.

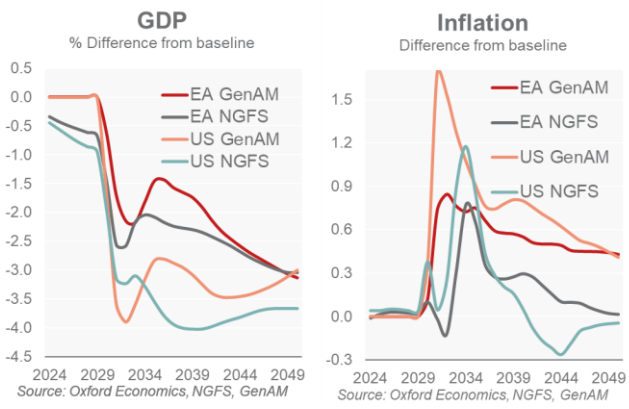
CONTENT

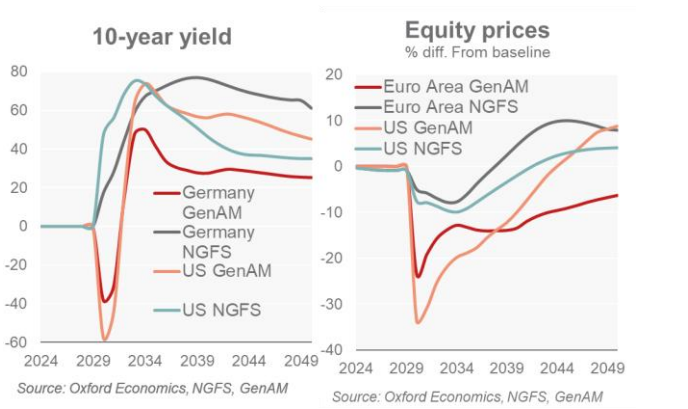
## APPENDIX: COMPARISON WITH THE NGFS DELAYED TRANSITION SCENARIO

As detailed in the text, the assumption on climate policies (carbon shadow prices and investment) in the Delayed Transition scenario are the same as to those deployed by NGFS. Moreover, the macro econometric model that NGFS uses (NiGEM) and that developed by Oxford Economics share the same theoretical framework and the climate/economy relationship is modelled in the same way. Yet, we diverge from NGFS in two crucial assumptions. First, while NGFS assumes that the central banks, after accommodating the negative impact on activity, shift quickly their focus on rising inflation: as a consequence, the policy rate rises markedly and remains above baseline despite the persistently negative effect of climate policies on GDP. In our simulation, central central banks take a softer approach, limiting the rate rise to stem higher inflation.




This delivers a less painful impact in our scenario, which however features higher inflation in the long term. This is reflected also in long-term rates with German yields remaining much higher than the baseline in the NGFS scenario. The sharp differences in the behaviour of the stock prices reflect in the short run the impact of uncertainty, which is not considered by NGFS, and the different evolution of GDP resulting from a less aggressive monetary policy, as shown by the much better performance of US equities.



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