MILLIMAN REPORT

Long-term inflation

Forecasting inflation trajectories using structural drivers and scenario modelling

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Executive summary

GOAL OF RESEARCH

This research aims to explore some of the structural drivers of long-term inflation in the Eurozone, particularly focusing on demographic trends and climate policy. The study investigates how these forces shape inflationary dynamics and examines the implications for the European Central Bank's (ECB) monetary policy. By modelling inflation trajectories and assessing their link to interest rate adjustments, the research seeks to provide insights into the long-term economic landscape and inform coordinated fiscal and monetary policy strategies to address structural inflationary pressures effectively.

Beyond monetary policy, these findings are also relevant for insurers managing inflation and interest rate risk. Understanding structural inflation drivers can help insurance companies refine their internal models and calibrate their Own Risk and Solvency Assessment (ORSA) approach. Given the long-duration liabilities of many insurers, structural shifts in inflation and interest rates could significantly impact asset-liability management, pricing strategies, and capital adequacy planning.

APPROACH AND DATA

The analysis employs a structural inflation model that integrates three core components: mean reversion, demographic dynamics, and climate policy impacts. Historical data spanning demographic trends, energy prices, and dependency ratios were combined with projections extending to 2050. These projections included 15 scenarios that reflect varying combinations of demographic and climate policy pathways.

A scenario-based methodology was adopted to capture the uncertainty and range of possible inflation outcomes. Sensitivity analyses were also conducted to assess the impact of alternative inflation targets and retirement age adjustments on inflation and interest rate trajectories.

RESULTS AND CONCLUSIONS

The research identifies those structural drivers, particularly demographic shifts and energy transition policies, that are likely to have profound and varied impacts on long-term inflation. Our analysis illustrated:

- **Demographics:**
  - High-fertility scenarios are likely to lead to the highest cumulative inflation by 2050. In the early years, increased consumption demand from a larger proportion of young dependents drives significant inflationary pressures. However, these pressures are likely to moderate over time as these cohorts enter the workforce.
  - In contrast, low-fertility and zero-migration scenarios are initially projected to result in lower cumulative inflation but are likely to face escalating pressures in the long term due to aging populations, rising dependency ratios, and labour shortages.
  - Higher migration is likely to mitigate inflationary pressures by increasing the working-age population, reducing dependency ratios, and alleviating labour shortages.
- **Climate policies:**
  - Ambitious climate policies, such as net-zero emissions by 2050, are expected to initially elevate inflation due to transition costs but are likely to stabilize prices in the long term.
  - Delayed energy transitions in less rapid transition scenarios are likely to sustain inflationary pressures in the medium to long term.

These findings point to four conclusions:

1. **Maintaining a 2% inflation target will be increasingly challenging for the ECB**
   Structural inflationary pressures from demographics and climate policies will likely make it increasingly difficult for inflation to return to pre-2020 levels. Persistent inflationary forces raise questions about whether the ECB's strict inflation target can be maintained without significant economic trade-offs.

2. **Upward interest rate pressure is likely to persist**
   As inflation remains structurally elevated due to demographic and climate-related factors, the ECB may be required to maintain tighter monetary policy for an extended period. This suggests that interest rates are likely to remain structurally higher compared to the past two decades.

3. **Trade-offs between climate transition and inflation control**
   A faster shift to a low-carbon economy may drive inflation in the short term, creating a potential policy dilemma. Balancing economic growth and price stability could require an inflation target above 2%, allowing for more flexibility in monetary policy.

4. **Raising the retirement age to 70 significantly reduces inflationary pressures**
   Raising the retirement age to 70 across the European Union helps mitigate demographic-driven inflation by reducing the dependency ratio, easing labour shortages, and curbing wage-driven inflation. This reduces the need for higher interest rates or inflation targets, providing a practical policy tool to address long-term inflationary pressures.

The interplay between structural inflation drivers and ECB policy highlights critical trade-offs. While stringent climate policies may drive short-term inflation, they could mitigate long-term risks. Similarly, demographic shifts may require adaptive fiscal strategies, such as retirement age adjustments, to manage dependency ratios. These dynamics also have implications for insurers, particularly in their management of inflation and interest rate risks, as many rely on economic models built on a stable 2% inflation regime.

In conclusion, the study emphasizes the importance of coordinated policy measures to address structural inflationary challenges. Investments in renewable energy and proactive demographic policies can help stabilize inflation while maintaining flexibility in monetary policy to support long-term economic stability.

CAVEATS AND LIMITATIONS

This research is inherently speculative and relies on a range of necessary simplifications and assumptions. While the model highlights structural forces that could drive long-term inflation, it does not capture all complexities of economic interactions or potential mitigating factors. The findings are not intended as precise forecasts but rather as a way to frame discussions on inherent inflationary developments and policy trade-offs. The study aims to promote further inquiry into how demographic and climate-related dynamics shape inflation and to encourage a broader conversation on the long-term challenges facing economic policy.

Introduction

COMEBACK OF INFLATION

For much of the 2010s, inflation remained subdued in most advanced economies. Central banks and policymakers, particularly in Europe and North America, operated in an environment of consistently low inflation and low interest rates. During this time, inflation was not seen as a pressing concern in macroeconomic policy, as it consistently remained well below historical averages. For instance, inflation rates frequently fell below the 2% target set by institutions like the Federal Reserve and the European Central Bank, as reflected in their annual reports.[1,2] However, starting in the spring of 2021, inflation re-emerged as a significant challenge, rising more sharply than forecasts had anticipated. While some policymakers had warned of inflationary risks tied to pandemic recovery efforts, the speed and persistence of price increases exceeded expectations in many advanced economies.[3,4]

The causes of this inflationary resurgence were multifaceted. A major factor was the disruption to global supply chains caused by the COVID-19 pandemic. As economies began to recover, demand for goods surged while supply remained constrained, particularly in industries that relied on global manufacturing networks. This mismatch led to bottlenecks, shortages, and rising prices for goods ranging from electronics to automobiles.[5] Additionally, fiscal and monetary stimulus measures, which were essential in mitigating the worst effects of the pandemic, contributed to increasing demand, adding further pressure on prices.[6]

Rising energy prices were another key driver of inflation in 2021. Global energy demand rebounded sharply as economies reopened post-pandemic, but supply lagged behind, partly due to OPEC+ production cuts that were implemented during the pandemic and eased only gradually.[7] This created a supply-demand imbalance, driving oil prices, like Brent crude, to multi-year highs. Simultaneously, natural gas prices in Europe surged due to supply shortages, particularly from Russia, and higher-than-expected winter demand. These energy price increases had a knock-on effect across industries, contributing to inflation in sectors such as transportation, manufacturing, and consumer goods.

Building on the inflationary pressures of 2021, the Ukraine war in early 2022 greatly exacerbated the global energy crisis, deepening the inflationary trend. Russia, a key supplier of oil and natural gas, faced severe sanctions and disruptions in its energy exports, particularly to Europe, which had relied heavily on Russian gas. As supplies dwindled, natural gas prices in Europe soared to record levels. This energy shock further pushed up inflation, particularly in sectors like transportation and manufacturing, where energy is a critical input, worsening the cost pressures from 2021.

The resurgence of inflation can be clearly observed in the evolution of the Harmonized Index of Consumer Prices (HICP), which measures inflation across the Eurozone, as illustrated in Figure 1. This chart captures the inflation trajectory in the Eurozone from 2002 to 2024, highlighting the prolonged period of subdued inflation during the 2010s and the sharp escalation that began in 2021. The figure prominently showcases the peak inflation rates reached in 2022 and 2023, marking the highest levels in decades. These spikes reflect the compounded impact of pandemic recovery dynamics, surging energy prices, and geopolitical tensions.

1. European Central Bank (2019). Economic Bulletin Issue 6. Retrieved from: https://www.ecb.europa.eu/pub/economic-bulletin/html/eb202106.en.html.
2. Federal Reserve (2020). Minutes of the Federal Open Market Committee, June 10, 2020.
3. Federal Reserve (2021). Minutes of the Federal Open Market Committee, June 15-16, 2021.
4. International Monetary Fund (2021). World Economic Outlook: Recovery During a Pandemic—Health Concerns, Supply Disruptions, and Price Pressures.
5. European Central Bank (2022). Supply Chain Disruptions: Causes and Global Impacts.
6. International Monetary Fund (2021). World Economic Outlook: Recovery During a Pandemic—Health Concerns, Supply Disruptions, and Price Pressures.
7. U.S. Energy Information Administration (EIA). OPEC+ decisions on production levels and market impacts.

FIGURE 1: EUROZONE INFLATION DYNAMICS: HISTORICAL STABILITY AND RECENT SURGE (2002–2024)

MONETARY POLICY RESPONSE AND INTEREST RATE HIKES

Following the inflationary surge that began in 2021, central banks around the world, including the ECB, responded with sharp monetary tightening. The ultra-low interest rate environment, which had persisted for many years, came to an end as the ECB initiated a series of interest rate hikes to curb inflation.

In 2022 and 2023, the ECB dramatically shifted its monetary policy to tackle inflation, with the deposit facility rate (DFR) playing a crucial role in this strategy. For much of the 2010s, this DFR had been in negative territory, an approach designed to encourage banks to lend rather than hold excess reserves, thus stimulating economic growth. However, as inflation surged in the post-pandemic recovery, the ECB had to reverse course.

The DFR, which had been set at -0.50%, began rising sharply in 2022, reaching 0.00% by mid-year. This shift was not merely symbolic, it marked the end of an era of ultra-loose monetary policy. Over the subsequent months, the ECB continued to aggressively increase the rate, bringing it to 4.00% by September 2023. These aggressive hikes had broad implications for market interest rates and yield curves, significantly increasing borrowing costs and affecting discount rates.[8]

The impact of the ECB's monetary tightening is illustrated in Figures 2 and 3. Figure 2 tracks the evolution of the ECB's deposit facility rate (DFR) from 2002 to 2024, highlighting the dramatic shift from a prolonged period of negative rates in the 2010s to the aggressive rate increases that began in 2022. This policy reversal underscores the ECB's efforts to combat surging inflation.

Figure 3 provides a complementary perspective by comparing the Eurozone yield curves in December 2019 and December 2023, derived from spot rates for AAA-rated bonds across a range of maturities.[9] The figure captures the elevation of the yield curve over this period, reflecting the broader impact of rising interest rates on borrowing costs and discounting. Together, these figures demonstrate how the ECB's policy shifts reshaped the interest rate environment and its implications for the Eurozone economy.[10]

8. European Central Bank (2024). Key ECB interest rates.

9. The yield curves shown in Figure 3 are based on spot rates for AAA-rated bonds issued in euros by central governments of Eurozone member states. These bonds are considered to have minimal credit risk and are widely used as a reference for discounting and monetary policy analysis in the Eurozone.

10. European Central Bank (2024). Euro area yield curves.

FIGURE 2: ECB DEPOSIT FACILITY RATE: POLICY SHIFTS FROM STABILITY TO AGGRESSIVE TIGHTENING (2002–2024)

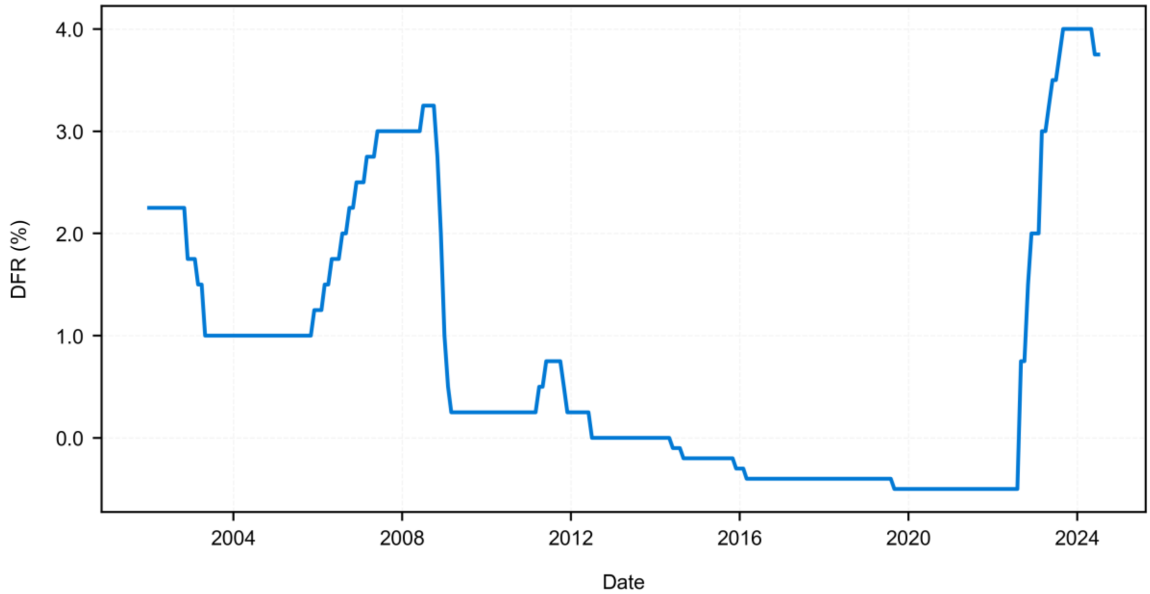
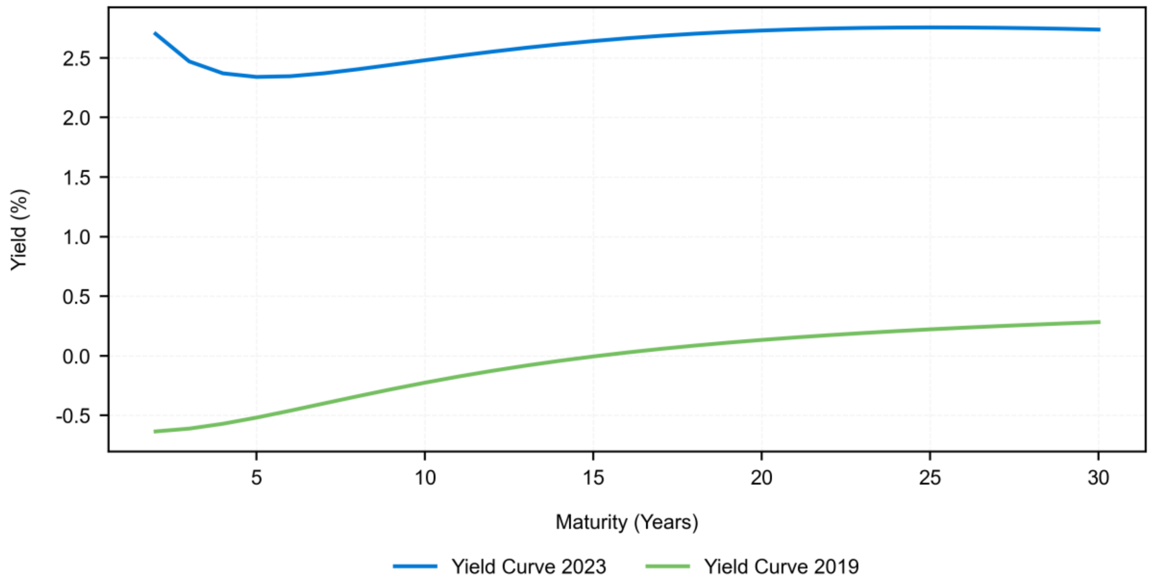


FIGURE 3: COMPARISON OF YIELD CURVES FOR AAA-RATED BONDS: SPOT RATES IN DECEMBER 2019 VS. DECEMBER 2023



RESEARCH FOCUS

Given the renewed relevance of inflation alongside the recent shift from prolonged negative and ultra-low interest rates, this research seeks to explore the potential persistence and possible implications for patterns of long-term inflation in the Eurozone. The study aims to assess how these inflationary trends might affect the European Central Bank's flexibility in deploying monetary policy, specifically examining its capacity for both tightening and loosening measures. Understanding this flexibility is crucial for determining how effectively the ECB can respond to sustained inflationary pressures, balancing its goals of price stability and economic growth in the evolving macroeconomic landscape. The research further examines this flexibility by linking inflation levels to interest rate adjustments, showing how monetary policy might evolve in response to persistent levels of inflation.

Implications for the insurance sector

Insurance is fundamentally a liability-driven business, meaning that the duration and nature of liabilities (the commitments made to policyholders) heavily influence how insurers allocate their assets. Insurers must carefully manage the duration gap between their assets and liabilities to minimize the risks posed by interest rate changes. When liabilities are longer-term than the assets that fund them (a negative duration gap),[11] insurers become more exposed to interest rate movements.[12] A decline in interest rates increases the present value of liabilities more than that of shorter-duration assets, negatively impacting solvency. Conversely, rising interest rates generally improve solvency because liabilities decrease in value more than assets. However, they can also create short-term challenges, such as unrealized losses on fixed-income portfolios, potential liquidity strains if assets need to be sold before maturity, and increased policyholder lapses in life and annuity products.

The capital positions of insurers are deeply affected by market-consistent valuation, a framework where both assets and liabilities are marked to market. This means that their value is continuously adjusted based on current interest rates and inflation expectations. Higher interest rates reduce the present value of liabilities, which can bolster an insurer's capital reserves. However, if asset values fall due to rising rates, this can offset some of the benefits.

A key complexity in interest rate movements arises from the role of risk premia and how assets and liabilities are valued differently under the Solvency II framework. Liabilities are discounted using a risk-free rate curve derived from market swap rates, reflecting future interest rate expectations and adjusted for credit risk. For long-dated liabilities, Solvency II applies the ultimate forward rate (UFR) to ensure stable discounting.

On the asset side, risk-sensitive assets, such as corporate bonds, are impacted by both rising interest rates and risk premia (e.g., credit, liquidity, and counterparty risks). As interest rates rise, asset values decrease, and during periods of economic uncertainty, risk premia can widen further, amplifying the decline in asset values.

This creates a potential asset-liability mismatch: liabilities are discounted using risk-free rates, while assets are more broadly affected by interest rate movements and spread widening. Insurers may see asset values decline significantly without a corresponding reduction in liabilities, leading to a potential erosion of own funds.

Solvency II includes the volatility adjustment (VA) to mitigate these effects by adjusting liability discount rates when spreads spike. However, the VA's efficacy is limited, especially in prolonged periods of stress, potentially leaving insurers exposed to solvency volatility as assets fall more sharply than liabilities. In addition, the assumptions made in the calculation of liabilities, such as future inflation and discount rates, directly influence how much capital insurers must hold. Underestimating inflation could lead to capital shortfalls, as claims end up costing more than anticipated.

IMPLICATIONS FOR LIFE INSURERS

For life insurers, rising interest rates can have a significant impact due to their long liability durations. With an average technical provisions' duration of ~9.5 years in the European Economic Area (EEA), life insurers typically have a negative duration gap between assets and liabilities.[12] As a result, they tend to benefit from rising interest rates, since the present value of their long-term liabilities decreases more sharply than the value of their shorter-duration assets. Interest rate sensitivity analysis from NN Life Insurance and Zurich Life show that the coverage impact increases by 2% when the interest rate increases by 0.5% and decreases with 2% when the interest rates decrease by 0.5%[13,14]. Meanwhile, the SCR ratio of Generali Life rises by 4% point when the interest rate rises by 0.5%.[15]

11. A negative duration gap is particularly relevant because insurers often hold long-term liabilities that are difficult to match with available assets of similar duration, making them more vulnerable to interest rate fluctuations.

12. EIOPA (2023).Impact of inflation on the insurance sector.

13. Zurich Life Assurance plc (2023). Solvency and Financial Condition Report 2023. Retrieved from: https://www.zurich.ie/-/media/project/zurichie/zurichmainsite/about-zurich-life/sfcr-docs/irl---zurich-life-assurance-plc_en---final-240326.pdf.

14. Nationale Nederlanden (2023). 2023 Solvency and Financial Condition Report. Retrieved from: https://www.nn.nl/Download/Solvency-and-Financial-Condition-Report-NN-Leven-2023.htm.

15. Generali Vie (2023). Rapport sur la Solvabilité et la Situation Financière. Retrieved from: https://www.generali.fr/sites/default/files-d8/2024-04/RSSF_Generali_Vie_2023.pdf.

However, while higher interest rates improve the solvency position of life insurers by reducing the discounted value of their liabilities, inflation poses a distinct risk.[16] Life insurers with inflation-linked products are particularly exposed, as the liabilities for these products grow in line with inflation, potentially eroding the gains from higher interest rates. Additionally, life insurers, although generally less affected by claims inflation, may still face increased operational expenses due to broader inflationary pressures.

IMPLICATIONS FOR NON-LIFE INSURERS

For non-life insurers, the situation is typically quite different. With shorter liability durations (~2.9 years on average in the EEA), non-life insurers tend to have a smaller duration gap between their assets and liabilities. This means that when interest rates rise, the impact on the present value of their assets and liabilities is more balanced. Because both their assets and liabilities are revalued over shorter timeframes, the overall benefit from rising interest rates is limited. As a result, non-life insurers generally experience less capital relief from interest rate rises compared to life insurers, who can benefit more from the mismatch between their longer-term liabilities and shorter-term assets.

Furthermore, non-life insurers are more directly exposed to claims inflation, as many of their liabilities, such as those related to property and casualty insurance, are tied to rising costs for repairs, medical services, and materials. The increase in claims costs as inflation rises puts additional pressure on their balance sheets. While non-life insurers can adjust premiums for future risks, inflation can erode the adequacy of reserves set for past claims, particularly for long-tail liabilities where payments extend over multiple years. The impact of claims inflation on profitability also depends on the timing of claim payments, with longer-duration claims being more vulnerable to sustained cost increases. Moreover, expense inflation, the rise in operational costs, further strains profitability in the non-life sector.

IMPACT ON INVESTMENTS AND TECHNICAL PROVISIONS

The combined effects of rising interest rates and inflation have significantly impacted insurers' investment portfolios and technical provisions.

By the end of 2022, total investments held by EEA insurers had fallen to €5.9 trillion, marking a €1.1 trillion decline (15.8%) from the previous year. This drop was primarily driven by falling bond prices, as government and corporate bonds, key components of insurers' portfolios, lost €0.8 trillion in market value due to rising interest rates.[17]

The impact on technical provisions has been particularly pronounced for life insurers, whose long-term liabilities are heavily influenced by discount rates. In contrast, non-life insurers, whose liabilities are shorter-term and more directly affected by inflation rather than interest rate changes, saw a much smaller reduction. Their technical provisions declined from €661.8 billion to €651.5 billion, a €10.3 billion decrease (1.6%) over the same period.[18]

16. Inflation can also negatively impact the asset side of insurers' balance sheets. Fixed-income investments, which constitute a large portion of life insurers' portfolios, may suffer from eroded real returns, and other asset classes, such as equities and real estate, may experience volatility in high-inflation environments. As a result, the solvency benefits of higher interest rates may be partially offset by inflation-driven declines in asset values.

17. The total investment figure (€5.9 trillion) reflects the aggregated investments of all EEA insurers, including life, non-life, and composite insurers. Investment figures are not provided separately per sector, but life insurers typically hold longer-duration bonds, while non-life insurers tend to have shorter-duration assets.

18. Unlike the total investment figure, which covers all EEA insurers, the technical provisions cited only include pure life (€3.52 trillion) and pure non-life (€651.5 billion). Health and unit-linked business are excluded from these figures, making them narrower in scope than the investment total.

Approach

This section outlines the motivation behind the selected analytical approaches for studying long-term inflation, including the examination of structural drivers, the application of mean reversion principles, and the use of a scenario-based approach.

STRUCTURAL DRIVERS

Inflation is shaped by the interaction of a variety of dynamics, with influences ranging from short-term fluctuations to deep-seated structural forces. While cyclical drivers, such as supply and demand dynamics, economic growth rates, or monetary policy changes, often dominate short- to medium-term inflation patterns, structural drivers can provide a clearer view of long-term inflation prospects.

Structural drivers are the macro-political influences that are expected to be more predictable and enduring, making them essential for understanding inflationary trends that may persist over decades. Unlike cyclical factors, which can be volatile, structural drivers tend to evolve more gradually, influencing inflationary or deflationary pressures through prolonged changes in the economy’s foundational elements. Focusing on these drivers offers insights into long-term inflationary pressures beyond shorter-term economic conditions.

In this report, we focus on two critical structural drivers: demographic trends and climate policy developments. Demographic trends, including aging populations and migration patterns, have a substantial impact on both labour supply and consumption patterns, which are key components of inflation. Additionally, climate policy is expected to be a powerful force in shaping long-term inflation. Policies aimed at reducing carbon emissions, increasing energy efficiency, or transitioning to renewable energy sources may impact production costs, resource availability, and overall economic productivity.

By examining these structural drivers over a timeframe extending from the present to 2050, this report aims to provide a perspective on the influence of these factors on inflation beyond immediate economic cycles. However, caution must be exercised in predicting long-term inflation, as emerging factors such as advancements in artificial intelligence and other unforeseen technological could significantly alter these dynamics.

MEAN REVERSION

In the Eurozone, the ECB maintains a clear inflation target of 2%, viewing it as essential for price stability across member states. This target functions as the anchor for ECB policy, and the bank actively works to steer inflation back to this level with the ability to take anticipatory action if it feels this is required. Mean reversion, in this context, reflects the ECB’s commitment to intervening as needed to correct inflationary or deflationary deviations, reinforcing the 2% target as a long-term equilibrium.

This report considers mean reversion as part of the ECB’s policy approach to maintain inflation stability over the long term. When structural drivers, such as demographic shifts or climate-related policies, apply sustained inflationary pressure, the ECB must decide the intensity of intervention required to counterbalance these forces. The extent of mean reversion applied thus indicates the ECB’s strategic response, revealing how strongly the bank may need to act to bring inflation back towards its 2% mandate.

The degree of mean reversion needed to realign inflation with the 2% target also provides insights into the ECB’s policy flexibility. For example, if persistent inflationary pressure from structural changes moves inflation significantly above the target, maintaining mean reversion may require higher interest rates or more restrictive measures. This, in turn, could reduce the ECB’s capacity to use policy tools flexibly to address broader economic goals such as employment and growth. When structural drivers create lasting upward pressure, achieving the target may necessitate strong corrective actions, indicating a lower degree of flexibility for the ECB.

As inflationary pressures arise, this report will also investigate the potential sustainability of the 2% target itself. Analysing how enduring structural forces may challenge the ECB's ability to maintain this target over the long term helps inform us on the potential for a material shift in inflation outlook, especially if external pressures consistently shift inflation away from the ECB’s 2% inflation goal. This examination will provide a nuanced perspective on whether the ECB’s current target remains viable or if adjustments may eventually be warranted.

SCENARIO APPROACH

Forecasting long-term inflation involves significant uncertainty, due to not only its complexity but also the reliance on historical data and projections of future conditions. Given the complex and evolving nature of inflation drivers, a single-point forecast is not only limited in scope but also unrealistic for capturing the wide range of potential outcomes. To address this inherent uncertainty, this report adopts a scenario-based approach, allowing for the exploration of multiple possible futures based on varied assumptions underlying the structural drivers of inflation.

Scenario analysis provides essential flexibility by accommodating a spectrum of inflationary conditions. This approach enables stakeholders to adjust expectations and strategies as conditions evolve, supporting more responsive and adaptive planning in an unpredictable economic landscape.

Each scenario in this report represents a plausible path for inflation, built on distinct assumptions about structural drivers and policy responses. By presenting these varied paths, the report offers stakeholders a comprehensive view of how different factors might shape inflation trajectories, informing policy options and strategic choices.

Structural drivers

DEMOGRAPHICS

Demographic trends have undergone significant transformations over the course of human history, with rapid changes becoming particularly evident in the past two centuries. According to United Nations estimates, the global population reached 1 billion in 1804, doubling to 2 billion by 1927, and increasing further to 3 billion by 1960. By 2022, the world population had grown to 8 billion. However, the pace of this growth is now slowing, particularly in developed regions, due to declining fertility rates and the tapering of increases in life expectancy. These shifts are contributing to aging populations and altering the demographic structures of many nations. Africa is almost the sole region where national populations are expected to grow significantly.

Europe exemplifies this demographic transition, with some of the lowest fertility rates globally and a rapidly aging population. The combination of declining birth rates and higher life expectancy has resulted in significant challenges, particularly in maintaining a balanced labour force and addressing the economic implications of an aging society. These demographic shifts are increasingly influencing labour markets and inflationary dynamics in the region.

Demographic changes have a significant impact on inflation, with many of these effects captured through the dependency ratio, which serves as a proxy for broader demographic processes. The dependency ratio, measuring the proportion of dependents (children and retirees) relative to the working-age population, reflects critical economic pressures. A higher dependency ratio signals a reduced share of the population actively contributing to economic output while maintaining or increasing demand for goods and services. This imbalance between supply and demand can drive up prices, particularly in aging societies.[19]

In the Eurozone, where dependency ratios are rising, this dynamic is further compounded by increasing public expenditures on pensions and healthcare, placing additional strain on government finances. Unlike countries that control their own monetary policy, Eurozone governments cannot individually finance deficits through monetary expansion. Whether these rising costs are financed through higher taxes or public borrowing, their inflationary impact depends on factors such as private sector savings behaviour, fiscal constraints, and the ECB’s monetary response. If fiscal pressures become widespread across the Eurozone, the ECB may ultimately resort to monetary expansion through government bond purchases to stabilize markets and ease financing conditions. Such a response would increase the money supply and contribute to inflationary pressures.[20]

Labour market dynamics are a key driver of the inflationary trends reflected by the dependency ratio. As aging populations reduce the size of the working-age population, labour shortages become more pronounced, leading to tighter labour markets. Employers are often required to offer higher wages to attract and retain workers, particularly in essential sectors such as healthcare and social services. These wage increases are directly inflationary, as they raise production costs that are frequently passed on to consumers. In the Eurozone, where labour-intensive industries are critical to supporting aging populations, these dynamics amplify inflationary trends and underscore the dependency ratio's role as a measure of economic pressures.

Migration can play a role in moderating some of the inflationary pressures associated with demographic changes. By increasing the working-age population, migration helps to address labour shortages and reduces the dependency ratio, thereby alleviating some of the imbalances between supply and demand in the economy. As a result, migration offers a potential tool for managing the broader economic challenges that the dependency ratio encapsulates. However, migration has become a highly politicised issue which is likely to significantly constrain its mitigating potential.

19. Andrews, D., Oberoi, J., Wirjanto, T., & Zhou, C. (2018). Demography and inflation: An international study. North American Actuarial Journal and Bobeica, Elena, et al. Demographics and inflation. No. 2006. ECB working paper.

20. The inflationary impact of public borrowing or taxation depends on how measures are financed and their effects on aggregate demand. Public borrowing is most inflationary when financed by central bank bond purchases (monetary expansion), as it directly increases the money supply. While Eurozone governments cannot individually monetize their deficits, sustained fiscal pressures across multiple member states may influence the ECB’s monetary stance, particularly if it engages in large-scale bond purchases. Borrowing financed by private sector savings has a more complex impact, depending on factors such as the velocity of money and crowding-out effects. Higher taxes, on the other hand, shift consumption from younger taxpayers to retirees, potentially generating both inflationary and deflationary pressures depending on the marginal propensity to consume of each group.

CLIMATE POLICIES

Energy crises, such as the oil shocks in the 1970s, demonstrated the susceptibility of economies to disruptions in energy supplies. These shocks led to sharp increases in oil prices, driving up inflation rates and causing a ripple effect through various sectors reliant on energy inputs. Recent fluctuations in energy markets have continued to underscore this vulnerability, as the price instability in fossil fuels was a significant element of the recent inflationary cycle. The increasing evidence for of climate change impacts, along with greater understanding of the imminency of their future potential, is now a primary driver for policy shifts worldwide, encouraging nations to decarbonize their economies and move away from fossil fuel dependency. Within the EU, this increasing evidence, from the impacts of extreme weather to disruptions in agriculture, is driving demand for a transition towards sustainable energy sources. In addition, the transition will reduce the dependency on fossil fuels over the long term. Although reserves are anticipated to be sufficient for the next 50 years, they will ultimately become depleted. In absence of alternatives, this will lead to substantially higher prices. A timely transition will delay the moment of depletion, mitigating inflation impacts.

Decarbonisation involves extensive restructuring of the global energy mix. These are investments which have inflationary implications, since the initial phase of this shift could elevate prices for both industries and consumers. Policies aimed at reducing carbon emissions, such as increased carbon taxes, will directly impact industries reliant on fossil fuels. In the short term, these costs are likely to be passed on to consumers, raising the prices of carbon-intensive goods. The objective, however, is to stabilize prices over time as renewables gain greater market share, initial investments in the green energy sector begin to yield returns, and carbon taxes no longer need to be imposed.

Whilst many renewable energy investments, including in wind, solar, and other clean technologies, are currently competitive or lower-cost than fossil fuel energy production, their installation may initially drive up costs. The transition requires capital-intensive infrastructure, and the growing demand for the critical minerals required in green technologies (such as lithium and copper) can further elevate prices. Eventually, though, as renewable capacity grows and technological advances reduce production costs, energy prices may stabilize at a lower cost.

The balance of fossil fuels and renewables within the energy mix directly affects energy prices. As global demand shifts from fossil fuels to renewable energy sources, markets for specific energy types may become constrained or oversupplied. This changing demand can drive up prices for certain fuels, especially if renewable energy capacities are insufficient to meet growing needs in the early stages of the transition.

Reserves refer to the portion of demonstrated resources that can be economically extracted using current or foreseeable extraction technologies. In this study, energy prices are adjusted based on the remaining reserves to account for their availability. The rationale is that as an energy source becomes scarcer, its price is expected to rise.

Carbon pricing creates additional costs for industries with high carbon footprints. As companies pay more to offset emissions, these expenses are often transferred to consumers in the form of higher prices for goods and services. While this adds inflationary pressure, the goal of carbon pricing is to gradually reduce emissions and drive investment in cleaner alternatives.

There are three key types of inflation that explain how climate policies and shifts in energy use drive changes in prices:

- **'Climateflation':** Climate change disrupts supply chains, agricultural productivity, and overall production stability. Climateflation arises when extreme events damage crops, delay shipments, or reduce availability of raw materials, all of which increase production costs. As the effects of climate change grow more pronounced, climateflation is expected to have a lasting impact on price volatility, particularly for agricultural goods and other climate-sensitive sectors.
- **'Fossilflation':** This refers to the inflationary pressures caused by rising fossil fuel prices, driven by geopolitical tensions, reduced supply, or increased costs of usage through heightened regulatory constraints on carbon emissions.
- **'Greenflation':** This refers to the inflationary pressures because of the shift to renewable energy. Greenflation occurs when the demand for renewable energy sources and the critical minerals essential for green technology production rises faster than supply can adjust.

This research model primarily focuses on fossilflation and greenflation, as these two types of inflation have more readily available quantitative data regarding their impact on prices. However, in the Discussion section, we incorporate insights from other studies to explore the influence of climateflation and its interconnected effects on economic trends.

Methodology

This research utilizes a linear regression model to analyse pressures on the delta inflation, emphasizing simplicity and interpretability. The model incorporates three primary components: a mean reversion component, a demographic component, and a climate policy component. The mean reversion component captures inflation's tendency to revert to a long-term average over time. The demographic and climate policy components reflect the impact of population dynamics and policy shifts related to climate change, respectively. Both are modelled as relative changes, aligning with inflation's inherent nature as a measure of relative change over time.

It is important to note that while this model focuses on mean reversion, demographic influences, and climate policy, other factors affecting inflation are not included. These exclusions are due either to the need for simplicity or the unavailability of sufficient data for those components. Despite these constraints, the model offers a clear and interpretable approach to understanding some main drivers of inflationary pressures.

THEORETICAL FRAMEWORK

For this paper, the dynamics of inflation have been modelled as a function of three key components: mean reversion, demographics, and climate policy. The change in inflation at time t is expressed as:

$$\Delta\pi_t = \underbrace{-\mu(\pi_{t-1} - \pi^*)}_{\text{Mean Reversion Component}} + \underbrace{\beta_D\left(\frac{D_t}{D_{t-1}} - 1\right)}_{\text{Demographics Component}} + \underbrace{\beta_E\left(\frac{E_t}{E_{t-1}} - 1\right)}_{\text{Climate Policy Component}},$$

where:

- π_t is the inflation rate at time t,
- π^* is the ECB target inflation rate, set to 2%,
- D_t is the dependency ratio at time t,
- E_t is the weighted energy price at time t,
- μ, β_D and β_E are coefficients representing the sensitivity of inflation to the respective components.

While the model treats demographics and climate policy as distinct inflation drivers, some interdependencies exist, for example, climate policy can influence migration and labor supply. However, it is assumed that their primary effects operate independently, with demographics shaping labor markets and consumption, while climate policy impacts inflation mainly through energy costs. Any interactions are considered secondary within the framework.

Mean reversion component

The mean reversion term, $-\mu(\pi_{t-1} - \pi^*)$, reflects the structural tendency of inflation to converge to the ECB's 2% target.[21] The parameter μ quantifies the speed and intensity of this adjustment, with larger values indicating stronger stabilization effects. Calibrated using historical data, μ remains constant across scenarios, ensuring consistency in the model's response to deviations from the target. What will vary is the extent of inflation deviations from the target, which in turn determines the intensity of the mean reversion response. A higher μ reflects a more robust correction of inflationary pressures, reflecting the ECB's role in stabilizing inflation through monetary policy.[22]

The mean reversion term is linked explicitly to lagged inflation (π_{t-1}), capturing the deviation of previous year's inflation from the target. This linkage accounts for the persistence of inflationary pressures and the delayed impact of monetary policy. By incorporating this delayed effect, the model reflects the gradual nature of inflation stabilization and aligns with historical patterns. The cumulative influence of past deviations ensures that the model realistically represents inflation dynamics and their connection to monetary adjustments over time.

A one-year time step is used in the model for mean reversion due to data availability constraints for long-term projections, as most macroeconomic datasets report annual figures for future data.

21. European Central Bank (2019). Economic Bulletin Issue 8. Retrieved from https://www.ecb.europa.eu/pub/economic-bulletin/html/eb201908.en.html.

22. Svensson, L. E. O. (1997). Inflation forecast targeting: Implementing and monitoring inflation targets. European Economic Review, 41(6), 1111-1146.

Interest rate dynamics

Interest rates are estimated based on the assumption that the central bank reacts to inflation changes following a twofold objective: immediate inflation control and long-term stabilization. The change in interest rates at time t, Δi_t, is expressed as:

$$\Delta i_t = + \underbrace{\gamma(\pi_t - \pi_{t-1})}_{\text{Immediate Response}} + \underbrace{\alpha(\mu(\pi_{t-1} - \pi^*)}_{\text{Deviation Stabilization}}$$

where:

- $\gamma(\pi_t - \pi_{t-1})$ captures the immediate response of interest rates to short-term inflation changes ($\Delta\pi_t$),
- $\alpha(\mu(\pi_{t-1} - \pi^*)$ reflects the central bank's effort to correct structural deviations from the inflation target, driven by the mean reversion dynamics of the inflation model.

These terms reflect the dual objectives of monetary policy: promptly addressing inflation changes and steering inflation towards the target over time. The model represents interest rate adjustments as incremental steps, aligning with observed central bank practices and long-term stabilization goals. Rather than prescribing nominal rates, it estimates changes in interest rates based on inflation dynamics. By linking adjustments to both immediate and lagged inflation effects, the model effectively captures the reactive and stabilizing roles of monetary policy.

Demographic component

The demographic term,

$$\beta_D \left(\frac{D_t}{D_{t-1}} - 1 \right),$$

quantifies the effect of changes in the dependency ratio on inflation. The dependency ratio measures the proportion of dependents (non-working-age individuals) relative to the working-age population and is calculated as:

$$D_t = \frac{N_{\text{Dependents}}}{N_{\text{Working Age}}},$$

where:

- $N_{\text{Dependents}} = N_{0-19} + N_{65+}$, representing the combined population of individuals aged 0–19 (children) and 65+ (elderly),
- $N_{\text{Working Age}} = N_{20-64}$, representing the population aged 20–64.

Demographic shifts, such as aging populations or changes in birth rates, alter the dependency ratio and, consequently, the pressure on inflation.

Climate policy component

The climate policy term,

$$\beta_E \left(\frac{E_t}{E_{t-1}} - 1 \right),$$

captures the impact of changes in the weighted energy price E_t on inflation. The weighted energy price is calculated as:

$$E_t = \sum_{n=1}^{N} a_{n,t} \cdot x_{n,t},$$

where:

- $a_{n,t}$ denotes the share of energy source n in total energy consumption at time t,
- $x_{n,t}$ represents the price of energy source n (in USD per gigajoule),
- N is the total number of energy sources considered.

The price of energy source n (in USD per gigajoule), is computed by:

$$x_{n,t} = (wp_{n,t} + cp_{n,t}) \cdot ra_{n,t},$$

where:

- $wp_{n,t}$ denotes the expected wholesale price of energy source n (in USD per gigajoule) at time t,
- $cp_{n,t}$ denotes the carbon price of energy source n in (in USD per gigajoule consumption) at time t,
- $ra_{n,t}$ represents the reserve adjustment factor of energy source n.

The reserve adjustment factor $ra_{n,t}$ of energy source n at time t is based on the expected reserves of the energy source at time t. Based on intuitive reason, the reserve adjustment is constructed so that if reserves drop below 15 years' worth of consumption, a 3% price increase is implemented for each year that reserves are below this threshold. After reserves are depleted, the price shock continues to rise, assuming that new resources will be economically viable to extract but will put upward pressure on the price. This will result in the following computation of the reserve adjustment factor:

$$ra_{n,t,} = \begin{cases} 1, & \text{if } \frac{R_{n,t}}{C_{n,t}} > 15, \\ 1.03 \cdot \left(15 - \frac{R_{n,t}}{C_{n,t}}\right), & \text{otherwise,} \end{cases}$$

where:

- $R_{n,t}$ denotes the global reserves of energy source n (in gigajoule) in year t,
- $C_{n,t}$ denotes the yearly global consumption of energy source n (in gigajoule) in year t.

For electricity, the reserve adjustment factor is calculated as the average of the reserves left of the key resources: copper, lithium, cobalt, and nickel.

The global reserves of energy source n (in gigajoule) at time t is computed by the global reserves at the end of the year 2024 minus the expected consumption of energy source n in the years between the end of 2024 and time t:

$$R_{n,t} = R_{n,2024} - \sum_{s=2025}^{t} C_{n,s}$$

where the expected consumption is computed with

$$C_{n,t} = CPP_{n,t} \cdot WP_t$$

where:

- $CPP_{n,t}$ denotes the expected consumption of energy source n (in gigajoule) per person at time t,
- WP_t denotes the world population at time t.

Note that this computation rests on the strong assumption that no significant new reserves of energy source n will be discovered after 2024. While historically new reserves have been consistently found, this method helps highlight the potential pressure on prices due to depletion of currently known reserves.

MODEL IMPLEMENTATION

The model integrates two interconnected components: the inflation model and the interest rate model. The inflation model estimates the dynamics of inflation changes, serving as the foundation for both forecasting and linking inflation to interest rate adjustments in the second component. Specifically, the mean reversion intensity (μ) is directly utilized in the interest rate model, while the structural driver coefficients (β_D for demographics and β_E for energy prices) influence interest rate dynamics indirectly through their impact on inflation.

The inflation model is estimated using ordinary least squares regression on historical data. A 75% to 25% train-test split was applied, and the chosen specification outperformed alternative models in predicting inflation dynamics. After validation, the model was re-estimated on the full dataset to determine the final coefficients used for forecasting. These include the mean reversion parameter (μ), which captures the speed of inflation's convergence to the target, as well as the structural driver coefficients (β_D and β_E), which quantify the contributions of demographics and energy prices to inflation changes.

The interest rate model calculates changes in interest rates as a weighted combination of immediate inflation changes and the mean reversion effect. The parameter γ, set at 0.2, reflects the assumption that 20% of short-term inflation changes translate into immediate interest rate adjustments. This value is consistent with the gradualist approach of central banks, such as the European Central Bank, which aim to respond to inflation changes without destabilizing economic conditions.

The parameter α**,** set at 0.5, captures the influence of mean reversion, accounting for past deviations of inflation from the target. This value aligns with the responsiveness to the inflation gap in the traditional Taylor rule and represents a moderate central bank response. Together, these parameters ensure that interest rate adjustments are incremental and balanced, addressing immediate inflationary pressures while guiding inflation back to the target over time. This approach captures the dual objectives of monetary policy, reflecting both reactive and stabilizing roles in maintaining economic stability.

MODEL PERFORMANCE AND COEFFICIENTS

The model was first trained on data from 1992 to 2016 and tested on data from 2016 to 2023.[23] Performance metrics indicate an in-sample R^2 of 0.50 and an out-of-sample mean absolute error (MAE) of 1.51, reflecting the model's ability to predict inflation trends based on structural factors. As shown in Figure 5, the model does not fully account for its extreme magnitude during the highly volatile periods, but captures the energy-price-related peak of inflation of the Ukraine war. However, during the relatively stable period from 2016 to 2020, the model closely follows observed inflation values.

This behaviour demonstrates the model's design focus on capturing long-term structural drivers rather than transient cyclical shocks, to capture insights on long-term projections. Following this evaluation, the model was calibrated on the full historical dataset to derive the final parameter estimates, which are presented in Figure 4.

FIGURE 4: ESTIMATED PARAMETERS OF THE MEAN REVERSION MODEL (1992–2023)

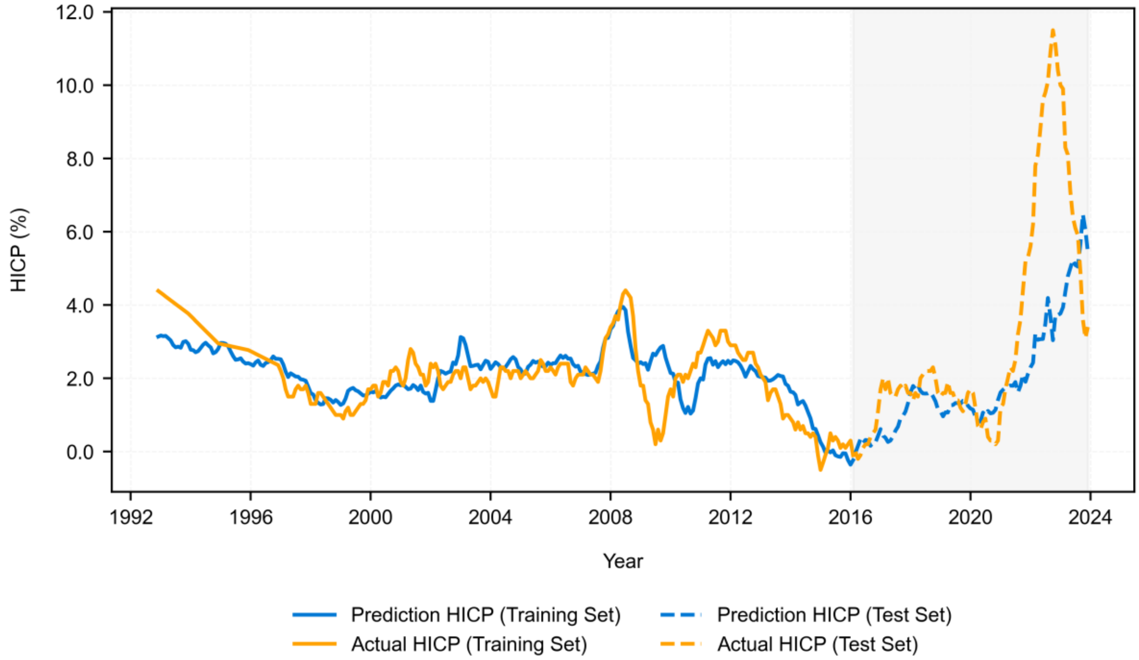
PARAMETER	COEFFICIENT	STANDARD ERROR	P-VALUE
μ	0.394	0.037	0.000
β_D	0.225	0.073	0.002
β_E	0.057	0.003	0.000

The positive sign of μ confirms that historically inflation was drawn back towards the ECB's 2% target, consistent with the mean reversion dynamics outlined in the model's theoretical framework. The magnitude of μ suggests that for every 1% deviation above the target, inflation is expected to decline by approximately 0.39% in the following period, demonstrating the strength of the mean reversion process.

The positive sign of β_D indicates that increases in the dependency ratio, reflecting demographic shifts such as aging populations, have contributed to upward inflationary pressures in recent decades. This result aligns with the model's theoretical framework, where a higher dependency ratio leads to inflation through changes in labour and consumption dynamics. Similarly, the positive sign of β_E reflects that rising energy prices exert upward pressure on inflation, as captured by the model's treatment of energy as a fundamental structural driver.

23. Since the HICP was only introduced with the euro, a proxy was used for the pre-euro period. This proxy is a GDP-weighted combination of inflation rates from the founding EU member states, ensuring consistency in historical inflation trends before the official introduction of the HICP.

FIGURE 5: HICP PREDICTION: MODEL PERFORMANCE ON 75/25 TRAIN-TEST SPLIT (1992–2023)



Data and scenarios

HISTORICAL DATA

The historical data utilized in this study includes demographic information on the dependency ratio within the European Union, trends in the EU's energy mix over time, and price data for oil, gas, coal, and electricity. The data sources for these variables are detailed in Figure 6.

FIGURE 6: SOURCES OF HISTORICAL DATA USED IN THE STUDY

DESCRIPTION	AVAILABLE PERIOD	SOURCE
Historic demographic data	1950 - 2023	World Population Prospects 2024 of the United Nations[24]
Historic energy mix	1990 - 2022	Eurostat[25]
Historic oil price	1974 - 2024	U.S. Energy Information Administration26
Historic gas price	1990 - 2024	FRED economic data[27]
Historic coal price	1990 - 2024	EI Statistical Review of World Energy[28]
Historic electricity price	1998 - 2023	Department for Energy Security & Net Zero UK Government[29]

DEMOGRAPHIC SCENARIOS

In this research, the impact of five population scenarios specific to European demographic trends will be analysed, each defined by varying levels of fertility and migration, with mortality kept stable. These scenarios are based on the World Population Prospects 2024 of the United Nations.[30] To create the high-migration scenario, the difference between the zero migration and base migration levels is tripled in the opposite direction, representing a significant upward shock to migration rates. While these scenarios serve as valuable guidelines, it is important to recognize that each comes with its own set of challenges and uncertainties. Some scenarios may even lean towards being overly optimistic. Nevertheless, they remain a useful tool for illustrating a range of possible energy mix outcomes.

FIGURE 7: DEMOGRAPHIC SCENARIOS

SCENARIO	FERTILITY	MIGRATION
Base	Medium (based on median distribution)	Medium (based on median distribution)
Low fertility	Low	Medium (based on median distribution)
High fertility	High	Medium (based on median distribution)
Zero migration	Medium (based on median distribution)	Zero from 2024
High migration	Medium (based on median distribution)	High

The demographic scenarios lead to varying projections of the dependency ratio in the European Union (EU), as illustrated in Figure 8.

24. United Nations, Department of Economic and Social Affairs, Population Division (2024). World Population Prospects 2024: Methodology of the United Nations population estimates and projections. UN DESA/POP/2024/DC/NO. 10, July 2024.

25. Eurostat (January 2025). Complete energy balances. Retrieved from: https://ec.europa.eu/eurostat/databrowser/view/nrg_bal_c__custom_11730222/default/table?lang=en.

26. U.S. Energy Information Administration (January 2025). Petroleum & Other Liquids. Retrieved from: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=f000000__3&f=m.

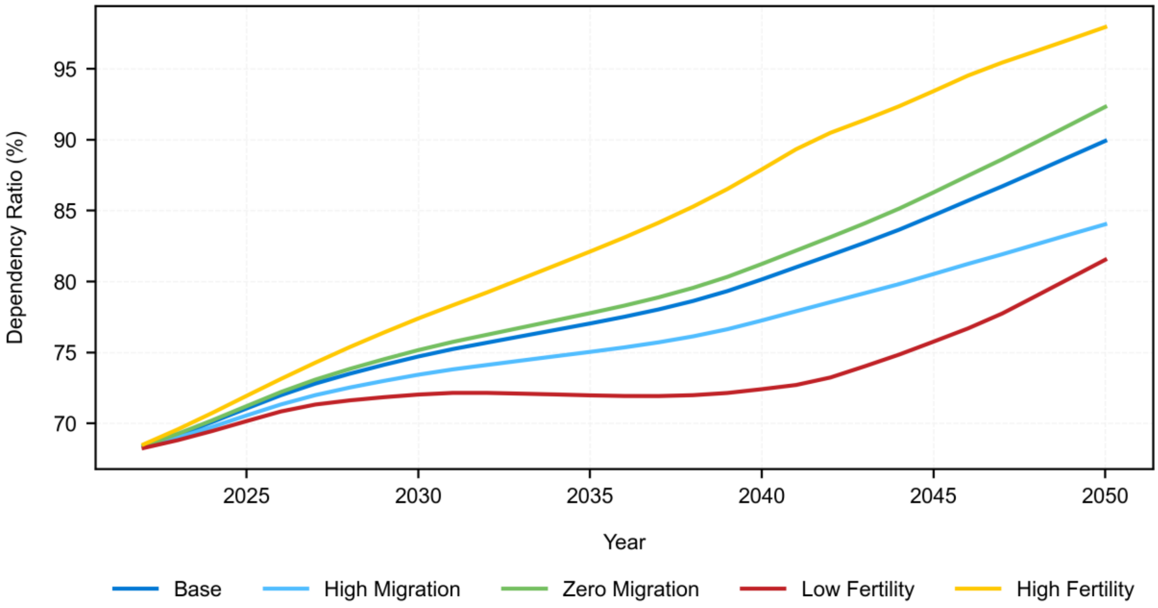
27. International Monetary Fund. Global price of Natural gas, EU [PNGASEUUSDM], retrieved October 15, 2024, from FRED, Federal Reserve Bank of St. Louis: https://fred.stlouisfed.org/series/PNGASEUUSDM.

28. EI Statistical Review of World Energy (2023). Energy institute statistical review of world energy 2023. Energy Institute.

29. Department for Energy Security & Net Zero (November 2024). Energy Prices, International Comparisons. Retrieved from: https://assets.publishing.service.gov.uk/media/66559f858f90ef31c23ebafa/table_541.xlsx.

30. United Nations, Department of Economic and Social Affairs, Population Division (2024). World Population Prospects 2024: Methodology of the United Nations population estimates and projections.

FIGURE 8: DEPENDENCY RATIO PROJECTIONS FOR THE EU UNDER DIFFERENT DEMOGRAPHIC SCENARIOS (2024–2050)



The base scenario shows a gradual rise in the dependency ratio, driven by an aging population. Migration has a limited impact on the dependency ratio: the zero-migration scenario results in a slightly steeper rise due to the shrinking workforce, as most migrants are of working age. Conversely, the high-migration scenario slows the increase in the dependency ratio, but it remains higher than in the low-fertility scenario. In the high-fertility scenario, the dependency ratio increases initially because of a larger population of children reliant on the working-age population. Over time, the ratio continues to rise as people tend to get older. In contrast, the low-fertility scenario keeps the dependency ratio stable for the first 20 years, as fewer children are born to depend on the working-age population. However, after two decades, the workforce also shrinks as fewer people enter working age, while the elderly population grows, ultimately causing the dependency ratio to rise.

CLIMATE POLICY SCENARIOS

Three main climate policy scenarios are used to explore different pathways for the energy sector to 2050. These scenarios are based on the International Energy Agency (IEA) World Energy Outlook. These scenarios are used because they give a granular detail on the energy mix and energy price projections and because they are widely used in the energy sector. Each scenario responds in different ways to the fundamental economic and demographic drivers of rising demand for energy services. These differences largely reflect the various policy choices assumed to be made by governments, which, in turn, shape investment decisions and the ways in which households and companies satisfy their energy needs. Note that these scenarios are used as a guideline, but they have their own challenges and uncertainties, or some might be too optimistic. Still, we are using these scenarios because they are useful as an illustrative range of different energy mix scenarios.

The scenarios that are investigated are defined by goals within the IEA framework:

- **Net-zero emissions by 2050 (NZE) scenario**: This scenario outlines a strategy for the energy sector to limit global warming to 1.5°C by 2100. It also aims to achieve key energy-related UN Sustainable Development Goals, including universal access to reliable energy by 2030 and significant air quality improvements. Although continued high emissions and slow progress make these goals harder to achieve, the scenario looks to leverage recent advancements in clean energy and within their modelling projections looks to show a pathway to meet them.
- **Announced pledges scenario (APS):** The scenario assumes that governments will fully meet all their climate-related commitments, including net-zero targets and nationally determined contributions (NDCs), as well as energy access goals. It also considers business and other stakeholder pledges that enhance these ambitions. While most governments lack sufficient policies to meet their commitments, the scenario assumes they will make significant progress. Countries without strong pledges are expected to benefit from cost reductions in clean energy technologies. If fully implemented, the IEA model projects that this scenario could limit global temperature rise to 1.7°C by 2100, with a 50% probability.

- **Stated policies scenario (STEPS):** This scenario assesses the real-world progress of the energy system based on current policies, focusing on what governments are implementing rather than what they aspire to achieve. It provides sector-by-sector outcomes based on existing or announced measures, without assuming that aspirational targets will be met. Currently, the STEPS scenario within the IEA model projects a global temperature rise of 2.4°C by 2100, with a 50% probability.

A summary of the climate policy scenarios based on the IEA model projections is shown in Figure 9:

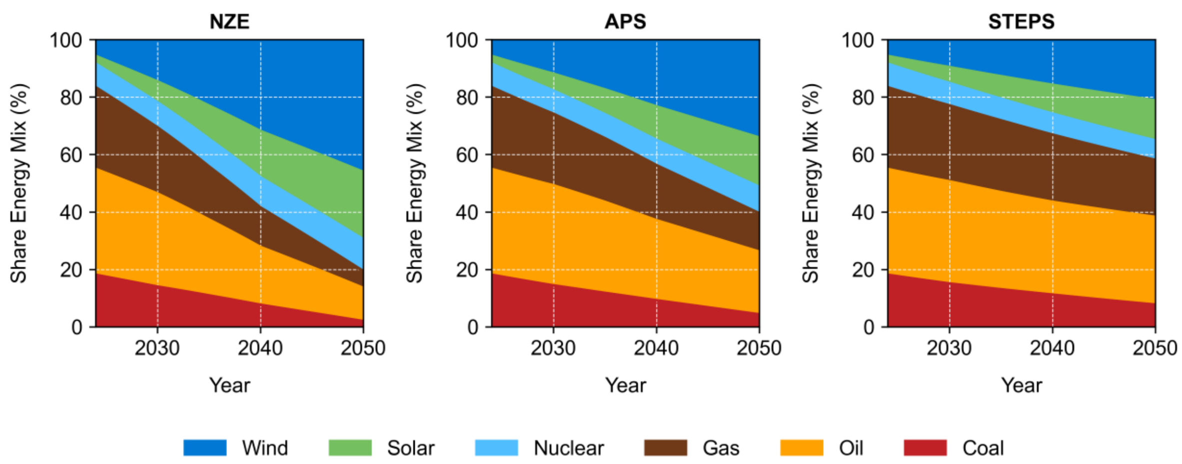
FIGURE 9: CLIMATE POLICY SCENARIOS

SCENARIO	DEFINITION	Δ TEMPERATURE 2100
NZE	Assumes achievement of net-zero emissions	1.5°C
APS	Assumes realization of climate pledges	1.7°C
STEPS	Assumes implementation of current policies	2.4°C

Energy mix

The different climate policy scenarios have influence on the energy mix that is used. In this research, for simplicity the energy mix consists of the components coal, oil, gas, and electricity. The electricity component consists of electricity from the following sources: wind, solar, nuclear, gas, and coal. The projected mix of these electricity sources depends on the climate policy scenario. As illustrated in Figure 10, the projected energy mixes for the EU show that the more ambitious the climate policy scenario is, the larger the share of renewable energy sources in the energy mix and the smaller the reliance on fossil fuels. Notably, even within the NZE scenario, a small proportion of energy production continues to rely on coal. This lingering dependence might appear at odds with the European Union's ambitious net-zero goals, which emphasize a complete transition to sustainable and renewable energy sources.

FIGURE 10: PROJECTED ENERGY MIX IN THE EU ACROSS CLIMATE POLICY SCENARIOS (2024–2050)



Energy prices

The impact of three climate policy scenarios on energy prices is analysed using data from the World Energy Outlook. The electricity prices are based on costs from sources like solar, wind, nuclear, gas, and coal, since these are the main electricity sources. The projections of the oil, gas, coal, and electricity prices including taxes in the European Union are shown in Figure 11. A decrease in electricity prices is observed over time, as investments in these sources begin to pay off, leading to lower overall costs.

FIGURE 11: PROJECTED ENERGY PRICES (PER GJ) BY SOURCE AND CLIMATE POLICY SCENARIO (2024–2050)

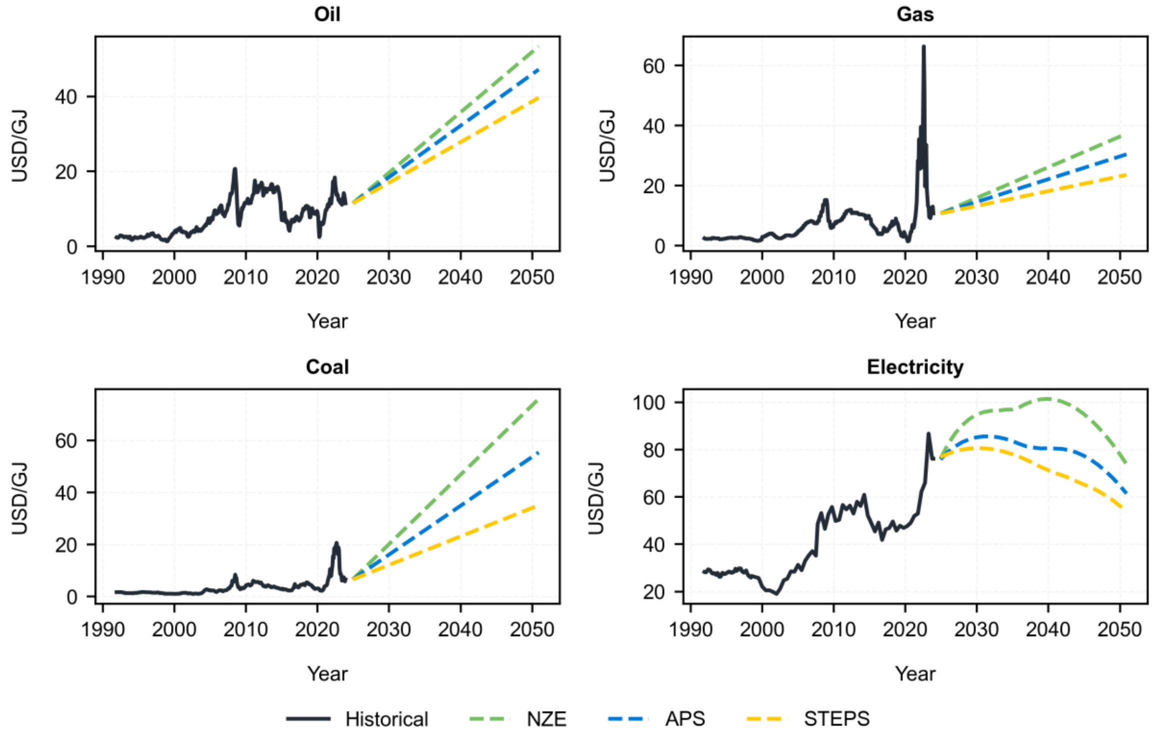
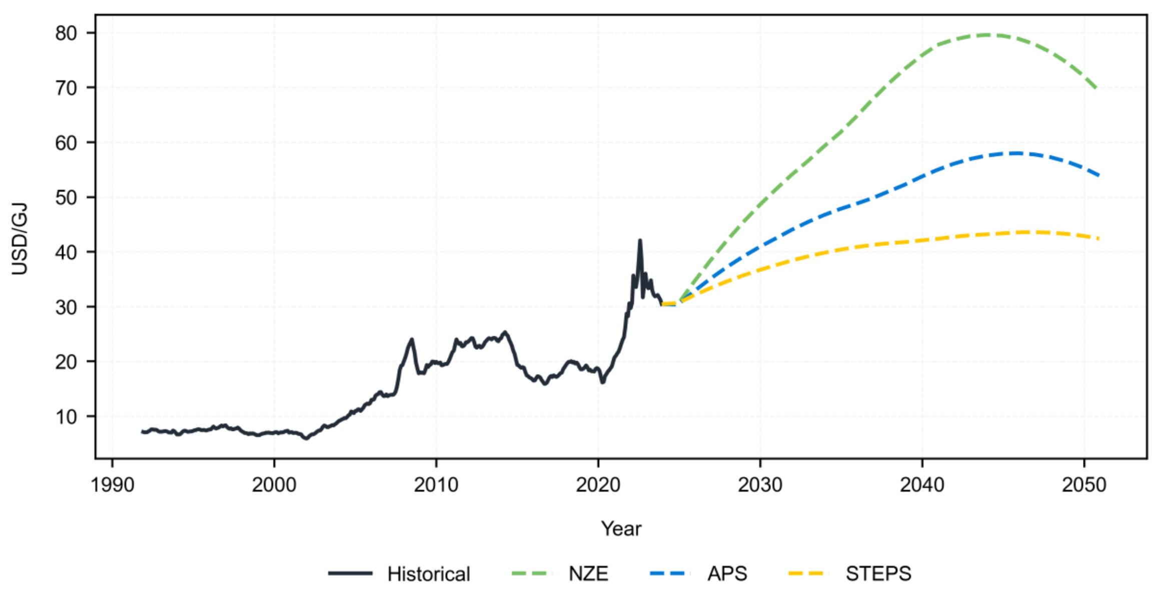


Figure 12 shows the weighted energy price including taxes for the European Union, which is based on the energy prices of Figure 11 and their corresponding weights in Figure 10. Note that the NZE scenario exhibits the highest energy prices; however, it also demonstrates the most significant decline over time, reflecting the impact of investments that eventually yield returns.

FIGURE 12: WEIGHTED ENERGY PRICE PROJECTIONS (PER GJ) ACROSS CLIMATE POLICY SCENARIOS (2024–2050)



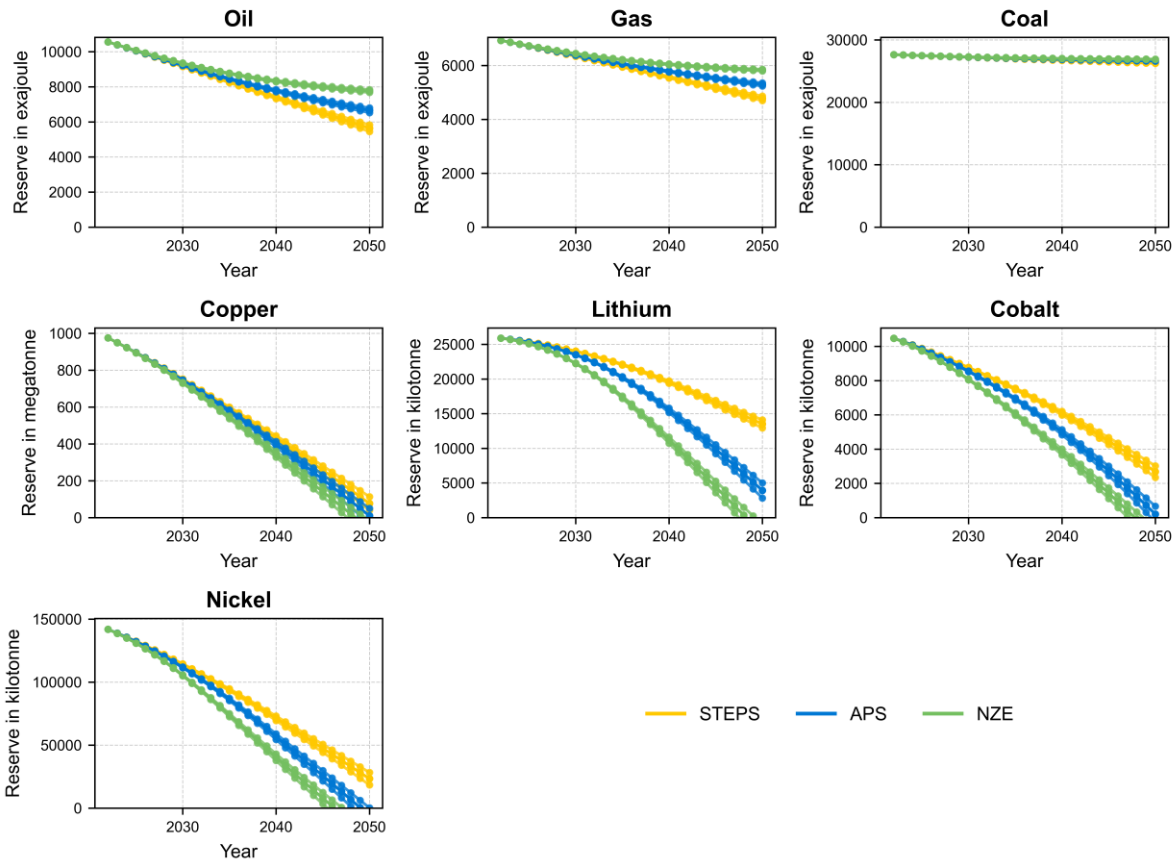
Consumption and reserves

The projected consumption of the sources per person is based on data from the World Energy Outlook[31] while the world population for the different population scenarios is from the World Population Prospects 2024 of the United Nations.[32] Together this will form the expected energy consumption for the different energy sources. Data on the reserves of energy sources in 2024 is from on the Statistical Review of World Energy.[33] Combining these datasets based on the methodology gives the projected global energy reserves over the years.

Figure 13 illustrates the projected global reserves of fossil fuels across various climate policy and demographic scenarios. The climate policy scenarios are represented by different colours, while the demographic scenarios are distinguished by varying line patterns of the same colour. Note that differences between demographic scenarios are minimal, and thus climate policies have a significantly greater impact on fossil fuel reserves than demographic changes. Note that oil reserves are expected to decrease by half by 2050 under the STEPS scenario, but would still not reach the 15 years reserve threshold, and therefore the oil prices will not be adjusted based on expected reserves.

Figure 13 illustrates the projected global reserves of critical minerals. Under all NZE scenarios, as well as certain demographic scenarios within the APS scenarios, copper, lithium, cobalt, and nickel are all expected to face shortages by 2050. Note that these projections assume that no new reserves will be discovered. Historically, however, new reserves of these minerals have been identified, suggesting that additional reserves may be available by 2050. Nonetheless, the potential scarcity of these minerals could exert upward pressure on their prices, as higher prices may be required to make extraction and recycling economically viable. For all critical minerals except for lithium in the STEPS scenarios, the reserve adjustment is triggered.

FIGURE 13: PROJECTED RESERVES OF FOSSIL FUELS AND CRITICAL MINERALS ACROSS SCENARIOS (2024–2050)



31. IEA (2023). World Energy Outlook 2023, IEA, Paris. Retrieved from: https://www.iea.org/reports/world-energy-outlook-2023.

32. United Nations, Department of Economic and Social Affairs, Population Division (2024). World Population Prospects 2024: Methodology of the United Nations population estimates and projections. UN DESA/POP/2024/DC/NO. 10, July 2024.

33. Energy Institute (2024). Statistical Review of World Energy. Retrieved from: https://www.energyinst.org/statistical-review.

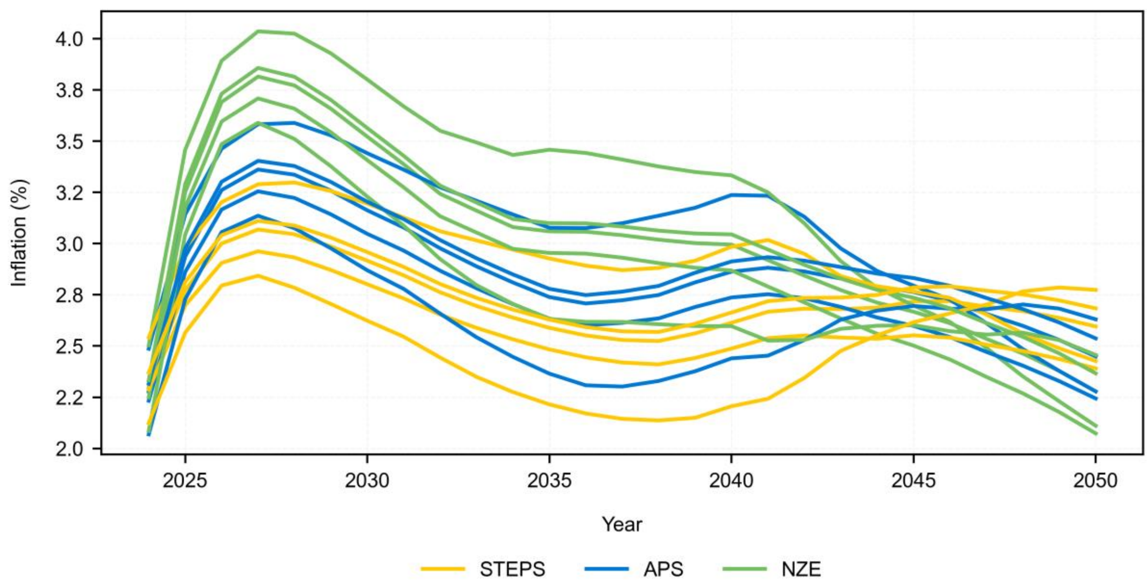
Results

INFLATION TRAJECTORIES ACROSS SCENARIOS

The inflation trajectories from 2024 to 2050 for all 15 scenarios (three climate change scenarios combined with five demographic scenarios) are shown in Figure 14. These scenarios combine varying demographic and climate policy drivers, reflecting diverse structural pressures on inflation over the projection period. Climate policies are differentiated by colours, with common patterns observed across scenarios, such as a rise and gradual decline in inflation.

Differences emerge in the magnitude of inflation peaks, particularly between stricter and looser climate policies. Stricter policies initially drive higher inflation due to transition investments and carbon taxation, which increases energy prices. However, these investments begin to pay off over time, enhancing energy efficiency and easing inflationary pressures. This explains the notable crossing of inflation trajectories around 2045, where stricter policy scenarios transition to lower inflation, while looser policies sustain higher inflation in the longer term. Later figures present a clearer distinction by separating climate and demographic effects, reducing the number of lines per graph for improved interpretability.

FIGURE 14: PROJECTED INFLATION TRAJECTORIES ACROSS COMBINED CLIMATE AND DEMOGRAPHIC SCENARIOS (2024–2050)



To gain deeper insights into the individual effects of demographic and climate policy drivers, the analysis now focuses on their impacts separately, using the baseline scenario for the other factor as a reference point.

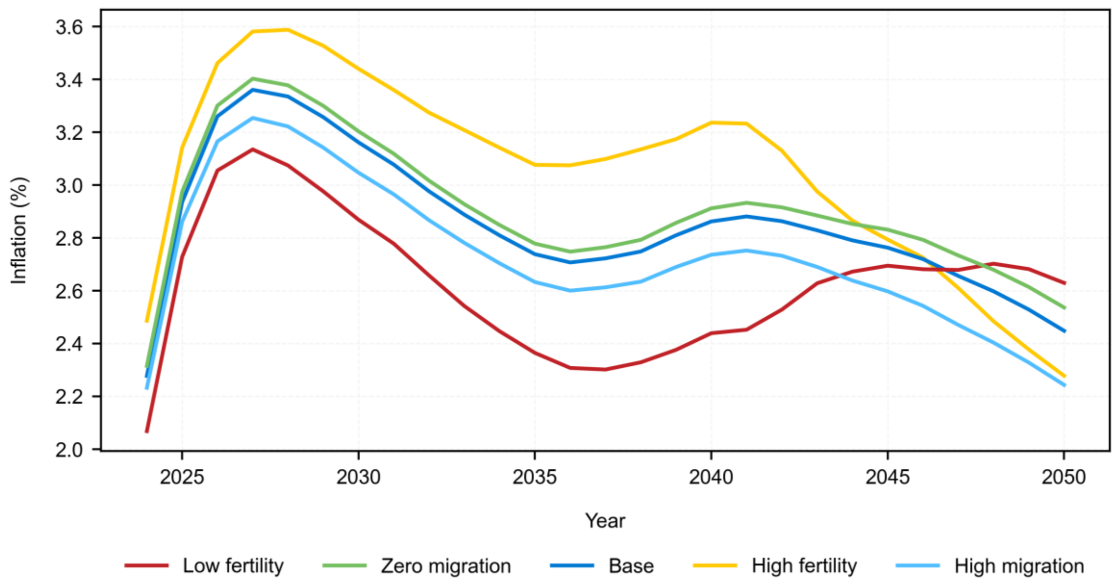
Demographic scenarios under APS climate policy

Figure 15 presents inflation trajectories for all demographic scenarios under the APS climate policy, isolating the role of demographic pressures on inflation outcomes. The trajectories highlight the influence of dependency ratios and population shifts:

- **High-fertility scenario:** Inflation starts higher due to increased consumption driven by a larger proportion of young dependents. Over time, inflation moderates because of the mean reversion effect of the model and because the increase in dependency ratio is slightly lower from 2040 than it was before.
- **Low-fertility scenario:** Inflation initially remains lower due to fewer young dependents. However, in the long term, inflation rises as workforce participation diminishes and dependency ratios grow due to aging populations.

- **Migration scenarios:** Persistently higher inflation is observed in the zero-migration scenario, driven by slightly higher dependency ratios and labour shortages. Conversely, high-migration scenarios maintain slightly more moderate inflation levels as the influx of working-age individuals moderates the dependency ratio and mitigates wage pressures. It is notable that the migration impacts are modest relative to the fertility scenarios, even though the high scenario is three times the base cases. This implies that a far more radical shift in migration policy would be required to significantly impact these projections.

FIGURE 15: INFLATION TRAJECTORIES BY DEMOGRAPHIC SCENARIOS UNDER APS CLIMATE POLICY (2024–2050)

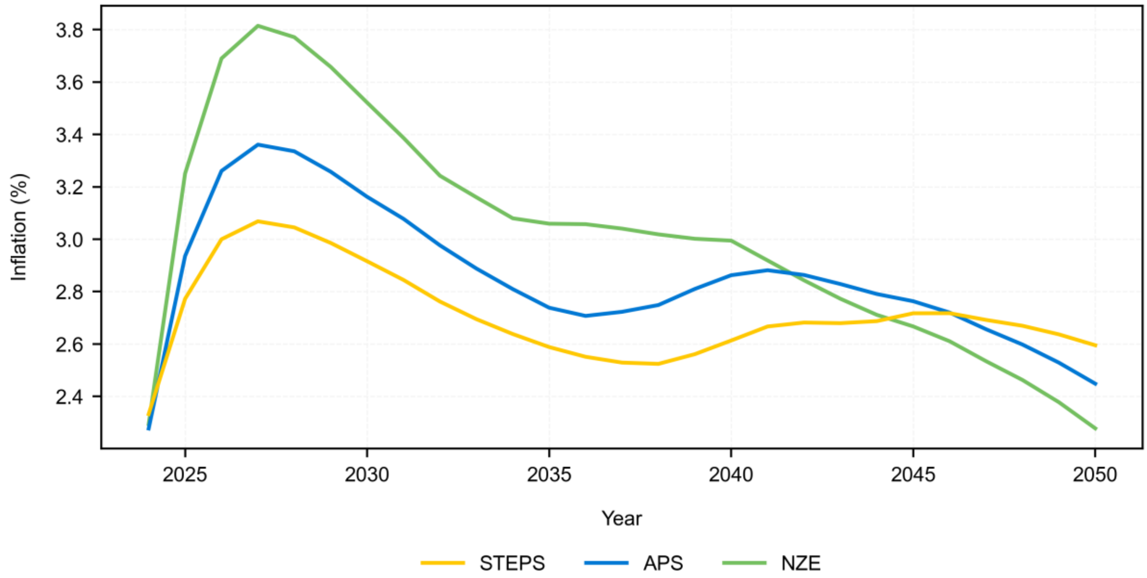


Climate policy scenarios under base demographic assumptions

Inflation trajectories for all climate policy scenarios under the base demographic scenario are shown in Figure 16. This analysis isolates the impact of climate policies on inflation dynamics:

- **NZE scenario:** Inflation rises sharply in the short term due to substantial transition costs associated with installing renewable energy investments. Over time, inflation stabilizes as energy prices normalize.
- **STEPS scenario:** Inflation levels remain relatively stable but are consistently higher due to prolonged reliance on fossil fuels.
- **APS scenario:** Representing a middle ground, this scenario reflects moderate inflationary pressures that gradually stabilize as incremental policy measures take effect.

FIGURE 16: INFLATION TRAJECTORIES BY CLIMATE POLICY SCENARIOS UNDER BASE DEMOGRAPHIC ASSUMPTIONS (2024–2050)



Cumulative inflation analysis

Figure 17 provides a summary of cumulative inflation over the 2024 to 2050 period. Scenarios characterized by high dependency ratios and ambitious NZE climate policies exhibit the highest cumulative inflation. This is driven by early inflationary pressures from transitional energy costs or rising dependency ratios.

However, the STEPS climate policy scenario, along with the low-fertility demographic scenario, catch up in cumulative inflation towards the latter part of the period. In the low-fertility scenario, inflation increases later due to rising dependency ratios as the aging population grows and the labour force diminishes. In the STEPS scenario, delayed energy transition prolongs reliance on fossil fuels; this has less immediate inflationary pressure but these inflationary pressures are sustained over time. By contrast, in the NZE scenario, early investments in renewable energy begin to yield benefits, leading to stabilization and a reduction in inflationary momentum in the later years.

These dynamics can be observed in Figure 14, where the inflation trajectories for each scenario highlight the timing and persistence of inflationary pressures.

The Discussion chapter later in this paper extends this analysis to the period beyond 2050, addressing the longer-term implications of the trends of the structural drivers. This includes the effects of delayed energy transitions under STEPS and APS, such as their impact on climate-related risks, including resource scarcity and extreme weather events, that directly amplify inflationary pressures. Additionally, the discussion explores how demographic projections, particularly rising dependency ratios in low-fertility scenarios, exacerbate inflationary pressures over the long term, emphasizing the structural challenges posed by aging populations.

FIGURE 17: CUMULATIVE INFLATION COMPARISON ACROSS DEMOGRAPHIC AND CLIMATE POLICY SCENARIOS (2024–2050)

	STEPS	APS	NZE
Low Fertility	93.8%	101.2%	109.5%
High Migration	99.0%	106.6%	115.2%
Base	105.8%	113.7%	122.5%
Zero Migration	108.7%	116.6%	125.6%
High Fertilty	117.1%	125.3%	134.6%

Most and least inflationary scenarios

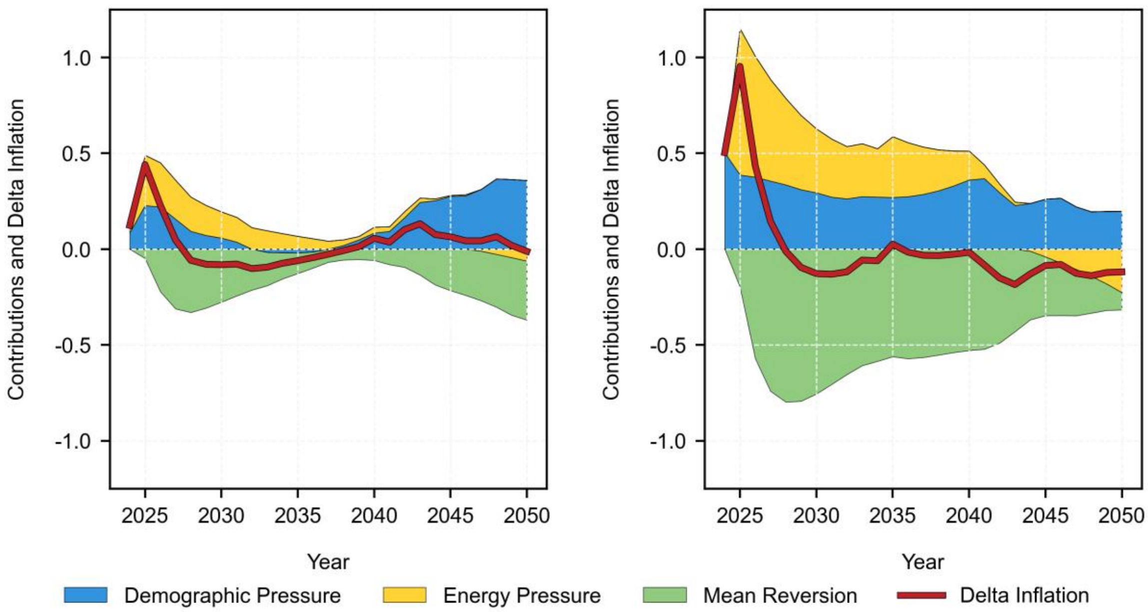
Figure 18 illustrates the evolution of the changes in inflation ($\Delta\pi$) over time, highlighting its key drivers, demographic, energy, and mean reversion components, for the most and least inflationary scenarios during the 2024 to 2050 period: the NZE policy paired with high-fertility demographics and the STEPS policy coupled with low-fertility demographics.

The most inflationary scenario, NZE with high fertility, exhibits significant early inflationary pressures primarily driven by the energy component. This reflects the substantial investment costs associated with transitioning to renewable energy sources, which dominate the initial years. Over time, the energy pressures subside as these investments stabilize energy prices. Demographic contributions remain moderate but positive throughout the projection period, driven by a growing young population and increasing consumption.

In contrast, the least inflationary scenario, pairing the STEPS policy with low-fertility demographics, demonstrates a more stable inflation trajectory. Initially, inflationary pressures are muted due to lower dependency ratios resulting from reduced fertility. However, as the population ages and the labour force contracts, demographic pressures rise sharply, contributing to an inflationary uptick towards the end of the period. Energy pressures in this scenario remain lower, reflecting the limited transition costs under the STEPS policy.

This analysis highlights the interaction between structural drivers and monetary policy. In the NZE scenario, significant early energy pressures necessitate more aggressive policy responses, as evidenced by the mean reversion contributions. Over time, these contributions taper off as inflationary pressures stabilize. Conversely, the STEPS scenario features lower mean reversion contributions throughout most of the period, though these increase towards the end in response to the rising demographic pressures.

FIGURE 18: DECOMPOSITION OF INFLATION DRIVERS: COMPARING STEPS - LOW FERTILITY AND NZE – HIGH-FERTILITY SCENARIOS (2024–2050)



INTEREST RATES ACROSS SCENARIOS

Figure 19 presents the average interest rates across different demographic and climate policy scenarios from 2024 to 2050. These values reflect the monetary policy adjustments necessary to manage inflationary pressures under varying structural drivers.

FIGURE 19: AVERAGE INTEREST RATES ACROSS DEMOGRAPHIC AND CLIMATE POLICY SCENARIOS (2024–2050)

	STEPS	APS	NZE
Low Fertility	2.95%	3.48%	4.46%
High Migration	3.41%	4.19%	4.88%
Base	3.99%	4.51%	5.19%
Zero Migration	4.10%	4.63%	5.31%
High Fertility	4.75%	5.16%	5.96%

Across all scenarios, interest rates in our model are directly determined by the mean reversion mechanism and changes in inflation. Since inflation remains above the target in all cases, the required mean reversion leads to higher interest rates, with differences across scenarios reflecting variations in inflationary pressures driven by demographic trends and climate policy choices.

The NZE policy scenarios have the highest average interest rates, as they experience the strongest inflationary pressures due to higher energy transition costs. In contrast, STEPS scenarios have the lowest average interest rates, as inflationary pressures emerge more gradually, primarily due to demographic shifts rather than immediate policy changes. APS scenarios fall in between, reflecting a more moderate inflationary environment and corresponding interest rate levels.

Demographic factors further influence the average interest rate levels. High-fertility scenarios lead to higher average interest rates that require stronger monetary policy responses. Low-fertility and high-migration scenarios tend to have lower average interest rates, as inflation remains more contained, reducing the required level of mean reversion.

Since interest rates in our model are directly linked to inflation and mean reversion, scenarios with the highest inflation levels necessarily have the highest required average interest rates over the period. Conversely, scenarios with lower inflation require less monetary tightening, leading to lower average interest rates.

SENSITIVITY ANALYSES

Sensitivity to inflation target

The sensitivity analysis evaluates the implications of adjusting the inflation target to 3%, 4%, and 5% in response to persistent structural inflationary pressures. The baseline target of 2% increasingly appears unsustainable due to upward pressures from structural factors such as demographic shifts and energy transition costs. Maintaining the 2% target would necessitate extended periods of elevated interest rates, which could increase debt servicing costs, pressure financial institutions holding long-duration assets, and amplify risks of market volatility and economic downturns. These factors, in turn, could weaken financial stability by straining corporate and sovereign balance sheets, increasing default risks, and reducing credit availability.

To assess the feasibility of alternative monetary policy strategies, sensitivity tests were conducted for inflation targets of 3%, 4%, and 5%. Higher targets reduce the scale of required interest rate adjustments, providing greater policy flexibility to accommodate structural inflationary pressures. However, inflation levels rise correspondingly under these scenarios. Because the interest rate model incorporates delta inflation as a direct driver of interest rate adjustments, the decline in mean reversion effects is partially offset by the increase in inflation. This dynamic underscores a trade-off between moderating interest rates and accepting higher inflation, highlighting the balance required to align inflation targets with long-term structural trends while managing the risks of tighter monetary policy and elevated price levels.

Figure 20 presents the average inflation and interest rates across all scenarios and years for varying inflation targets. The results emphasize the inherent trade-off: As the inflation target increases, average inflation levels rise, while the average required interest rates decline. This reflects reduced mean reversion pressures and improved monetary policy flexibility to manage structural inflationary trends. However, the higher inflation targets entail economic costs, underscoring the careful consideration required when recalibrating inflation targets.

FIGURE 20: SENSITIVITY OF AVERAGE INFLATION AND INTEREST RATES TO TARGET INFLATION LEVELS

TARGET INFLATION RATE	AVERAGE INFLATION RATE	AVERAGE INTEREST RATE
2%	2.84%	4.46%
3%	3.71%	4.06%
4%	4.54%	3.80%
5%	5.28%	3.62%

Sensitivity to retirement age

The analysis highlights the tensions in retaining a retirement age of 65, which is implied in the baseline demographic assumptions of the model. This is consistent with the average statutory retirement age across the EU, which is approximately 64.3 for men and 63.5 for women.[34] Rising dependency ratios, particularly in low-fertility and zero-migration scenarios, become increasingly pronounced towards the end of the projection period.[35] This indicates a growing proportion of retirees relative to the working-age population, leading to persistent inflationary pressures from labour shortages, increased consumption demands associated with aging populations, and a larger share of state pensions that need to be financed by governments through taxes and social security premiums. The model results show that these late-period structural pressures significantly strain the economy, further limiting the flexibility of monetary policy.

A sensitivity analysis was conducted to evaluate the impact of extending the retirement age to 70. This scenario assumes a gradual, linear increase in the retirement age, reaching 70 by 2030, after which it remains fixed. Given the current retirement age and societal pressures against significant increases, further rises beyond 70 were deemed unrealistic and were therefore excluded from the analysis.

Figure 21 summarizes the impact of increasing retirement ages on average inflation and interest rates over all scenarios:

FIGURE 21: SENSITIVITY OF AVERAGE INFLATION AND INTEREST RATES TO RETIREMENT AGE

RETIREMENT AGE	AVERAGE INFLATION RATE	AVERAGE INTEREST RATE
65	2.84%	4.46%
70	1.86%	2.45%

Raising the retirement age has a deflationary effect by substantially increasing the working-age population, reducing labour shortages and wage. At the same time, it decreases the number of dependents, creating a double-edged dynamic. This lowers inflationary pressures, requiring fewer interest rate increases and providing greater monetary policy flexibility to support economic stability.

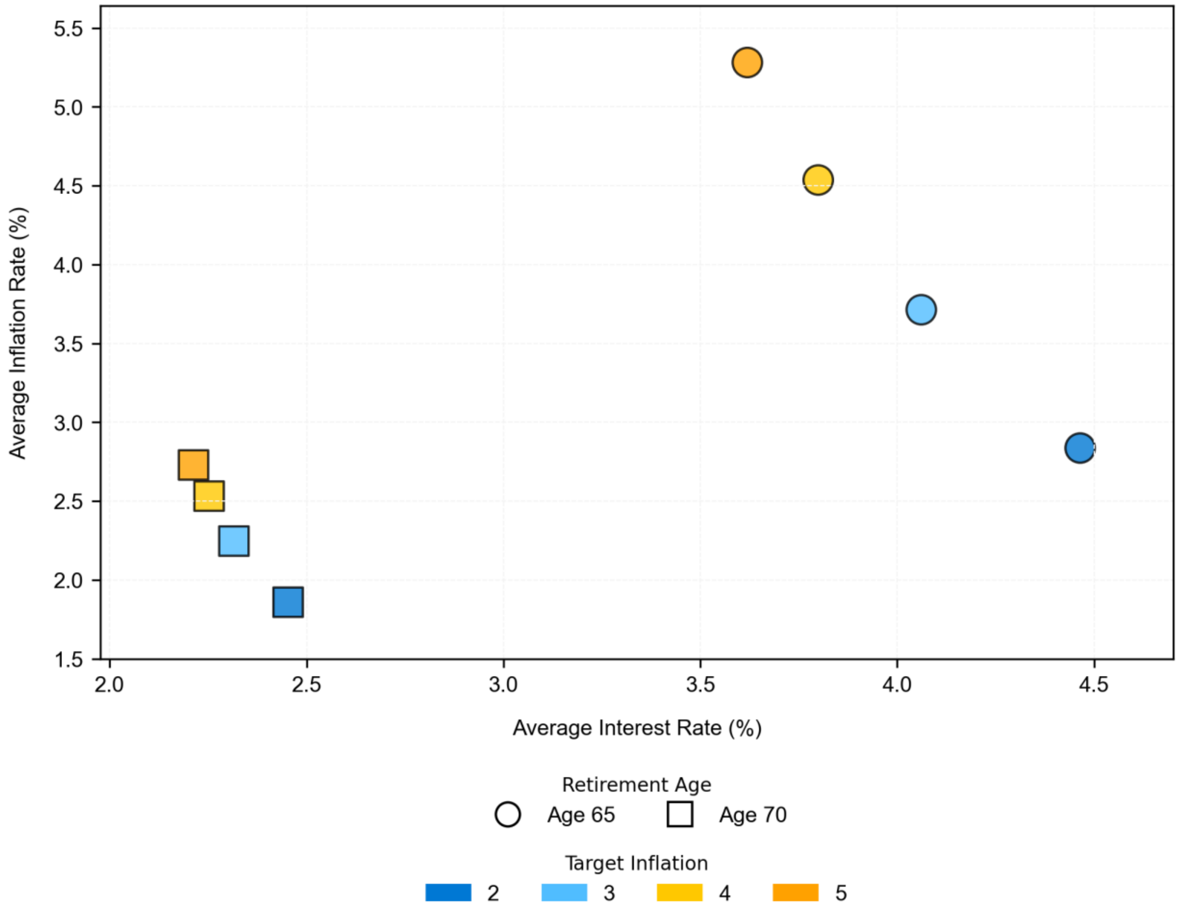
34. Euronews (2023). Pension reform in France: Which countries have the lowest and highest retirement ages in the EU? Retrieved from https://www.euronews.com/next/2023/04/06/pension-reform-in-france-which-countries-have-the-lowest-and-highest-retirement-ages-in-eu.

35. For further discussion on how dependency ratios continue to rise beyond 2050, particularly in the low-fertility and zero-migration scenarios, see the Discussion section on long-term demographic trends and their implications.

Combined sensitivities

Figure 22 demonstrates the combined effects of raising the retirement age and increasing the target inflation rate on average inflation and interest rates throughout the period from 2024 to 2050.

FIGURE 22: SENSITIVITY OF AVERAGE INFLATION AND INTEREST RATES TO RETIREMENT AGE AND INFLATION TARGETS



The figure highlights the effects of retirement age and inflation targets on inflation and interest rates. Raising the retirement age from 65 to 70 consistently reduces both inflation and interest rates by easing labour shortages and reducing wage-driven inflationary pressures. This makes raising inflation targets less necessary, as the inflationary pressures are effectively managed through higher labour force participation. Even if inflation targets are increased, the actual inflation often remains below these targets, reducing their overall impact.

At a retirement age of 65, however, the trade-off between higher inflation targets and lower interest rates becomes more pronounced. Raising inflation targets allows for lower interest rates as monetary tightening becomes less aggressive. However, this comes at the cost of higher average inflation. While this trade-off may provide some flexibility in monetary policy, it highlights the challenges of balancing price stability with economic growth. The figure demonstrates that these higher inflation targets result in persistently elevated inflation levels, whereas raising the retirement age offers a more consistent and sustainable approach to stabilizing inflation and interest rates.

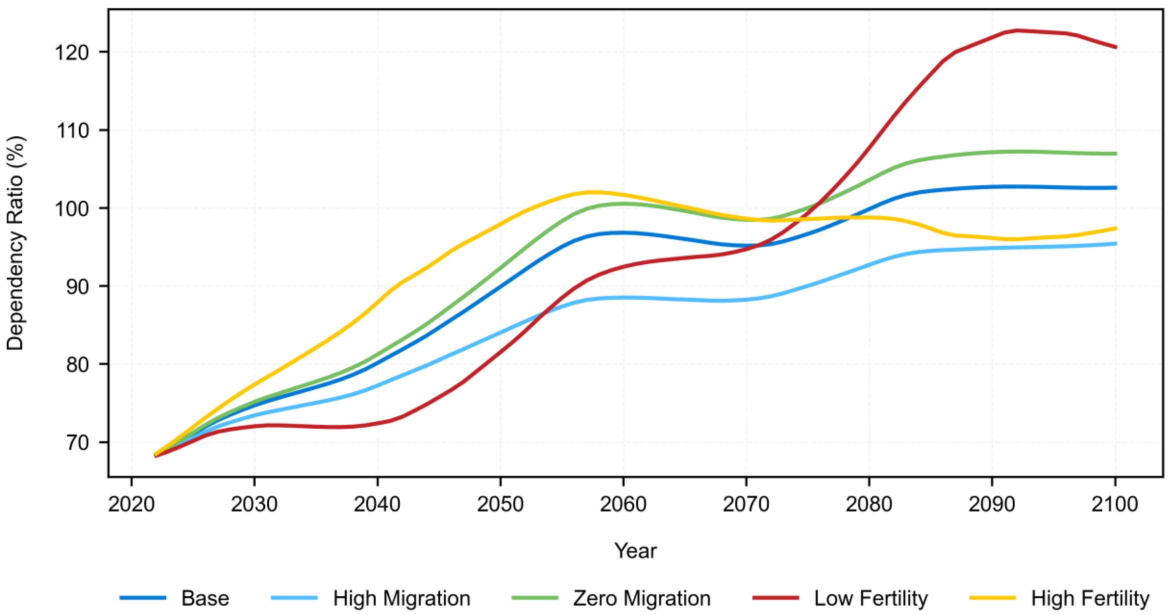
Discussion

AFTER 2050

While specific data on energy prices beyond 2050 is not available, projections indicate that energy prices could continue to decline in the NZE scenario when compared to the STEPS and APS scenarios. This anticipated drop is largely attributed to significant investments in renewable energy, which are expected to yield long-term returns and help lower energy costs.

The United Nations has projected dependency ratios through to 2100, as shown in Figure 23. Notably, after 2075, the low-fertility scenario is expected to result in the highest dependency ratio, while the high-fertility scenario will lead to a lower dependency ratio than the base scenario. This represents a shift from trends before 2050, when the low-fertility scenario will initially have the lowest dependency ratio due to fewer children entering the dependent population. However, over time, the long-term effects of low birth rates will shrink the working-age population, leading to a larger dependent elderly group and a rising overall dependency ratio.

FIGURE 23: DEPENDENCY RATIO PROJECTIONS ACROSS DEMOGRAPHIC SCENARIOS (2024–2100)

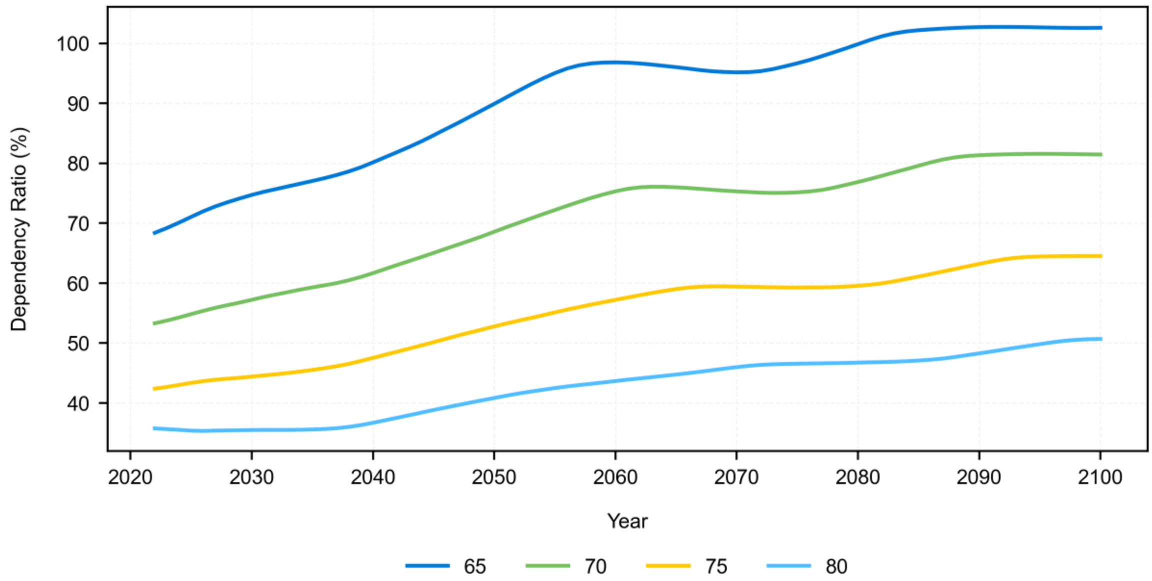


In all population projections, the European Union is expected to experience a rising dependency ratio due to demographic shifts, such as aging populations and declining workforce participation. Inflationary pressures are likely to be most pronounced under low-fertility scenarios because our results showed that a higher dependency ratio will lead to a higher inflation. To address these pressures, raising the retirement age is a viable strategy to reduce dependency ratios.

As illustrated in Figure 24, increasing the retirement age from 65 to 70 significantly lowers the dependency ratio, with further increases to 75 and 80 leading to even greater reductions. These effects persist over the long term, as projections extending to 2100 demonstrate that higher retirement ages consistently mitigate the rise in dependency ratios. This underscores the critical role of adapting retirement policies to counteract demographic-driven inflationary pressures in the coming decades.

It is important to note that the scenarios where the retirement age is raised to 75 or even 80 are included purely for illustrative purposes. Such increases are not deemed realistic given societal, economic, and health-related constraints but are shown to highlight the theoretical long-term impact of higher retirement ages on the dependency ratio. Additionally, changes to the retirement age are typically implemented gradually. Consequently, adjustments do not result in abrupt shifts in the dependency ratio from one year to the next. Instead, they gradually bring the dependency ratio in line with the outcomes seen in higher-retirement-age scenarios. In this figure, the retirement age is modelled as if the change is implemented immediately from 2024 onwards. If phased implementation were considered, the trajectory of the 65-year retirement line would slowly converge toward the 70-, 75-, or even 80-year retirement lines over time.

FIGURE 24: DEPENDENCY RATIO PROJECTIONS BASED ON RETIREMENT AGE SCENARIOS (2024–2100)



Additionally, climate change may trigger increased global migration, particularly from regions like Africa, which are significantly impacted by environmental changes which could well lead to food shortages and repeated damages from severe storms and flooding. In contrast, whilst the impact on the European Union is expected to grow and may be severe, it is expected to face relatively less significant climate-related disruption. If permitted, increased migration could help reduce the dependency ratio in the European Union, a trend that may be more pronounced in the STEPS scenario compared to the APS and NZE scenarios.

In our study, we did not account for the costs associated with natural catastrophes or investments in infrastructure improvements to mitigate the effects of flooding, due to limited data availability. A significant portion of these costs is expected to be covered by governments, ultimately funded through tax payments.

In conclusion, the interplay between energy prices, demographic shifts, and climate change will shape the future economic landscape, particularly in the European Union. While investments in renewable energy could help lower energy costs in the long term, the evolving dependency ratios, driven by changing fertility rates and an aging population, also pose significant challenges. Governments may need to adopt policies such as raising the retirement age to manage the rising dependency ratio and mitigate inflationary pressures. At the same time, if migration were allowed to increase, it would provide some relief by lowering the dependency ratio in the European Union.

CLIMATEFLATION

This study examines the impact of demographic changes and climate policies on inflation, focusing on three types of inflationary pressures: climateflation, fossilflation, and greenflation. The analysis incorporates fossilflation and greenflation into the model, while climateflation, arising from disruptions to supply chains, agricultural productivity, and production stability due to climate change, was outside its scope. However, the influence of climateflation is expected to intensify as global temperatures rise, amplifying its effects on the economy and pointing to even larger inflationary impacts than this analysis has shown.

The findings indicate that all the transition scenarios lead to higher inflation through to 2050. The stricter climate policies have the largest impact, especially in the shorter-term. This is primarily driven by increased taxation and regulatory measures aimed at reducing carbon emissions, which elevate costs across the economy. Fossilflation, driven by rising costs of fossil fuels, and greenflation, fueled by the transition to renewable energy and sustainable technologies, both contribute to this upward pressure. However, stricter climate policies also offer the potential to mitigate long-term inflationary pressures associated with climateflation. By limiting global warming and its associated disruptions, robust policies could reduce the destabilizing effects on supply chains and production systems, which are central drivers of climateflation.

A study from the Potsdam Institute for Climate Impact Research estimates that inflationary pressure in Europe could be 0.5 percentage points higher in a high-emissions scenario compared to a low-emissions scenario by 2035.[36] This highlights the 'no escape' inflationary consequences of climate policy: While faster transition measures increase inflation in the short to medium term, they also act as a preventive mechanism against more severe inflationary shocks linked to unmitigated climate change. This climateflation element cannot be directly added to the results in our study since different scenarios are used in our research compared to the research from the Potsdam Institute for Climate Impact Research. Future research integrating all three types of inflation into one framework could provide further insights into the interactions between climate policies, economic transitions, and inflationary dynamics.

36. Kotz, M., Kuik, F., Lis, E. et al. (March 2024). Global warming and heat extremes to enhance inflationary pressures. Commun Earth Environ 5, 116 (2024). Retrieved from: https://doi.org/10.1038/s43247-023-01173-x.

Key takeaways from our analysis

This study examines the some of the potential structural drivers of long-term inflation in the Eurozone, focusing on the period from 2024 to 2050. Demographic trends and climate policies are identified as key forces shaping inflation dynamics, with significant implications for economic and policy frameworks.

Demographic shifts, particularly aging populations and changes in dependency ratios, are likely to play a critical role in long-term inflationary trends. Based on our analysis, high-fertility scenarios are likely to be the most inflationary until 2050 due to the economic impact of a larger proportion of dependents (children) relative to the working-age population, which increases consumption and inflation. Over time, however, these pressures moderate as younger generations enter the labour force. Conversely, on analysis shows that low-fertility scenarios initially experience lower inflation due to fewer young dependents, but inflationary pressures are likely to intensify post-2050 as workforce participation diminishes and aging populations drive up dependency ratios. Migration could play a pivotal role in mitigating these pressures, with high-migration scenarios helping to reduce dependency ratios and the inflationary impacts, while zero-migration scenarios amplify labour shortages and wage pressures. Although to have a significant demographic impact, EU migration levels would need to be much higher than current levels. Beyond 2050, in our analysis low fertility emerges as the most inflationary demographic scenario as the effects of an aging population take precedence.

Raising the retirement age to 70 provides an additional lever to address demographic-driven inflationary pressures. Our analysis demonstrates that increasing the retirement age significantly reduces dependency ratios, eases labour shortages, curbs wage-driven inflation, and lowers the need for higher interest rates. While further increases in the retirement age may be unrealistic, raising it to 70 serves as a practical and effective policy measure to stabilize inflation over the long term.

Climate policies are also likely to influence inflation trajectories. Our analysis indicates that the net-zero emissions (NZE) scenario is likely to introduce significant short-term inflationary pressures due to the high investment costs associated with transitioning to renewable energy sources. However, our analysis shows that these investments are likely to lead to long-term stabilization of energy prices as renewable energy scales and fossil fuel reliance diminishes. In contrast, our analysis of the stated policies (STEPS) scenario, characterized by delayed energy transitions, illustrates potential long-term inflationary pressures by prolonging reliance on volatile fossil fuel markets. While specific data on expected energy prices beyond 2050 is unavailable, projections indicate that NZE investments could continue to lower energy costs well into the future.

Monetary policy faces considerable challenges in addressing these inflationary pressures. Maintaining the European Central Bank's (ECB) 2% inflation target based on these projections would require significant interventions, and even with these interventions it will be hard to achieve, particularly in scenarios of persistent structural inflation. Adjusting inflation targets upward may provide greater policy flexibility but risks higher long-term inflation levels, reflecting the delicate balance between price stability and economic growth.

Although this study focuses on the period to 2050, the post-2050 horizon brings additional challenges. Low-fertility scenarios see rising dependency ratios intensify inflationary pressures as workforce participation declines. If accepted, significantly increased migration patterns may partially alleviate these challenges by reducing labour shortages in the European Union. On a more positive note, energy prices are expected to continue declining in the NZE scenario beyond 2050, driven by returns on renewable energy investments.

Ultimately, stabilizing inflation trajectories requires coordinated efforts across fiscal, monetary, and structural domains. Structural factors, such as demographic shifts and ambitious climate policies, play distinct roles in shaping inflationary trends. In the short to medium term, climate policies are likely to be inflationary. Early investments in renewable energy, while essential for long-term stabilization of global temperatures and inflation, may significantly elevate costs during the transition phase due to infrastructure development, commodity constraints, and regulatory changes. Demographic changes, particularly aging populations, also influence inflation, though their effects are more nuanced. These trends are likely to exacerbate labour shortages and wage pressures, amplifying inflationary forces in the near term. However, the inflationary impact over time is primarily driven by structural factors, rather than by policy interventions, which have a modest impact.

However, these upfront inflationary pressures can be viewed as necessary trade-offs to achieve future economic resilience. Early investments in renewable energy, despite their initial costs, reduce reliance on volatile fossil fuel markets and are likely to contribute to long-term price stability. Likewise, demographic strategies such as extending working lives and implementing managed migration policies address dependency ratio challenges, gradually alleviating inflationary pressures. These measures would lay the groundwork for economic stability beyond 2050, ensuring sustainable inflation management despite the enduring effects of climate and demographic shifts.

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