The energy transition and inflation

Simulating a future oil and gas prices shock under varying scenarios with the E3ME model.

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Executive Summary

The 1970s and the early 2020s were marked by energy supply and demand shocks driving up oil and gas prices, resulting in much higher-than-normal inflation. In this paper, we analyse the potential contribution that the energy transition can make to improving the global economy's resilience to such oil and gas price shocks, principally by limiting the impact that these have on economy-wide inflation. We do this by simulating a future oil and gas price shock, similar to the scale observed in the 1970s, in our global macroeconomic model E3ME. We compare macroeconomic outcomes for future years (2024-2040) in a business-as-usual scenario versus a 1.5°C scenario. Our analysis confirms that faster decarbonisation of the energy system and increased energy efficiency could make a significant contribution to maintaining price stability, should another oil and gas price shock occur.

1. Introduction

The 1970s saw a significant and unique episode of inflation and stagnant economic growth, driven by a series of oil price shocks disrupting global energy markets. A first crisis was triggered by the Arab oil embargo in response to geopolitical events. This was followed by the Iranian Revolution in 1979, leading to a second oil crisis. In both instances, economy-wide global inflation reached double digits (World Bank, 2023a).

2021 marked another year of geopolitical turmoil, combined with a recovery from the COVID-19 pandemic. While global inflation did not reach the same level as we saw in the 1970s, average annual global inflation reached close to 10% in 2022, posing major challenges for economic policy makers and households in many countries across the globe – Europe and the US in particular. It is generally accepted that this inflation was caused by a combination of factors, among which a shock to both energy supply and energy demand (caused by a strong rebound in demand following the pandemic, low inventories, the geopolitical tensions, and weather conditions).

The relationship between energy prices and inflation is a complex and debated topic in economic research. Energy prices have a direct effect on inflation because energy prices feed into the way consumer price indices are calculated. At the same time, they have an indirect effect on general prices levels because they contribute to business production costs, and ultimately changes in energy prices are passed through to consumers in the price of the goods and services they are selling, to maintain profitability.

This is not a one-to-one relationship. The extent (and speed) to which general prices are affected depends on various factors, such as the size and persistence of the energy price shock, expectations of future prices, the behaviour of consumers and producers (e.g. price gouging), and the policy response of central banks and governments. Furthermore, the energy mix of an economy (i.e. the dependence on particular fuels and energy sources), as well as the level of energy efficiency, affect an economy's reliance on oil and gas, and therefore its exposure to changes in the prices of these commodities.

Such factors also help explain observed variation across countries and over time. An analysis by the European Central Bank on 'energy price developments in and out of the pandemic' suggests that countries that relied more on renewable energy sources or domestic energy production were less exposed to the fluctuations of global energy markets, and that increasing decarbonisation of the energy system and increasing energy efficiency could reduce consumer energy prices in the long run (Kuik et al., 2022). Another recent paper by Dezernat Zukunft suggests that renewable energy can help fight inflation in the short and long run, and thereby facilitate price stability (Krahé & Hellmann, 2023).

We are interested in exploring this hypothesis further, and analyse the difference that faster decarbonisation and greater energy efficiency can have on the global economy's resilience to global commodity price shocks. We do this by simulating a future oil and gas price shock similar to the scale seen in the 1970s in the global macroeconomic model E3ME, and compare macroeconomic outcomes for future years (2024-2040) in a business-as-usual scenario versus a 1.5°C scenario.

Section 2 of this paper provides information on the methodology. We then describe the modelling results in Section 3 and provide some conclusions in Section 4.

2. Methodology

2.1. The E3ME model

E3ME is a global dynamic econometric simulation model of the economy-energy-environment systems, developed by Cambridge Econometrics over several decades, with contributions from academics at various institutions. E3ME applies economic (national) accounting identities and empirically estimated behavioural equations to model interactions between the economy, energy system and the environment, solving for each year with path dependency.

E3ME provides global coverage and comprehensive analysis of:

- Direct impacts, for example reductions in energy demand and emissions, fuel switching and renewable energy.
- Secondary effects, for example on fuel suppliers, energy prices and competitiveness impacts.
- Rebound effects of energy and materials consumption from lower prices, spending on energy or other economic activities.
- Overall macroeconomic impacts; on jobs and the economy at a high level of sectoral detail and (where data allow) household income group.

E3ME is designed primarily as an empirical tool. It draws on the Cambridge (UK) tradition of macroeconomics, supplemented by more recent applications of complexity theory to economics. The key properties of the model include recognition of fundamental uncertainty, possible non-rational behaviour and market structures determined by the available data. Considering the model's scope, it can be used for obtaining insights into sectoral and regional consequences for the global macro-economy.

E3ME incorporates bottom-up technology models of four major energy-using sectors (power, personal transportation, steel and household heating). These models follow the 'S-shaped' diffusion paths of new technologies as they gain market acceptance and incorporate cost reductions through learning-by-doing effects.

The econometric specification of E3ME gives the model a strong empirical grounding. E3ME uses a system of error correction, allowing short-term dynamic (or transition) outcomes, moving towards a long-term trend.

2.2. Energy prices and inflation in the model

E3ME captures both the direct and indirect effect from increased oil and gas prices, based on the parameters and elasticities estimated from time series data over the 1970-2018 period. In the model, a shock to oil and gas prices penetrates through the economy and affects groups of economic agents through different channels:

- Power generators are faced with higher costs of oil and gas use for electricity generation, leading to an increase in the average cost of electricity that is charged to businesses and consumers.
- Firms that use oil or gas as inputs see their cost of production increase, therefore passing on some of the cost increase to their consumers by raising the price of their goods and services. The extent to which this happens is estimated econometrically, by sector.
- Households that use petrol (produced from oil, e.g. for transport) and gas (e.g. for heating and cooking) face higher retail prices.

2.3. Scenario design

Four scenarios are simulated in the E3ME model:

1. A business-as-usual scenario calibrated to the IEA Stated Policies (STEPS) scenario, which assumes all current energy policies will be maintained and stated policies will be implemented effectively, while per-unit oil prices will continue to grow at 1.1% per annum over the years to 2050 after accounting for inflation. Per-unit gas prices will not change significantly in real terms (IEA, 2022).
2. A global 1.5°C-compatible scenario, driven by comprehensive decarbonisation of energy-related emissions and globally coherent policy implementation.
3. A variant of the STEPS scenario with shocks to oil and gas prices (see below)
4. A variant of the 1.5°C scenario with the same shocks to oil and gas prices (see below)

The oil and gas price shock simulated in the model is derived from historical data on global commodity prices of crude oil and natural gas during the 1970s crisis, from The Energy Institute's Statistical Review of World Energy Data (Energy Institute, 2023) and the US Energy Information Administration (EIA, 2023). The trends in oil and gas prices observed over this period are adjusted for GDP growth and assumed for the projection period (2023-40).

It is assumed that if the price shocks lead to impacts on governments' fiscal balances, then all governments adjust tax rates to remain budget-neutral relative to the BAU scenario without price shocks.

Figure 1: Assumptions for oil and gas prices

The price shock scenarios are compared with the corresponding scenario that does not include such a shock (i.e. STEPS with price shocks compared to STEPS without shocks, and similarly for 1.5°C scenarios).

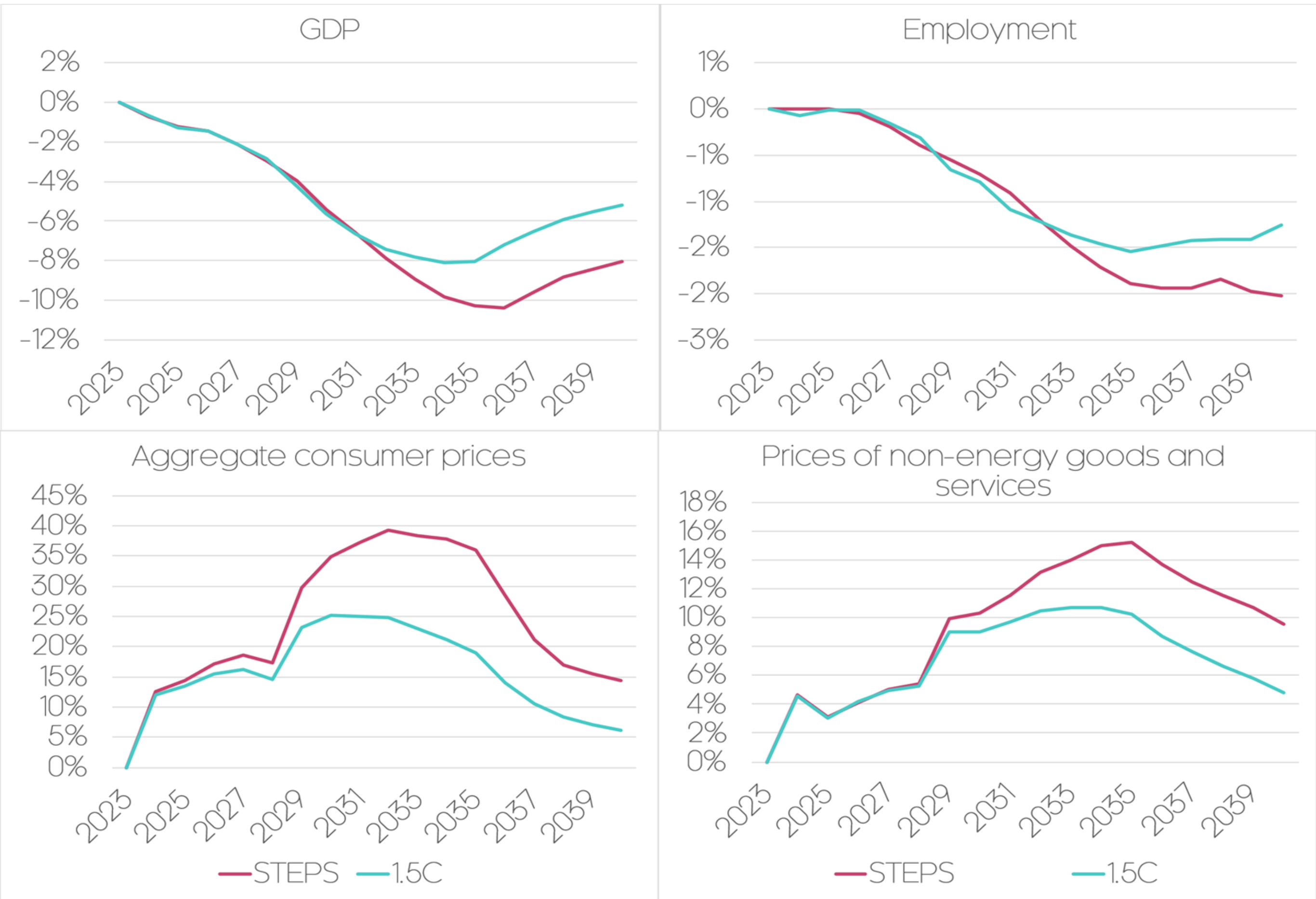
The model produces a range of macroeconomic indicators to evaluate the projected impacts of the price shocks:

- GDP – a measure of the size of the economy in monetary terms, defined as the sum of household consumption expenditures, capital investment, government final spending and net trade.
- Employment – the number of jobs formally occupied by the population.
- Household energy prices – prices of energy paid for by household consumers, which include wholesale prices offered by energy producers plus any mark-ups, taxes and subsidies.
- Aggregate consumer prices – a measure of general price levels which represent the purchasing power and an indicator of overall health of the economy, measured by the weighted average price of a typical household's consumption basket of energy and non-energy goods and services.
- Price inflation – represents the change in aggregate consumer prices over a period of time (e.g. quarterly or annually). High rates of inflation lead to value depletion of GDP and savings and often an increase in interest rates which increase debt levels (especially for low-income groups) and deters new capital investment that fuels future economic growth.

3. Modelling results

When the shocks are introduced, the prices of gas, petrol and electricity for households increase relative to the relevant reference scenario, mirroring the trajectory of the shocks. The shocks lead to higher general price levels which do not fully return to baseline levels by 2040, suggesting a permanent effect on prices. Annual inflation, i.e. the year-on-year change in prices, starts to stabilise at a similar rate as in the baseline scenario in the last few years of the modelled period, yet prices remain at a higher level overall. The price of petrol has the most influence on aggregate consumer prices, as spending on petrol has vastly exceeded spending on electricity and gas in absolute terms over relevant history, and that is expected to continue over the projection period. The price of non-energy consumption is also expected to increase noticeably but the change is much smaller than in the price of energy. This is because cost pass-through rates are lower than 100% (i.e. firms will absorb some of the cost increases, passing only a proportion to final consumers).

Figure 2: Impacts of oil and gas price shocks (relative to the corresponding reference scenario)



The model projects negative economic impacts from the prices shocks:

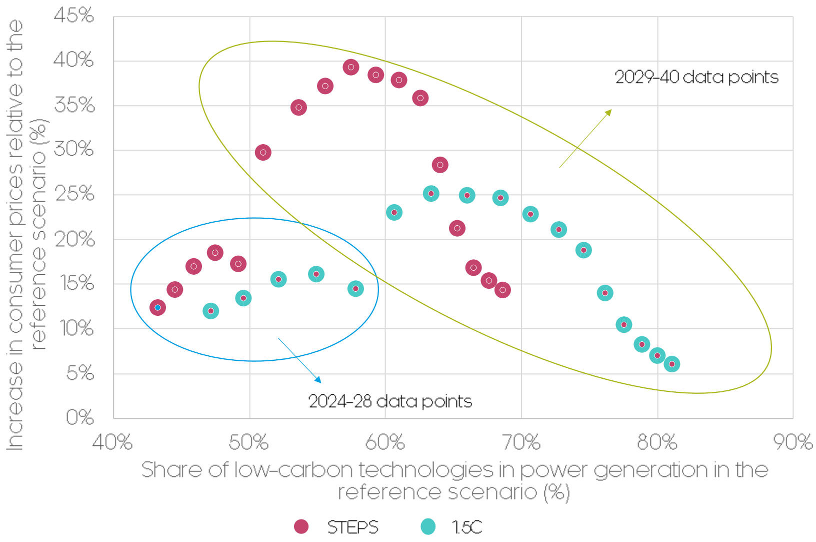
- **In the STEPS scenario** without accelerated climate action, the most severe GDP impacts of a global oil and gas shock are observed at the peak of the assumed gas price trajectory, with a -10% difference from baseline around 2035, and a -8% difference by 2040. Measured in today's US dollars, the difference would equate to almost $10trn lower global GDP by 2040 (or $555bn less every year on average between now and 2040), almost half the size of the US economy in 2022 (World Bank, 2023b). There are also fewer jobs expected than in the reference scenario, equivalent to 75,000 jobs globally being lost. The relative change in employment is smaller than in GDP, which can be explained by positive induced effects from investment, a gradual shift towards renewables (which are more labour intensive), as well as potential labour hoarding in response to inflation outstripping wage growth and high unemployment.

- **In the 1.5°C scenario**, the effects are similar but smaller. For GDP, the model projects a -8% difference to baseline around 2035 and a -5% difference by 2040 (equivalent to a global GDP loss of $6.5trn in 2040 in current dollar terms). The effects are smaller because stronger decarbonisation policies in the 1.5°C scenario result in less dependence on fossil fuels in future years, which reduces exposure to the price shocks. Consumer prices are projected to also peak earlier and at a lower rate in the 1.5°C scenario.

In both scenarios, higher prices for oil and gas leads to some changes in the mix of technologies that are used. The high prices of oil and gas are projected to lead to a substitution by coal in the STEPS scenario, whereas in the 1.5°C scenario the substitution towards coal is only expected in the medium term and there is a much bigger move towards renewables. The price shocks make oil and gas-fired power plants more costly to operate, thus providing an incentive for investors to switch to renewables. This substitution effect from the price shock is more visible in the STEPS scenario, because in the 1.5°C scenario the switching is already happening to a larger extent, driven by strong decarbonisation policies. Nevertheless, even with rapid decarbonisation (in the 1.5°C scenario), shocks to global oil and gas prices are still projected to lead to even more rapid renewable deployment. By 2040, the proportion of electricity being generated from low-carbon sources is projected to reach 73% and 82% in the STEPS and 1.5°C scenarios with price shocks, compared to 69% and 81% respectively in the corresponding scenarios without price shocks.

Figure 3 illustrates the effect that faster decarbonisation could have to limit global inflation from the same oil and gas price shock. The figure plots the projected share of low-carbon technologies in power generation against the projected general price increase from the oil and gas price shock, for both scenarios.

Figure 3: Correlation between shares of low-carbon power generation and inflation impacts.



In the earlier years, the effect is present but less pronounced. This may be because of potential short-term constraints on the deployment of storage solutions required to address renewable intermittency, which means that as the shares of low-carbon generation increase, either storage would come at higher costs (which are passed on to consumers through the electricity price premium) or some fossil fuels-based generation would be relied on to support renewables during peak hours of demand (which is also reflected in higher electricity prices). In later years, higher renewable shares (from 2023 onwards) are more clearly correlated with smaller inflation impacts. As such, short-term barriers to the accelerated deployment of renewables (such as financing conditions and public infrastructure rollout) could not only delay and limit the potential benefits of decarbonisation in GDP and jobs terms, but also affect price levels in the long run, particularly should oil and gas prices spike.

4. Conclusions

Our analysis shows that faster decarbonisation of the energy system and improved energy efficiency could make a significant difference for the global economy (and households) should another oil and gas price shock occur:

- The shock would lead to permanently higher price levels for consumers, for both energy and non-energy consumption, with oil having the most influence on consumer prices. This means that it would be more expensive for households to heat their homes, fuel their cars and buy groceries, while businesses would also be faced with higher costs of production, not to mention further impacts on debts and investments if governments and central banks try to tackle high rates of inflation in the medium term by raising interest rates.
- The shock has negative impacts on GDP and employment, which are more severe in the STEPS scenario than in the 1.5°C scenario, due to less dependence on fossil fuels in the latter.
- The shock itself induces some substitution of oil and gas by coal and renewables in the power sector, with renewables gaining greater market share in the 1.5°C scenario, as a result of decarbonisation policies.
- A faster decarbonisation of the energy system can limit potential general price increases from oil and gas price shocks by close to half on average, at the global level. In particular in the later years of the projected period, higher renewable shares lead to less severe inflation impacts, due to lower fossil fuel dependence. This also means that any permanent increases in price levels following the shock would be smaller when renewables are a greater share of energy demand.

This suggests that investing in renewables and energy efficiency today will help limit the negative effects of oil and gas price shocks in the short and long run, and make the global economy more resilient to such shocks.

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