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Global temperatures and inflation: More volatile, less homogeneous inflation pressures across countries

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Climate change can cause large economic disruptions by introducing new risks to supply chains and changing demand patterns. This economic memo explores how climate change, via its impact on global temperatures, transmits to inflation in Europe, with a country-specific focus on Denmark, Norway and Spain. The results indicate that global temperature shocks primarily affect inflation through energy, food and service price channels. The impacts vary across countries, indicating that warmer countries tend to face higher inflationary pressures, while colder countries experience deflationary pressures. Awareness of these heterogeneous effects is important for central banks in safeguarding price stability.

A global temperature shock tends to increase inflation in warmer countries and decrease inflation in colder countries

Empirical results show that a global temperature shock causes short-term deflationary pressure in Denmark, Norway and Spain. However, after one year, inflation in Spain increases, while inflation in Norway decreases. In Denmark, the effect becomes muted. These differing impacts likely reflect underlying climate characteristics, such as variations in average temperatures.

The effects on core and headline inflation pass through energy, food and service channels

Energy inflation decreases across Denmark, Norway and Spain following a global temperature shock. This is likely due to shifts in demand patterns, such as reduced heating needs. The effects on food and service inflation vary across countries, suggesting that agricultural sectors and labour productivity may be impacted differently by such a shock.

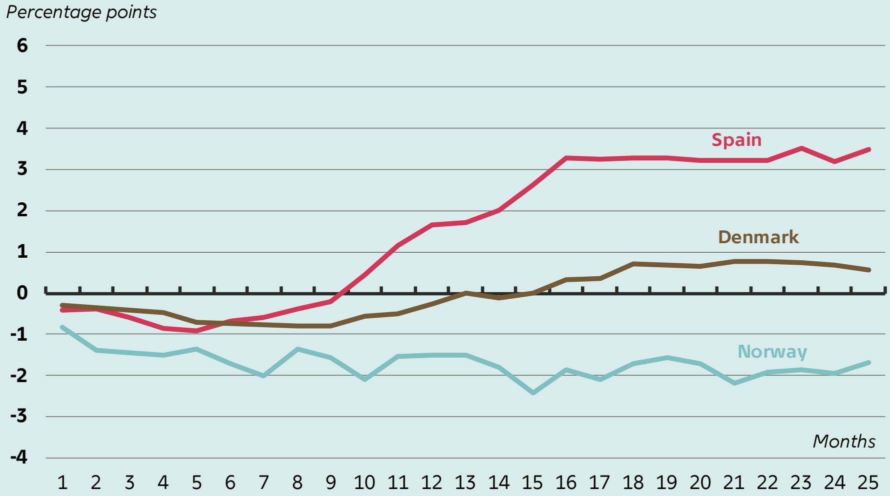
More shocks to global temperatures can increase inflation volatility, potentially requiring central banks to act

Going forward, climate change can make global temperature shocks more frequent and extreme. This can lead to greater price volatility and transmit to inflation. As a result, central banks may be obliged to respond by either tightening or loosening monetary policy.

Why is this important?

Central banks are tasked with ensuring price stability, which can be influenced by more frequent and extreme weather events. Understanding how these factors transmit to consumer prices and thereby inflation is essential for maintaining inflation targets and formulating effective monetary policy. If extreme weather events increase inflation volatility, it may require central banks to act.

Main chart:
A global temperature shock affects inflation differently across countries



Note: The chart shows impulse responses of headline inflation in Denmark, Norway and Spain (solid lines), expressed as percentage changes, to a 1°C global temperature shock. The global temperature shock is estimated following the approach used in Hamilton (2018) and has been linearly scaled to match a 1° C change to ease interpretation, aligning with established methods. Standard errors are calculated using Newey–West standard errors.
Source: Own calculations.

> "If we do not account for the impact of climate change on our economy, we risk missing a crucial part in our work to keep prices stable."
>
> — Christine Lagarde, 2022
> President of the European Central Bank

Keywords

Climate **Inflation and price development**

01

Changes in global temperatures affect inflation

Climate change makes extreme weather events more frequent and destructive, posing an increased risk to the economy.[1] In Europe, the economic impact of climate change is likely to be uneven across regions, potentially increasing inflation gaps among economies.

Rising global temperatures drive more extreme weather and are used as a proxy for climate change
The Intergovernmental Panel on Climate Change expects global temperatures to rise by 1.5°C above pre-industrial levels by the early 2030s. Higher global temperatures have been shown to play a key role in the climate system, driving more extreme weather events, such as storms, floods and heatwaves. Because of this, changes in temperatures have been used as a proxy for climate change, providing a measurable indicator of an otherwise complex system.

Earlier studies have concentrated on local temperatures, potentially neglecting the impacts of climate change

Previous research on the economic impact of climate change has generally focused on shocks to local temperatures to assess its consequences.[2] However, there are two important considerations regarding this approach. First, climate change refers to a permanent change, while weather shocks are usually transitory. This means that such shocks may not accurately reflect long-term climatic effects – a consideration discussed further in Chapter 5. Second, relying solely on local temperatures can underestimate the full economic impact, as this does not account for global dynamics.[3] Regarding the latter, recent macroeconomic research suggests that global temperatures more effectively capture the systemic effects of extreme weather events, thus better reflecting the broader economic impacts of climate change.[4] To contribute to this emerging area of research, this memo presents the initial results on the impacts of global temperature shocks on inflation in Europe.

Global temperature shocks affect consumer prices directly and indirectly, thereby transmitting to inflation

Changes in global temperatures can pass through to consumer prices and thereby inflation, via different channels. As shown in Chart 1, earlier research has primarily focused on three main channels: energy, food and services.[5] First, higher temperatures have a direct effect on consumer prices through household purchases of items relying on stable weather conditions. On the one hand, higher temperatures can increase prices by impacting supply channels in sectors like agriculture or energy, for example through disruptions of critical

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[1] Breckenfelder et al. (2023) argue that climate change poses a potential risk to different areas of the economy. For instance, they mention income divergence across individuals, sectors and regions, adjustment in energy markets, increased inflation variability, financial market stress, intensified innovation, increased migration and rising public debt.

[2] See e.g. Ciccarelli et al. (2024), Lucidi et al. (2024) or Bilal and Känzig (2024).

[3] See Bilal and Känzig (2024).

[4] No comprehensive assessment has yet been made of how transitory and permanent global temperature shocks affect the economy. However, Rebei (2025) has shown the different effects of permanent and temporary local temperatures. This is discussed further in Chapter 5.

[5] A global temperature shock may also affect other channels such as industrial goods, which also rely on energy input and labour productivity. However, to simplify the analysis and to follow existing literature, this memo focuses on the three channels: energy, food and services.

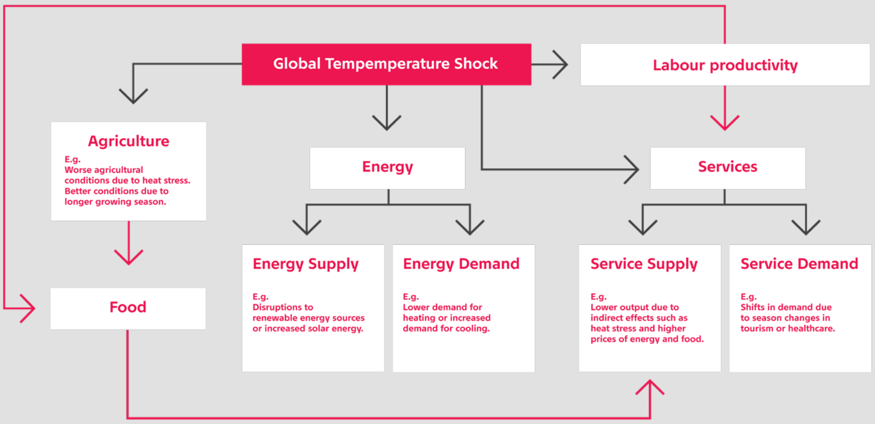
infrastructure.[6] Higher temperatures can also raise demand for cooling energy, thereby increasing consumer prices. On the other hand, higher temperatures might reduce prices by increasing supply through extended agricultural growing seasons or increased solar energy production. Higher temperatures can also reduce the need for heating energy, putting downward pressure on prices.

Second, as firms rely on energy and food as inputs in their production[7], a global temperature shock can increase or decrease producer prices or prices of other goods and services. This might affect consumer prices more broadly, for example in transportation or healthcare.[8] Prices can also be indirectly impacted by labour productivity, as higher temperatures and extreme weather conditions can lower work efficiency due to heat stress in warmer periods but increase work efficiency in colder periods.[9] These combined direct and indirect effects can feed through to core inflation, for example via wage pressures.[10]

CHART 1

A global temperature shock can affect inflation through agriculture, energy and services

A simplified illustration of the channels through which a global temperature shock may affect consumer prices and thereby inflation



Note: The chart illustrates the primary channels which are directly or indirectly affected by a global temperature shock. The black arrows represent direct effects, while the red arrows represent indirect effects.
Source: Own illustration.

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[6] For instance, the severe European summer drought in 2022 which led to significant yield losses and the shutdown of power plants, reducing both energy and food output. This resulted in an upward pressure on consumer prices (Toreti et al. 2022).
[7] Energy and food items serve as inputs in the production of services such as restaurants, tourism or transportation.
[8] See e.g. Zhao et al. (2024) for the effects of heatwaves on mortality, or Patz et al. (2005) for the increased health risk under future climate scenarios.
[9] Heat stress refers to a condition in which the body experiences stress from overheating. Studies show that labour productivity declines when temperatures are above 25°C. This indicates that higher global temperatures could decrease labour productivity.
[10] A global temperature shock may transmit to wage pressures if workers demand higher wages to offset the loss of purchasing power. This wage adjustment can further contribute to inflationary pressures on core inflation, also known as second-round effects.

This memo analyses the transmission of a global temperature shock to inflation through different channels

In this memo, I use a local projection framework to estimate the transmission of a global temperature shock to inflation in the euro area, Denmark, Norway and Spain. A global temperature shock can affect inflation through energy, food and service prices, and may also transmit to core inflation. To investigate this, I estimate the average effect of a one-time global temperature shock on both headline and core inflation, as well as a breakdown of the transmission channels for energy, food and service inflation. Since shocks to global temperatures can be both cold and warm, I assess the potential asymmetric effects by employing a non-linear model to explore the responses of both positive and negative global temperature shocks.

02

Estimating the effect of a global temperature shock using local projections

The goal of this statistical analysis is to describe the relationship between changes in global temperatures and inflation. Chart 2 shows the yearly evolution of global temperatures over recent decades, indicating that between 1950 and 1980, global temperatures were relatively stable at around 14°C. Since this period, global temperatures have increased, showing similar behaviour as that of consumer prices.[11] Because of this, a simple regression of global temperatures on prices will likely lead to spurious and misleading results.

To address this challenge, I use a two-step empirical approach commonly used in the literature. In the first step, I define unexpected shocks to global temperatures as the part of global temperatures previous historical records cannot predict. In the second step, I employ these shocks to estimate the transmission to inflation for a selected sample of European countries, using a local projection (LP) model.

I use the LP framework to estimate impulse responses by running separate regressions on the outcome variable for each country across different time horizons.[12] I thereby obtain the inflation response to a one-time, temporary 1°C global temperature shock. This means that I do not estimate the effects of a permanent temperature change, which is typically associated with climate change. However, long-term climatic changes are related to temporary shocks, as they drive their frequency and intensity.[13] The LP framework further allows me to explore the possible asymmetry of negative and positive global temperature shocks due to its flexible structure. For a more detailed explanation of the method, see box 1.

I use the monthly global surface temperature anomalies provided by the NOAA National Oceanic and Atmospheric, spanning from January 1950 to December 2019. I only include temperature shocks from January 2000 to December 2019 to match the availability of data on consumer prices. I exclude observations beyond 2019 due to the COVID-19 pandemic, as it is difficult to account for all relevant factors during that period.[14]

Table 1 shows the descriptive statistics for Denmark, Norway and Spain, indicating that Spain's average temperature of 14.04°C is closest to the global mean. In contrast, Norway exhibits significantly lower temperatures, with an annual maximum temperature of 3.45°C. Denmark's average temperature of 8.86°C falls between those of Spain and Norway. The climatic differences across these countries provide a basis for assessing potential heterogeneous effects at country level.

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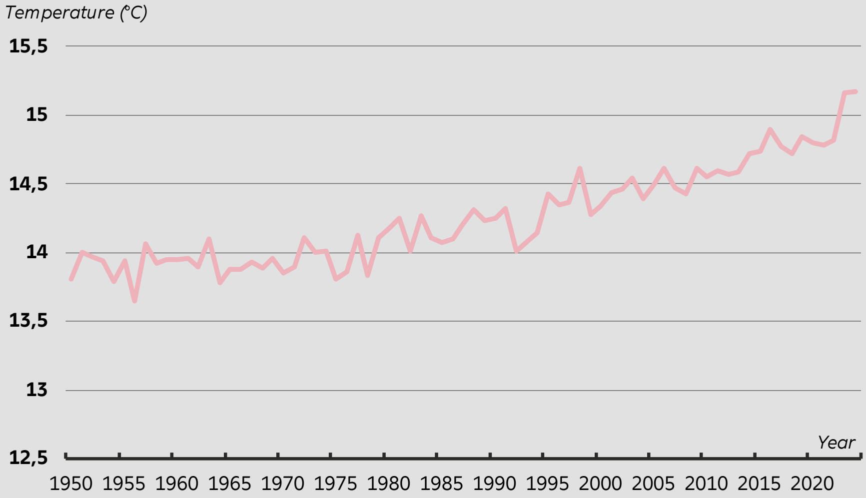
[11] The evolution of consumer prices (index) shows similar upward trending behaviour as that of global temperatures between 2000 and 2019. This can be seen from the Eurostat database.
[12] See Jorda (2023).
[13] See Seneviratne et al. (2021).
[14] Similar approach has been used by Lucidi et al. (2024) and Ciccarelli et al. (2024).

CHART 2

Global temperatures have been rising since the 1980s

Evolution of the absolute global mean surface temperatures



Note The chart shows the yearly evolution of the absolute global surface temperatures and is calculated by adding the anomalies measured by NOAA National Centers for Environmental Information to the historical mean of 13.9°C.
Source NOAA National Centers for Environmental Information

TABLE 1

Spain's mean temperature aligns closely with the global average, while Norway is the coldest country in the sample. Denmark falls in between

	Mean	SD	Max	Min
Global	14.16	0.34	15.16	13.65
Denmark	8.86	0.91	10.23	6.56
Norway	2.24	0.93	3.45	-0.27
Spain	14.04	0.65	15.16	12.26

Note: The table shows the descriptive statistics of the mean, standard deviation, maximum and minimum values of global mean surface temperatures and local temperatures of Norway, Denmark and Spain from 1950 to 2023.
Source: World Bank

Identifying shocks to global temperatures

The literature on climate change and its impacts on inflation is still relatively limited.[15] As such, there is no standard approach on how to identify temperature shocks. One proposed method is to use the Hamilton filter, which isolates the exogenous component of temperature fluctuations by extracting forecast errors.[16] In this memo, I follow previous literature and obtain the twenty-four step-ahead forecast errors to account for short- and medium-term climate

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[15] See e.g. Ciccarelli et al. (2024), Faccia et al. (2021) or Lucidi et al. (2024).
[16] See Hamilton (2018).

effects.[17] I do this since I am working with monthly data, and therefore estimate the response to inflation over a two-year period. I define the shocks as the unexpected changes in global temperatures, which cannot be predicted based on previous recorded temperatures.

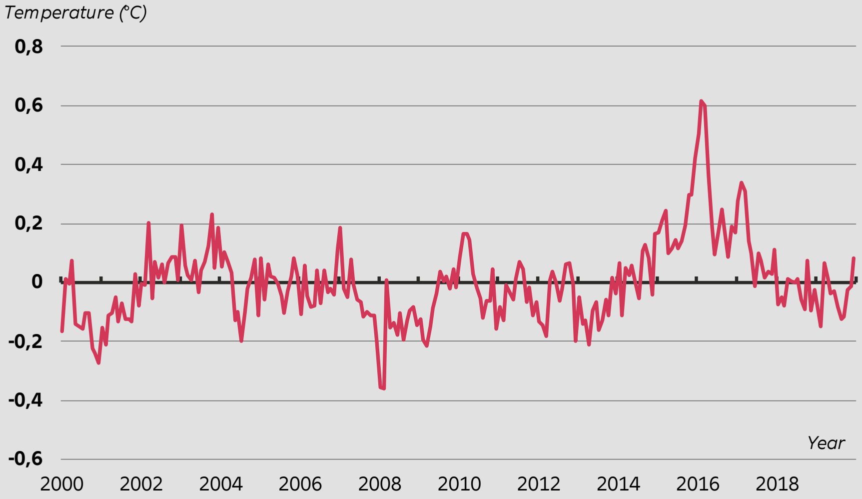
The estimated shocks to global temperatures are shown in Chart 3. The shocks are characterized by both positive and negative shocks, fluctuating around zero degrees. The largest positive shock occurred around 2016, reaching around 0.6°C, while the largest negative shock appeared around 2008 at almost -0.4°C. For interpretation purposes, the effect on inflation shown in Chapters 3, 4 and 5 are estimated using a 1˚ C change in global temperatures. However, it is important to note that none of the estimated shocks actually reflect a 1˚ C change, which is thereby a much larger shock than what has historically been observed. Bilal and Känzig (2024) argue that this scaling is relevant, considering future scenarios of tipping points, which could trigger even greater shocks than a 1˚ C change.

A potential downside of the global temperature shock series is that it includes autocorrelation. This suggests that the shocks may not be entirely exogenous, violating important econometric assumptions.[18] To address this, I include twelve lags of the shock series in the LP model, aligning with established approaches in the literature.[19]

CHART 3

Global temperature shocks appear larger around 2016

Estimated shocks to global temperatures



Note: The chart shows the estimated global temperature shocks using the approach in Hamilton (2018), setting H=24 and P=24. The global temperature shocks are included in the LP model with 12 lags to account for autocorrelation.
Source: Own calculations and National Centers for Environmental Information

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[17] Solar cycles, volcanic eruptions and the El Niño cycle can lead to medium-run fluctuations in the Earth’s mean temperature (Bilal and Känzig, 2024).
[18] See Ramey (2016).
[19] See Bilal and Känzig (2024) and Lucidi et al. (2024).

BOX 1

Using local projections to analyse the effect of global temperature shocks to inflation

To investigate how global temperature shocks affect inflation, I estimate a local projection model through a two-step procedure. In the first step, I identify unexpected shocks to global temperatures by using the approach outlined in Hamilton (2018). The method decomposes the time series into its cyclical and trend components using forecast errors.[20] Since I am working with monthly data, I set the forecast horizon to twenty-four (H=24) and include previous twenty-four lags of the global temperature series (P=24). This accounts for medium-term dynamics within the climate system, such as solar cycles, volcanic eruptions and the El Niño cycle.[21] This method has been used in a similar analysis by Bilal and Känzig (2024), and using error terms has often been a standard approach to extracting the exogenous part of a time series.[22] As such, I focus on estimating the effects of a temporary global temperature shock rather than the effects of a permanent change.

One drawback of this approach is that the shocks obtained by the Hamilton filter include autocorrelations.[23] This violates the assumption of exogeneity and may introduce bias into the estimates.[24] I compensate for this by including twelve lags of the shock series in the local projection model, following previous literature.[25] However, I do recognise that by determining the shocks solely based on global temperature data, I may miss complex patterns or interactions in the climate system, which more sophisticated models might capture.

In the second step, the global temperature shock series is used in a local projection model. Local projections are useful for this task because they do not rely on specific assumptions about the direction or size of the response to the shock in question. Additionally, they do not impose linearity assumptions on the relationship between the shock and outcome variables, which is useful as global temperatures may not transmit linearly onto prices.[26] The local projections are also suited to exploring the possible heterogeneous effects between positive and negative global temperature shocks.

The dependent variables used in the LP model include headline HICP, core HICP, energy HICP, food HICP and service HICP. These variables are collected individually for the euro area, Denmark, Norway and Spain and are included in the local projection model as annual log differences. This means that they express the annual change in consumer prices, or in other words, inflation. To address potential endogeneity, I include country-specific industrial production as a control, which is also included in the model in annual log differences. Additionally, the model incorporates lags of the dependent variable and other global variables, such as oil prices and the interest rate for one-day loans between European banks. All control variables are included in the model with twelve lags.[27]

Continues …

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[20] See Hamilton (2018).
[21] See Bilal and Känzig (2024).
[22] See Ramey (2016).
[23] I use the Ljung-Box test to evaluate the autocorrelation of the estimated residuals from the Hamilton filter.
[24] Other definitions of global temperature shocks – such as global anomalies or a Hamilton filter setting of H=12 – yield similar results.
[25] See Lucidi et al. (2024) or Bilal and Känzig (2024).
[26] See Burke et al. (2015).
[27] For the LP model of energy, food and services, I include all three as controls to account for their interdependencies. A similar approach has been employed by Lucidi et al. (2024).

... continued

	Enters the model in	**Unit**	**Start date**	**End date**	**Source**
Danish, Norwegian, Spanish and euro area Harmonised Index of Consumer Prices (HICP).	Annual log differences	Index, 2015=100	JAN 2000	DEC 2019	Eurostat
Danish, Norwegian, Spanish and euro area HICP excluding energy, food, alcohol and tobacco	Annual log differences	Index, 2015=100	JAN 2001	DEC 2019	Eurostat
Danish, Norwegian and Spanish HICP energy	Annual log differences	Index, 2015=100	JAN 2001	DEC 2019	Eurostat
Danish, Norwegian and Spanish HICP food	Annual log differences	Index, 2015=100	JAN 2001	DEC 2019	Eurostat
Danish, Norwegian and Spanish HICP service	Annual log differences	Index, 2015=100	JAN 2001	DEC 2019	Eurostat
Danish, Norwegian, Spanish and euro area industrial production	Annual log differences	Index, 2015=100	JAN 2000	DEC 2019	Eurostat
US, crude oil, brent Europe spot price FOB	Annual log differences	Index, 2015=100	JAN 2000	DEC 2019	FRED
Eonia rate – Historical close, average of observations through period, euro area	Per cent	Per cent	JAN 2000	DEC 2019	ECB
Global time series, average temperature anomaly	Celsius	Celsius	JAN 2000	DEC 2019	NOAA
1° × 1° gridded monthly average temperature across Europe	Celsius	Celsius	JAN 2000	DEC 2019	Berkeley Earth
Population counts per country (1km resolution)	Population weight	Number of people	2015	2015	WorldPop

03

A global temperature shock affects inflation heterogeneously across countries

Europe is generally characterized by a temperate climate. However, national differences in average temperatures and seasonal patterns are evident across the continent, which can impact economic outcomes. Chart 4 shows how a 1° C global temperature shock affects headline inflation after one year on a sample of European countries plotted against their average temperatures.[28] The spread of countries suggests that there is a positive relationship between the inflation response to a global temperature shock and a country's average temperature.[29]

In the sample, Spain is among the countries with the highest average temperatures and shows a large inflationary response following a global temperature shock. In contrast, Norway, which has the lowest average temperature in the sample, shows one of the most pronounced downward pressures. Denmark exhibits a more moderate response, similar to that of other countries with comparable average temperatures. Overall, the spread indicates that European countries are affected differently one year after a global temperature shock. In other words, inflation tends to increase in countries with higher average temperatures and decrease in those with lower average temperatures.

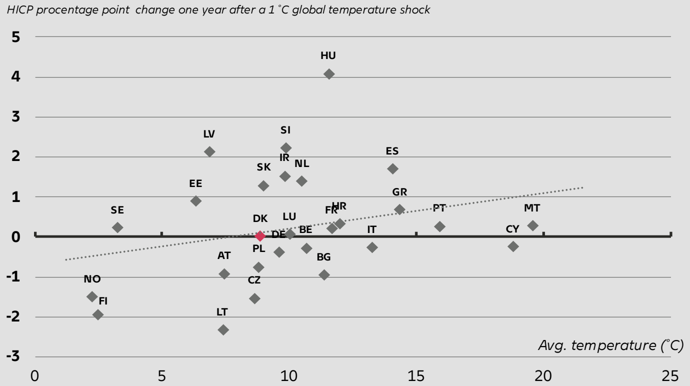
[28] The euro area is not included in Chart 4 due to the difficulty in accurately measuring its average temperature.

[29] Inflation can respond with a lag to a global temperature shock, which is why Chart 4 shows the impact observed one year after the shock.

CHART 4

A country's average temperature correlates with the effect on headline inflation following a global temperature shock

Scatter chart showing the relationship between average temperatures and change in headline inflation one year after a global temperature shock



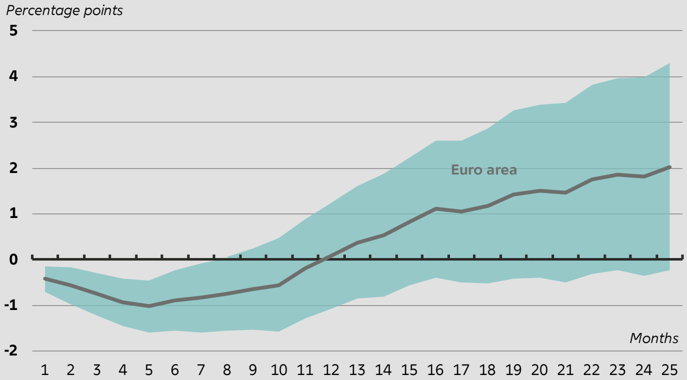
Note: The chart shows the spread of European countries across their average temperatures and the change in headline inflation one year after a 1˚ C global temperature shock.

Source World Bank and own calculations.

CHART 5

A global temperature shock decreases headline inflation in the euro area in the first year

Impulse response of headline inflation in the euro area



Note: The chart shows the impulse response in percentage change to a 1˚ C global temperature shock on headline inflation for the euro area (solid lines). Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).

Source Own calculations.

In the euro area, a global temperature shock puts an initial downward pressure on headline inflation

Chart 5 shows the full headline inflation response for the euro area to a global temperature shock over two years. Initially, inflation falls by around 0.5 percentage points but exerts upward pressure in the second year. The response reflects an averaging effect of different national responses, potentially overlooking cross-country heterogeneity. To further understand how individual European countries respond to a global temperature shock, this memo explores the impact on inflation in Denmark, Norway and Spain, as these countries represent warm, cold and middle temperature countries in Europe.

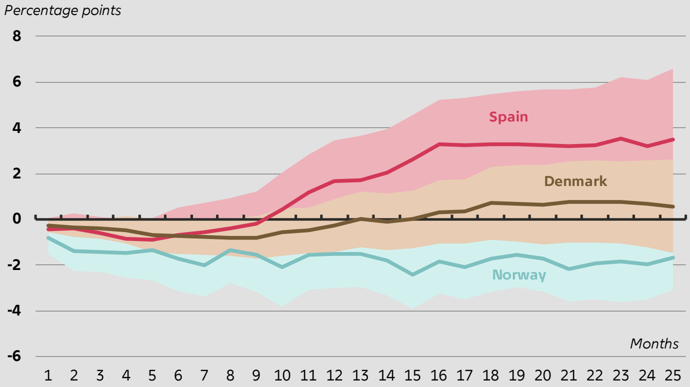
A global temperature shock raises inflation in Spain, lowers it in Norway, and affects Denmark similarly to the euro area

Charts 6 and 7 show the headline and core inflation responses to a global temperature shock in Denmark, Norway and Spain. The responses show that inflation in each country responds differently to such a shock.

CHART 6

A global temperature shock affects headline inflation differently in Denmark, Norway and Spain …

Impulse responses of headline inflation for Denmark, Norway and Spain

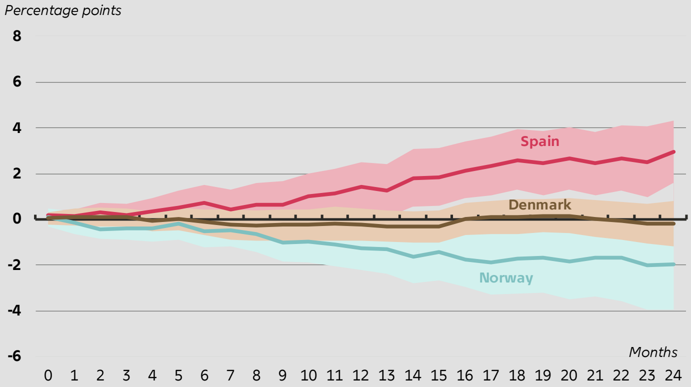


Note: The chart shows impulse responses of headline inflation in Denmark, Norway and Spain (solid lines), expressed as percentage changes, to a 1°C global temperature shock. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).
Source: Own calculations

CHART 7

… and similarly for core inflation

Impulse responses of core inflation for Denmark, Norway and Spain



Note: The chart shows impulse responses of core inflation in Denmark, Norway and Spain (solid lines), expressed as percentage changes, to a 1°C global temperature shock. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).
Source: Own calculations

In the first six to seven months, the responses of headline inflation in Denmark, Norway and Spain all decrease, mirroring that of the euro area. However, after a year the responses begin to diverge. In Spain, headline inflation increases by around two percentage points compared to the initial level, while the effect in Denmark becomes muted. In Norway, headline inflation decreases by around two percentage points. The heterogeneous responses may stem from differences in how a global temperature shock impacts components like energy and food across the countries. For further details on these transmission channels, see Chapter 4.

The responses of core inflation – which exclude volatile components like energy and food – are similar to those of headline inflation for all countries. This indicates that a global temperature shock passes through to core inflation via indirect effects on production costs and possible second-round effects on wages, as outlined in Chapter 1.

The sizes of the responses shown in Charts 6 and 7 appear relatively large considering other exogenous shocks to inflation.[30] This is primary due to a linear scaling of the global shocks, enabling them to represent a 1°C temperature rise. This approach aligns with Bilal and Känzig (2024) and is used to ease interpretation.[31] To assess the effect of a one-standard deviation shock, the estimated effects should be divided by around three, as indicated in Table 1.

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[30] For instance, Parker (2018) finds that weather disasters impact headline inflation by 0.26 percentage points. This result is based on an aggregate measure of 212 countries. Likewise, Beirne et al. (2024) find that headline inflation in the euro area increases by 0.1 percentage points after a disaster shock.
[31] Bilal and Känzig (2024) argue that this scaling is appropriate given the likelihood of potential tipping points, which could increase global shocks beyond 1°C.

Demand-side factors may drive the initial downward pressure on headline inflation

It can seem surprising that inflation initially falls in the euro area, Denmark, Norway and Spain, as earlier research has generally shown that weather shocks drive negative supply shocks, which typically puts an upward pressure on prices.[32] For instance, Bilal and Känzig (2024) show that a global temperature shock reduces European GDP by around seven per cent, which they argue is caused by supply disruptions from extreme weather events.[33] Combining their result with the initial decrease in inflation for the euro area, shown in Chart 5, indicates that demand-side effects may dominate supply-side effects in the short term, resulting in lower consumer prices. For central banks, distinguishing between supply and demand shocks is essential for setting the right monetary policy response. More details on demand dynamics can be found in Chapter 4.

Other studies using local temperature shocks find similar responses

The inflation responses shown in the charts above resemble the responses to a temperature shock found in earlier research using local temperatures. For instance, the shapes of the response of Spanish core inflation and the response of the euro area headline inflation align with the findings of Lucidi et al. (2024).[34] For further insight into the effects of local versus global temperature shocks, see Box 2.

Furthermore, the results showing that a global temperature shock affects countries heterogeneously are also consistent with previous research. While the impacts of temperature shocks are less studied among advanced economies, Ciccarelli et al. (2024) find that southern European countries experience greater inflationary pressures than other European countries. Empirical results from outside Europe generally show that developing and warmer countries are more affected by temperature changes than colder and more advanced economies.[35]

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[32] In this context, weather shocks refer to indicators of climate change other than temperature shocks. For instance, Beirne et al. (2024) show that weather-related disasters have a positive effect on inflation in the euro area, mainly through negative supply and positive demand channels, rather than negative demand channels. See also e.g. Parker (2018) for empirical results of the effects of specific weather events, such as droughts and earthquakes.

[33] Bilal and Känzig (2024) use a similar methodological approach as used in this memo.

[34] Lucidi et al. (2024) do not look at the effects of local temperature shocks on inflation in Norway and Denmark.

[35] See e.g. Mukherjee and Ouattara (2021).

BOX 2

Impact on inflation: Global temperatures versus local temperatures

The literature on climate change and its economic impacts is growing rapidly. Most recently, the research has focused on whether global or local temperatures more accurately reflect the dynamics of the climate system.[36] Table 2 shows descriptive statistics for the global and Danish local temperature shock series over the period 1950 to 2019. The statistics are categorized based on whether the shock represents a positive or negative change in monthly temperatures. Both series are obtained using the Hamilton filter as described in Box 1.

The descriptive statistics in Table 2 show that Danish local temperature shocks are both larger and more volatile than global temperature shocks. This indicates that local variability tends to average out on a global scale.[37] The shock series are weakly correlated, suggesting that the local and global shock series are largely independent of each other.

Table 2

Descriptive statistics of both global and Danish local temperature shocks

	Positive shocks					Negative shocks				
	N	Mean	SD	Min	Max	N	Mean	SD	Min	Max
Global	139	0.111	0.098	0.012	0.531	125	-0.098	0.085	-0.003	-0.510
Local (DK)	138	0.95	0.751	0.002	3.502	102	-1.003	0.821	-0.001	-5.601

Note The table presents the descriptive statistics for the global and Danish temperature shock series. The shocks are estimated using the Hamilton filter on monthly data and are categorized as either positive or negative changes in temperatures. N indicates the number of positive and negative shocks, while the mean represents the average shock size in each category. SD denotes the standard deviation, and min and max indicate the minimum and maximum shock sizes, respectively. Danish temperatures are calculated as population-weighted local temperatures.

Source National Centers for Environmental Information, Berkeley Earth and own calculations.

Chart 8 shows the headline inflation responses in Denmark to both a global and local temperature shock. The response of a global temperature shock is around ten times greater than the corresponding response of a local temperature shock after one year. Both responses are derived using the same empirical model on the same sample size, described in Box 1.

There are two possible explanations for why global temperature shocks have a greater impact on inflation than local temperature shocks.[38] Firstly, Bilal and Känzig (2024) show that a global temperature shock has a larger and more permanent impact on other extreme weather events and on ocean temperatures than a local temperature shock. This indicates that global temperatures capture the effects of other climate events better than local temperatures. Secondly, the impact of a global temperature shock may be amplified through spillover mechanisms. A global temperature shock affects all countries simultaneously, creating uniform impacts that can be difficult to stabilize through trade patterns. For instance, disruptions in agricultural production can reduce the availability of certain food products worldwide, limiting the ability of countries to stabilize domestic prices through imports. Similarly, energy markets – which are highly interconnected – may experience synchronized shifts in demand or supply, increasing price volatility globally. In contrast, the effects of a local temperature shock may be more limited to individual countries, leading to a smaller impact on consumer prices and thereby inflation.

Continues ...

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[36] See Bilal and Känzig (2024).

[37] This holds for all local temperatures in the countries included in the sample.

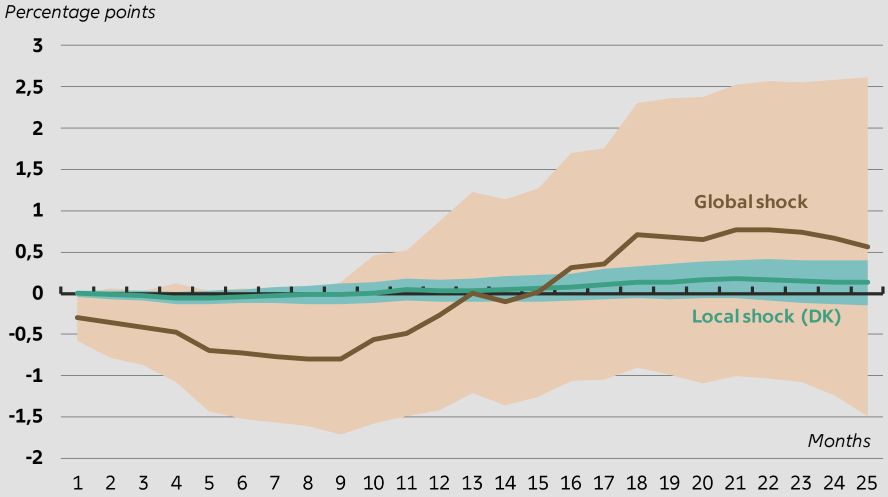
[38] For interpretation purposes, the effect size of a global temperature shock has been linearly scaled to correspond to a 1° C temperature increase. This approach is consistent with Bilal and Känzig (2024). To interpret the effect of a one standard deviation, the estimated effects should be divided by approximately three, as shown in Table 1.

… continued

Chart 8

A global temperature shock has greater impact on headline inflation in Denmark than a local temperature shock

Impulse responses of Danish headline inflation to a global and a local temperature shock



Note The chart shows impulse responses of headline inflation in Denmark, expressed as percentage changes, to a 1°C global temperature shock (brown line) and a 1°C local temperature shock (green line). Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Both local and global temperature shocks are estimated following the approach used in Hamilton (2018). Local temperature shocks are calculated as population-weighted temperatures.

Source Own calculations.

04

The effect of a global temperature shock passes through energy, food and service inflation channels

To investigate the underlying mechanisms driving the effects on inflation discussed in the previous chapter, the literature commonly identifies three main channels through which a temperature shock affects inflation: energy, food and services.[39] Overall, the responses of energy, food and service inflation follow similar patterns as the headline inflation responses, indicating a strong pass-through effect.

Energy consumer prices may fall due to reduced demand for heating, putting downward pressure on energy inflation

Chart 9 shows that a global temperature shock initially decreases energy inflation by around five percentage points for all countries. After around a year, the response of energy inflation rebounds in both Spain and Norway, rising by up to ten percentage points in Norway, while in Spain the effect remains mostly muted. In Denmark, energy inflation decreases by around three percentage points under the initial level.

The initial decline in energy inflation can be caused by immediate changes in household energy demands. Lucidi et al. (2024) show that lower energy inflation in the euro area is driven by reduced demand for heating during warmer periods. This effect outweighs the increased need for cooling, which normally push prices up. In other words, due to Europe’s relatively colder climate, a temporary period of milder weather can have an instant effect on consumption patterns, leading to reduced energy demands and lower consumer prices. As a result, it may lead to a deflationary pressure in the short-term.[40]

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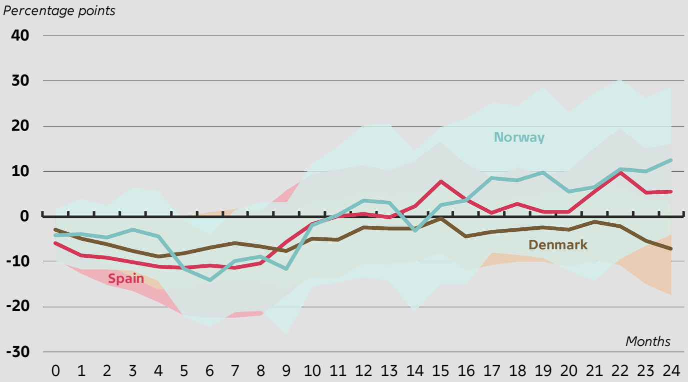
[39] See e.g. Ciccarelli et al. (2024) or Faccia et al. (2021).

[40] The energy inflation responses can also be caused by supply disruptions. In countries with greater reliance on solar energy, like Denmark and Spain, higher temperatures can result in more hours of sunlight, as shown by Van den Besselaar et al. (2015). This can potentially boost solar energy production, leading to lower prices and putting downward pressure on inflation. Denmark and Spain rank among the top 10 European countries in terms of reliance on solar energy, with solar power accounting for 9.9 per cent of electricity generation in Denmark and 15.1 per cent in Spain.

CHART 9

A global temperature shock puts an initial downward pressure on energy inflation in Denmark, Norway and Spain …

Impulse responses of energy inflation for Denmark, Norway and Spain

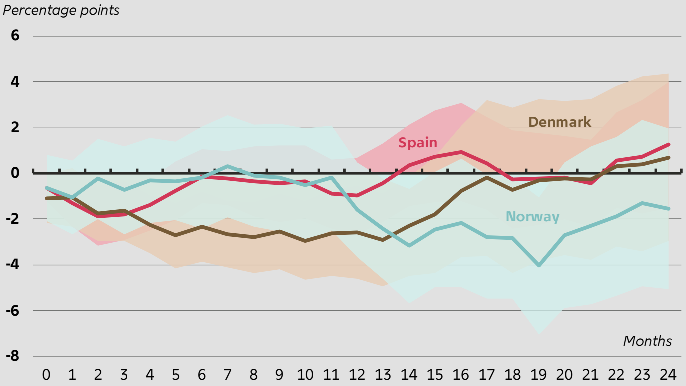


Note: The chart shows impulse responses of energy inflation in Denmark, Norway and Spain (solid lines), expressed as percentage changes, to a 1°C global temperature shock. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).
Source: Own calculations.

CHART 10

… and also on food inflation in Denmark and Spain, whereas the impact on food inflation in Norway is initially muted

Impulse responses of food inflation for Denmark, Norway and Spain



Note: The chart shows impulse responses of food inflation in Denmark, Norway and Spain (solid lines), expressed as percentage changes, to a 1°C global temperature shock. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).
Source: Own calculations.

Food production may increase under milder conditions in Denmark and Norway, lowering food inflation

The change in energy prices following a global temperature shock can also affect the prices of other goods, such as food, by influencing production costs.[41] Chart 10 shows that food inflation initially declines by around one percentage point in all three countries. In Denmark, food inflation falls to around three percentage points after a year, whereas in Spain, the impact is mostly muted. The impact on Norwegian food inflation is subdued during the first year, followed by a decrease of around three percentage points in the second year. This delayed effect could stem from Norway's high reliance on food imports, where the impact becomes evident once existing stockpiles are depleted or long-term contracts expire.[42]

The diverse impact on food inflation may indicate that each country's agricultural sector is affected differently.[43] Given the lower average temperatures in Denmark and Norway, a temporarily milder winter may extend the growing season, leading to a longer cultivation time. This may ultimately increase food supply and lower prices, thereby putting a downward pressure on food inflation.[44]

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[41] The food sector is one of the largest energy consumers globally, accounting for around thirty per cent of total energy consumption. Energy is essential for various food-related processes, including heating, cooling, drying, refrigeration, processing, packaging and transportation (Corigliano and Angelo, 2024).
[42] Imported food items account for nearly half of Norway's total food consumption (Norwegian Institute of Bioeconomy Research).
[43] Schlenker and Roberts (2009) show that temperatures beyond 29-30˚ C lead to unfavourable agricultural conditions.

Since both food and energy are highly tradable goods[45], the impact of a global temperature shock on local production may spill over to trading partners.[46] For instance, the 2023 summer drought in Europe led to a sharp decline in olive oil production in Southern Europe, driving prices significantly higher in the rest of the world.[47] However, Bilal and Känzig (2024) show that economic spillovers have a limited role in the effect of a global temperature shock on GDP, which could also apply to other areas, such as food and energy inflation. A more comprehensive analysis of how global temperature shocks influence trade patterns is necessary to fully understand their influence on inflation.

Higher global temperatures may reduce labour productivity, which is reflected in service inflation along with pass-through effects on energy and food costs

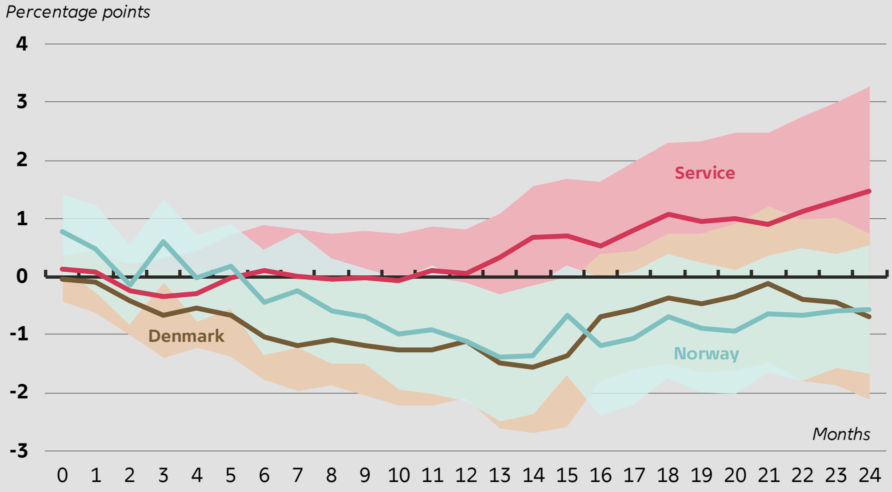
Chart 11 shows the responses of service inflation to a global temperature shock. Services covers different sectors such as transportation, tourism and healthcare, where operating costs are highly influenced by energy prices and food prices. As a result, the impact of a temperature shock typically affects service-related items indirectly.

In Spain, the impact on service inflation is mostly muted within the first year after a global temperature shock but rises by more than one percentage point in the second year. By contrast, service inflation in Denmark and Norway falls by around one percentage point around the one-year mark.

CHART 11

A global temperature shock raises service inflation in Spain but lowers it in Denmark and Norway

Impulse responses of service inflation for Denmark, Norway and Spain



Note: The chart shows impulse responses of service inflation in Denmark, Norway and Spain (solid lines), expressed as percentage changes, to a 1°C global temperature shock. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).
Source: Own calculations.

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[45] In 2022, the European Union imported 62.5 percent of the energy it consumed, and in 2023 the European Union recorded a €70.1 billion trade surplus in food products.
[46] Both Denmark and Spain are net exporters of food items, whereas Norway is a food net importer (EUROSTAT and Statistics Norway).
[47] See International Monetary Fund, Global Price of Olive Oil

The service sector is highly influenced by labour productivity and labour supply. Dasgupta et al. (2024) show that rising temperatures lead to greater labour losses, which can lower service output and push up consumer prices. They also note that Northern European countries may experience temporary labour improvements, possibly due to more favourable outside conditions. This could explain some of the observed decrease in service inflation in Denmark and Norway.[48]

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[48] A more detailed breakdown of how a global temperature shock affects various service components is necessary to comment on the specific drivers behind the overall services inflation response. For related analysis, see Beirne et al. (2024), which examines the effects of a weather-related disaster measure on different services components.

05

Inflation responds asymmetrically to a positive and negative global temperature shock

The impulse responses in Chapters 3 and 4 are estimated on both positive and negative global temperature shocks, showing the average effects of these. However, the impact on inflation might depend on whether global temperatures rise or fall. Because of this it is important to assess whether positive and negative shocks have symmetric effects, as asymmetry can drive both deflationary and inflationary pressures.

Inflation responds asymmetrically to a positive and negative temperature shock in the euro area, Denmark and Norway, while the results in Spain are mixed

Charts 12 and 13 show the impulse responses of headline inflation for the euro area and Denmark to both a positive and negative global temperature shock. For comparability, the negative shock is inverted.[49] In both areas, a positive shock decreases inflation by around one percentage point in the euro area and two percentage points in Denmark. By comparison, a negative shock has a muted effect for the first six months, but thereafter the effect is larger than that of a positive shock. In other words, inflation responds asymmetrically to a positive and negative global temperature shock in both the euro area and Denmark.

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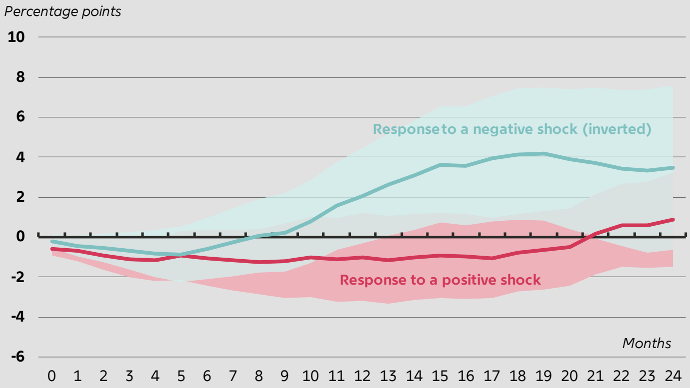
[49] Generally, a negative shock would indicate a fall in global temperatures. However, to analyse the asymmetry between a positive and a negative shock, the negative shock has been inverted. This means that a negative shock reflects a rise in global temperatures, similar to a positive shock.

CHART 12

In the euro area, inflation responds asymmetrically to a positive and a negative global temperature shock…

Impulse responses of headline inflation in the euro area to a positive and negative global temperature shock



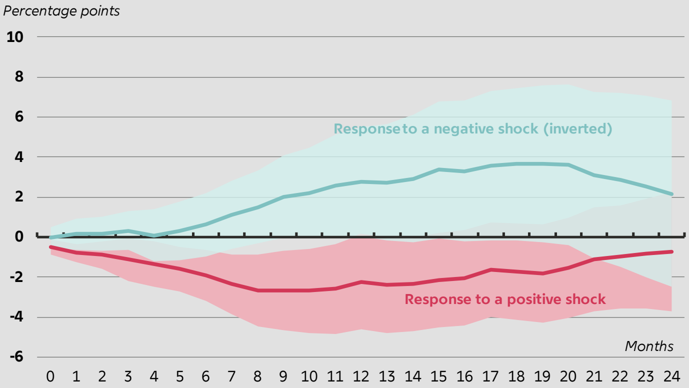
Note: The chart shows impulse responses of euro area headline inflation (solid lines), expressed as percentage changes, to a positive and a negative global temperature shock. The response to a negative global temperature shock has been inverted. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).

Source Own calculations.

CHART 13

… which also holds true for Denmark

Impulse responses of headline inflation in Denmark to a positive and negative global temperature shock



Note: The chart shows impulse responses of Danish headline inflation (solid lines), expressed as percentage changes, to a positive and a negative global temperature shock. The response to a negative global temperature shock has been inverted. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).

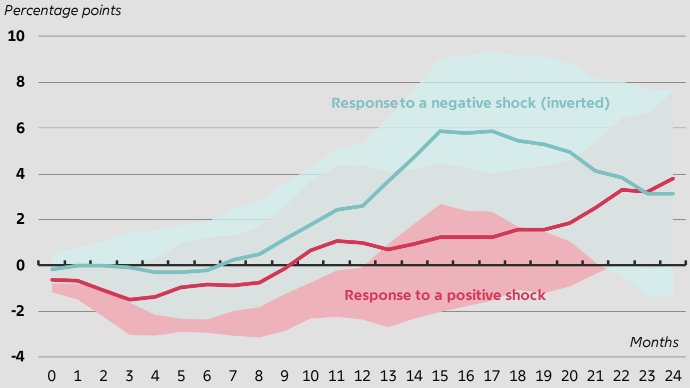
Source Own calculations.

Charts 14 and 15 show the responses of Spanish and Norwegian inflation to both a positive and negative global temperature shock. During the first year, Spanish inflation responds with relative symmetry, while in the second year, a negative shock has a greater impact, indicating asymmetric responses. This provides a mixed interpretation of the overall impact in Spain. In Norway, the effect of a positive shock is mostly muted, while the effect of a negative shock is deflationary. This suggests that the responses to a positive and negative shock in Norway are asymmetric.

CHART 14

In Spain, a positive and negative temperature shock produces a similar inflation response in the first year ...

Impulse responses of headline inflation in Spain to a positive and negative global temperature shock

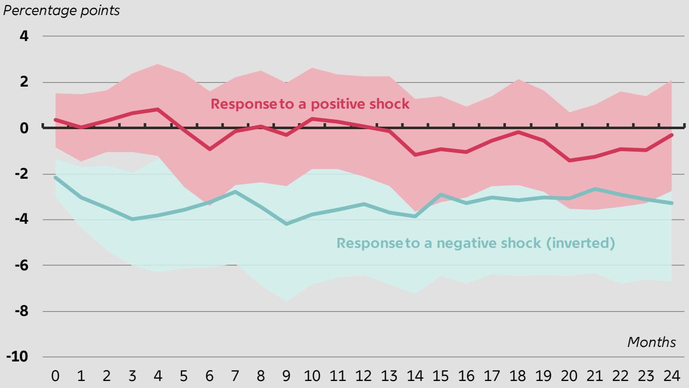


Note: The chart shows impulse responses of Spanish headline inflation (solid lines), expressed as percentage changes, to a positive and a negative global temperature shock. The response to a negative global temperature shock has been inverted. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).
Source: Own calculations.

CHART 15

.... whereas in Norway, a negative temperature shock has a greater effect than a positive temperature shock

Impulse responses of headline inflation in Norway to a positive and negative global temperature shock



Note: The chart shows impulse responses of Norwegian headline inflation (solid lines), expressed as percentage changes, to a positive and a negative global temperature shock. The response to a negative global temperature shock has been inverted. Standard errors are calculated using Newey-West standard errors, and 90 per cent confidence intervals are shown (shaded area). Global temperature shocks are estimated following the approach used in Hamilton (2018).
Source: Own calculations.

Permanent climate shocks may cause more heterogeneous responses among European countries than temporary temperature shocks

It is important to emphasize that the results presented above are based on temporary shocks, which deviate from the long-term climatic trend. This means that the responses do not reflect the effects of permanent changes, which are typically associated with climate change. The extent to which temporary global shocks accurately capture the permanent economic impacts of climate change remains an open question, requiring further research.

However, for local temperatures, Rebei (2025) finds that the impacts of a permanent and temporary shock to GDP are different. Specifically, Nordic countries – including Denmark and Norway – experience the most substantial losses following a permanent local shock, whereas a temporary local shock tends to increase GDP in these countries.[50] This suggests that although the results of a temporary global shock in Chapters 3 and 4 show short-term deflationary pressures for Denmark, Norway and Spain, the permanent effects of climate change could be different.[51] Furthermore, Rebei (2025) shows that a permanent local shock leads to more heterogeneous responses among advanced economies than in developing countries.[52] Again, this indicates that the heterogeneity among European countries may become even more pronounced

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[50] Note that although Rebei's (2025) findings align with the results in this memo – potentially suggesting that prices fall due to higher output following a temporary shock, the results are based on a different methodology. For methodological consistency, the results in this memo compare to the ones of Bilal and Känzig (2024), showing that European GDP falls by 7 per cent following a global temperature shock.
[51] A likely explanation is that advanced economies are better at mitigating temporary shocks but face greater challenges in addressing persistent effects of climate change.
[52] Rebei (2024) shows that the opposite holds for a temporary local shock, with greater variation in responses among developing countries than among advanced countries.

under permanent global shocks. This could potentially widening inflation gaps further.

06

Inflation volatility and heterogeneous responses may increase demand for monetary and fiscal policy

The results of Chapters 3, 4 and 5 show that a shock to global temperatures exerts different pressures on inflation across European countries. Given the expectations of more volatile global temperatures in the future, it puts forward two economic implications: 1) inflation may become more volatile and 2) inflation will potentially become more heterogeneous across countries. This can have important implications for central banks, potentially requiring them to act.

An increased risk of extreme global temperatures can prompt central banks to incorporate these factors into their monetary policies

Going forward, climate literature anticipates that extreme weather events – including temperature extremes – will increase, potentially contributing to greater price volatility. This volatility can create both inflationary and disinflationary pressures, depending on how a global temperature shock affects supply and demand dynamics across countries. On one hand, if inflationary pressures emerge, central banks may need to tighten monetary policy to reduce demand in the economy and thereby lower inflation. On the other hand, if countries encounter deflationary pressures, central banks may consider loosening monetary policy.

More shocks to global temperatures can also affect inflation expectations. This may occur if sustained increases or decreases in energy, food and service prices lead households and businesses to adjust their expectations about future inflation.[53] As a result, it is crucial that central banks continue to assess whether global temperatures shocks could alter inflation expectations or increase inflation volatility, so they can adjust monetary policy if necessary. This may place greater demands on both their analytical capabilities and communication efforts. Clear and transparent communication is essential to prevent households, businesses and financial markets from misinterpreting the central bank's policy intentions.

Heterogeneous responses across countries may increase the demand for fiscal policy

As shown in the previous chapters, southern European countries, like Spain, might face higher inflationary pressures following a global temperature shock. By contrast, northern European countries, like Denmark and Norway, tend to encounter deflationary pressures. These diverse responses may add more complexity to the task of maintaining price stability for monetary unions. If inflation gaps across member states become large enough, it may increase the need for fiscal policy measures to address the country-specific inflation

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[53] The effect on inflation expectations is due to increases in the price of, for example, heating or cooling, which are particularly salient to households because these items are homogenous, purchased frequently and account for a large proportion of certain households' expenditures. Similarly, price increases in, for example, process energy are an additional cost for firms. For further discussion on this, see Branner and Ingholt (2023). For empirical results, see e.g. Tenreyro (2023), D'Acunto et al. (2021) and Coibion et al. (2018).

pressures. Furthermore, the implications of the results might also apply to other parts of the world. For instance, large countries, such as the US, may face similar challenges, as they span multiple climate zones while maintaining a single monetary policy.

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