Estimating the rise in expected inflation from higher energy prices^{*}

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Abstract

When the price of electricity increases by 1%, households' expected inflation increases by 1.2 to 1.5 basis points. But, if those expectations have become unanchored, then the effect is higher by 0.2 to 1.5 bps. This paper arrives at these estimates by exploiting variation both in the time series, and especially in the cross section, from newlyavailable public data on expected inflation by Euro area households across region, gender, education, and income, and on the cost of energy across region and source. New measures of supply shocks to energy prices derived from the structure of the electricity market raise expected inflation gradually for 8 to 12 months. The rise in energy prices in 2021-23 accounts for only a small share of the rise in expected inflation.

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1 Introduction

The correlation between households' expected inflation and real oil prices is 0.54.¹ At the same time, when people are asked about their sources of information about inflation, they invariably mention energy bills in the top three (D'Acunto and Weber, 2024). A naive conclusion from these two facts is that energy prices are a major driver of inflation expectations and, potentially, that expectations are too sensitive to energy prices. Yet, a long literature has found that people are inattentive and that expectations move sluggishly. Moreover, the standard reference in the empirical literature (Coibion and Gorodnichenko, 2015) finds that a 1% increase in oil prices raises expected inflation by a measly 1.6 basis points.

This puzzling connection came to the forefront of economic debates during the recent inflation disaster. Between May of 2021 and 2022, annual inflation in the euro area (EA) went from 2% to 8.1%. At the same time, energy prices rose by 33%, and expected inflation increased by 2.3 percentage points.² Because sharp changes in energy prices are often temporary, there is a policy view to "see through them" and not respond by changing policy rates. But, because changes in expected inflation are often persistent, a clashing policy view calls for aggressive monetary tightening to re-establish the expectations anchor of inflation. Teasing out how much of the increase in expected inflation was solely due to the rise in energy prices, as opposed to other more persistent causes (including a lack of credibility of monetary policy) is a crucial question to understand the roots of this inflation disaster.

This paper makes progress on the empirical connection between energy prices and expected inflation by asking three related questions. The first of these is: *by how much does expected inflation over the next year increase on average when energy prices rise by* 1%? Much of the literature linking energy prices to expected inflation has used time-series variation and has focused on oil and gasoline prices. We provide new estimates by relying on cross-sectional variation, by focusing on electricity prices, by using recently-available expectations data, and by proposing new series of exogenous energy supply shocks.

More specifically, we use the Consumer Expectations Survey (CES) for the EA, which has between 9,000 and 22,000 monthly respondents across 11 countries between 2020:4

¹This is the correlation between the mean expected inflation in the household survey by the Michigan survey research centre, and the ratio of West Texas Intermediate spot crude oil prices and the consumer price index, for a sample between January of 2020 and August of 2024.

²Inflation measured using the 12-month change in the log HICP, energy prices using the energy component of the HICP, and expected inflation is the median answer to the consumer expectations survey.

and 2023:12. We exploit both the sharp changes in energy prices during this time, as well as (and especially) their large variation across countries, while using the many respondents per country to control for the large fixed national differences in expected inflation. Variation across regions within a monetary union differences out the potential monetary policy response to energy shocks, as well as other confounding omitted aggregate demand factors that affect both inflation expectations and the demand for energy. The short but large panel with plenty of cross-sectional variation can deliver precise estimates.

By focusing on the price of electricity paid by households, as opposed to oil and gasoline prices as the literature before us, we are also able to provide new measures of energy supply shocks. Electricity is, arguably, just as relevant as gasoline for households, and it has a larger share of energy spending.³ The features of the European electricity market allow us to propose three new plausibly exogenous measures of energy prices to address the reverse causality from expected inflation potentially driving demand for all goods including energy, and thus affecting electricity prices. The first relies on a shift-share strategy that exploits cross-region differences in the weight of energy in consumers' baskets. The second uses differential regional exposure to conventional time-series shocks to oil supply. The third exploits variation in the use of wind to generate electricity across time and region. We complement regressions that estimate the cumulative effect of the shocks with local projections that separate their dynamic effect from month to month.

All combined, we find that a 1% increase in electricity prices raises expected inflation by 1.17–1.53 basis points (bps). This effect is significantly smaller than either the weight of energy in the consumption basket, or the empirical connection between energy prices and actual inflation. This leads us to conclude that people are inattentive in absolute terms to energy prices, even if in relative terms they may be more attentive to energy than to other pieces of information. Moreover, we find that a one-standard deviation exogenous shock to energy prices raises expected inflation by 19–61bps, with the impact growing until 10 to 12 months after the shock. Again, this is consistent with inattention and the sluggishness of expectations, as opposed to excessive sensitivity to energy.

The second question is: by how much more does the 1% rise in energy prices increase inflation expectations when those expectations are less well anchored? All central banks strive to anchor inflation expectations since expectations that are sensitive to shocks will amplify these shocks. The theoretical literature has emphasized the importance of the ex-

³In the European HICP energy consumption basket, electricity has a weight of 25% versus 10% for oil and petroleum products.

pectations anchor for stabilizing inflation. Yet, as far as we know, there are no empirical answers available to this question.

The cross-sectional size and richness of the CES data provide measures of unanchoring based on disagreement about the long-run that are systematically different both across countries, as well as across demographic and socio-economic groups. Because of the significant cross-sectional variation in the time-series change of both energy prices and unanchoring across countries and groups, we can provide sharp estimates of their connection.

We find that when measures of the expectations anchor drift between their average level during 2021 and the one during 2023, the 1% increase in electricity prices raises expected inflation by an additional 0.20–1.50bps. Further, the peak of the impulse response to exogenous energy shocks can be twice as high when disagreement in expectations increases more than average versus less than average. That significant boost empirically confirms the importance of keeping inflation expectations anchored, as has been suggested by theory.

Armed with these estimates, we answer a third question: *how much of the up and down of expected inflation in 2021-23 was due to energy shocks?* Using our empirical model, we first calculate the predicted increase in expected inflation in 2021-22 solely from the rise in energy prices. This turns out to be very little. Then, we calculate the impact on expected inflation of a rise in electricity prices at each point in the sample. When expectations were most unanchored, in the first half of 2022, a doubling of electricity prices over six months would raise expected inflation by 90–120bps. By the end of our sample, a doubling of electricity prices in the second half of 2023 would raise expected inflation by only 55–75bps.

Contribution to the literature: Starting with the first question, an old literature emphasized the correlation between households' average inflation expectations and oil prices, or the food and energy component of inflation (Trehan, 2011, Arora, Gomis-Porqueras and Shi, 2013). As with most time-series correlations between two aggregate variables, this one is not reliable: it is unstable across samples and countries, and the two variables are mutually correlated with so many other aggregate time series that controlling for any number of them easily flips the sign of the partial correlation.

Moving beyond correlations, Coibion and Gorodnichenko (2015) followed by Binder (2018) answered the first question by regressing household expectations of inflation over the year ahead on the rate of change of wholesale oil prices over the past 6 months and gasoline prices at the pump, and obtained estimates of 1.6bp and 1.0bp, respectively. Be-

cause the oil price is the same for all, and the micro data from the Michigan survey is mostly a repeated cross-section with households interviewed only twice, the Coibion and Gorodnichenko (2015) estimate used almost entirely time-series variation.⁴ Yet, there is a time-series bias in the estimates because central banks closely watch both variables, they respond to them, and monetary policy affects inflation and aggregate demand and through them expectations and energy prices. Related, a shock to aggregate demand will both raise inflation and expectations of it directly, as well as increase the demand for all goods including energy, and so raise energy prices.⁵ Our estimates instead use the country-group variation within a currency union where common monetary policy and aggregate demand factors are controlled for. We are introducing to the literature on expectations a strategy that has been useful to answer other classic macroeconomic questions, like fiscal multipliers and business cycles (Nakamura and Steinsson, 2014, Beraja, Hurst and Ospina, 2019).

In terms of approach, like us, two recent papers exploited cross-sectional variation. Binder and Makridis (2022) used state-level variation in real gasoline prices, but measured their impact on indices of consumer sentiment, as opposed to inflation expectations. Wehrhofer (2023) used cross-household variation on when electricity contracts are renewed to find that, in a context of rising energy prices, a renewal raises expected inflation by 1.8bp. However, lacking information on how much the electricity price rose with the new contract, it cannot estimate the coefficient of interest for our first question.⁶

Next, using the new focus on electricity, as opposed to oil, we put forward three new instruments for supply shocks to energy prices. Kilian and Zhou (2022) used a combination of sign and zero restrictions in a vector autoregression to identify the effects of gasoline price shocks. Känzig (2021) constructed high-frequency changes in the oil price expectations reflected in oil price futures around OPEC production announcements in a

⁴With time fixed effects, there is little variation left, and the estimates become quantitatively and statistically indistinguishable from zero (Armantier et al., 2016).

⁵A complementary literature looked at the impact of changes in oil prices on the expected inflation over the next 5 years in the Michigan survey (Celasun, Mihet and Ratnovski, 2012, Binder, 2018), which arguably may respond less to other short-term shocks. These measures of long-term expectations move much less than the one-year-ahead ones. With this limited time-series variation, it is harder to estimate the effect precisely, and results are varied. The few estimates that are statistically significant and different from zero point to a negligible impact of oil prices on expected inflation.

⁶Earlier studies used the very limited US cross-sectional variation to show that estimates could vary across states and groups. Coibion and Gorodnichenko (2015) had a version of their baseline estimate broken by states and groups. More explicitly, Binder (2018) used the 4 regions in MSC to separately estimate the impact of oil prices on inflation expectations, and found that these line up with expenditure shares, and also correlated expected gas prices and expected headline inflation across the regions.

local projection. Closer to this paper, Miyamoto, Nguyen and Sergeyev (2024) followed Känzig (2021) but separated periods where nominal interest rates were at the zero lower bound in Japan to control for the confounding effect of monetary policy and aggregate demand. Together, these studies found that a 1% increase in gasoline prices raises expected inflation by 1.8–3bp within the first three months, but zero within 6 months.⁷ Our instruments are different and, hopefully, can be applied to learn about the impact of energy prices on other outcomes. Our estimates are also different, since we find a larger and more persistent effect, perhaps because we focus on a sample where there were large shocks and much variation in expected and actual inflation.

Closer to us in identification strategy (and written contemporaneously) two studies also use cross-sectional strategies but focusing on gasoline prices. Hajdini et al. (2024) regress weekly expected inflation on gas prices times the share of households in a US county that use their own car for commuting. However, they explain levels of expectations within one week alone, whereas we focus on their changes over six months or more, so we can answer macro questions. Our impact results are consistent with theirs. Jo and Klopack (2024) measured the impact of temporary changes in gasoline taxes on inflation expectations in five US states in 2022. Their estimates are one order of magnitude larger (13bp) than any other, but they combine the signaling impact of energy with its fiscal implications, and are boosted by intertemporal substitution.

Turning to the second question, to our knowledge, this is the first paper to use household micro data to empirically investigate whether the impact of energy prices on expected inflation is different when expectations are unanchored. Theories of inattention naturally link unanchoring to responsiveness to shocks (Angeletos and Lian, 2016, Mankiw and Reis, 2010), and we theoretically justify our regression building on models by Angeletos, Huo and Sastry (2020), Flynn and Sastry (2024), and Reis (2020). There are only two (distant) related papers. Bonomo et al. (2024) finds unanchoring linked to a change in monetary policy in Brazil, while we find a smaller but still significant amount of unanchoring during 2021-22 in the EA linked to energy prices. Pfäuti (2023) proposes a model in which after an energy shock, inflation surges, the public's attention to inflation rises, and negative supply shocks become more inflationary. It estimates that between a lowand high-attention regime the impact of a negative supply shock on inflation expectations doubles. This is consistent with our estimates.

⁷Kilian and Zhou (2024), Wong (2015) and Aastveit, Bjørnland and Cross (2023) found even weaker responses.

Finally, turning to the third question, a recent literature has tried to explain the 2021-23 inflation disaster with measures of inflation expectations (Reis, 2023), measures of energy prices (Gagliardone and Gertler, 2023), interactions between the two (Acharya et al., 2023), and propagation over time (Vlieghe, 2024). Quantifying the relative contribution of expectations and energy prices (and other supply shocks) is hard since both affect each other and are related to other major macroeconomic aggregates. We make progress by isolating one specific channel between two of these factors.

Outline: The paper is structured as follows. The next section discusses the data and the variation we will exploit. Section 3 presents a model of the link between energy prices and expected inflation that justifies our empirical strategy to answer the questions posed in this introduction. Sections 4, 5 and 6 present the estimates that answer the three questions in turn. Section 7 concludes.

2 The setting and variation in the data

Our setting has data on expected inflation with rich variation in time as well as in the cross section by person, group and country, combined with also rich variation in energy prices. Our focus on electricity prices leads to three suggested supply drivers of this variation.

2.1 Expected inflation

Let $\pi_{i,c,g,t}^e$ be the answer by household *i*, who is a resident of region/country *c*, and is part of a demographic or socio-economic group *g*, in month *t*, to the question: "How much higher (lower) do you think prices in general will be 12 months from now in the country you currently live in?" The data come from the ECB's CES, where *i* goes from 9,000 to 22,000 respondents, depending on the month, *c* are eleven countries in the euro area, there are eight demographic groups *g* from crossing gender (male/female), income bracket (above/below 60th percentile), and education (college/below), and the months *t* go from April of 2020 to December of 2023 for six countries, and from April 2022 for the remaining five (first available in February of 2024).

Panel (a) in figure 1 shows the variation in the data, by plotting average expected inflation for the eight groups in two of the countries, following Fofana, Patzelt and Reis (2024). Noticeably, Italians always expect higher inflation than Germans. At the same time, separate groups within each country also systematically disagree on what inflation

Figure 1: Time-series and cross-sectional variation in the data

(a) Expected inflation: Germans and Italians

(b) Anchored expectations: Germans and Italians





(c) Electricity prices across countries

(d) Wind electricity generation across countries



Note: Panel (a) plots the average expected inflation 12-months ahead by country (for Germany and Italy) and by demographic group. Panel (b) plots the average inter-quartile range of expected inflation three years ahead within country (for Germany and Italy) and demographic group. Groups are defined as follows: male (1,2,3,4) or female (5,6,7,8); college education (3,4,7,8) or below (1,2,5,6); and income bracket above 60th percentile (2,4,6,8) or below (1,3,5,7). Panel (c) plots HICP electricity rescaled with base period 2020:4 for the 6 largest countries in the survey. Panel (d) plots wind electricity generation for the 6 largest countries.

will be, and switch roles between optimists and pessimists during the sample. At an extreme, a woman resident of Italy without college that is poorer usually expects much higher inflation than a richer German man with a college degree.

Even though we have a short time series, covering less than four years, it is one where inflation varied more over time than in the previous two decades of the life of the euro. We measure actual inflation as the log change between the harmonised index of consumer prices from Eurostat in date *t* and 12 months earlier, per country: $\pi_{c,t}$, and denote average year-on-year inflation in the last year by $\bar{\pi}_{c,t} = \sum_{i=1}^{12} \pi_{c,t-i}/12.^{8}$

2.2 Inflation expectations anchor

The degree of anchoring of inflation expectations within a country-group is $a_{c,g,t}$, where a higher $a_{c,g,t}$ stands for more unanchored.

The literature has used data on longer-term inflation expectations to measure unanchoring in two ways.⁹ One uses higher-order moments of the distribution of inflation expectations, arguing that disagreement among households reflects an unanchoring of expectations. This would be the case in models with incomplete information and dispersed expectations. The other uses the difference between expected inflation and the inflation target, arguing that unanchoring reveals itself as a loss of credibility of the target. Models of learning and reputation support these measures.

We use one measure from each of these two classes: the 6-month change in the interquartile range of expected inflation 3-years ahead within country-group, and the 6month change in the absolute difference between expected inflation 3-years ahead and the ECB's inflation target averaged by country-group.

Panel (b) in figure 1 shows the first of these measures for the same two countries and eight groups. Again, there is a clear country fixed effect: Italians have less anchored expectations than Germans. Again as well, there is significant variation across group-time, as the expectations of different groups unanchor and then reanchor during this sample.

2.3 Energy prices

Eurostat provides an index for harmonised electricity prices per country paid by households inclusive of taxes and subsidies. Let $e_{c,t}$ denote the log of that index, while e_t is its counterpart for the whole EA.¹⁰

Electricity markets in the EA are segmented across regions (that can include more than one country) connected by distribution networks that use different sources of energy (like renewables, nuclear, or natural gas). The Russian invasion of Ukraine raised prices everywhere at the end of 2021, but both the size of this increase and its reversal were

⁸Appendix figure A7 shows that inflation varied greatly across countries and over time.

⁹See, for instance, Bonomo et al. (2024).

¹⁰This is a nominal variable, but since we will include inflation as a control variable in all regressions, using instead its real equivalent makes little difference.

very different across regions. Panel (c) of figure 1 shows that changes in electricity prices varied considerably in 2020-23, both in the cross-section and the time series.

2.4 Supply shocks to energy prices

The literature on energy prices has focused on the impact that shocks to the supply of energy have on aggregate variables.¹¹ Our instruments are different and, hopefully, can be applied to learn about the impact of energy prices on other outcomes. Our estimates are also different, since we find a larger and more persistent effect, perhaps because we focus on a sample where there were large shocks and much variation in expected and actual inflation.

In part, this is because energy plays a central role in production so changes in the macroeconomy feed into shifts in the demand for energy and so drive the price. Supply shocks are arguably more driven by changes specific to the energy sector. Moreover, in most macro models, the supply of energy is exogenous, so estimating the response of inflation expectations to a supply shock maps into the model objects of interest.

In our sample, it may well turn out that the actual prices mostly reflected supply shocks. The increase in electricity prices was driven by the invasion of Ukraine, to which each country responded with different measures. While these differential responses may have been correlated with that country's inflation experience (which we will control for), they were plausibly not a response to differences in expected inflation.

Using the cross-sectional variation in the data, we can move further. First, note that there are large differences in how much households spend on energy across regions. This is in part because of country differences in temperature, whether home heating is mostly based on gas, electricity, or solar panels, and the share of electric vehicles, among other factors. The literature has further shown that household characteristics—like income, location, home ownership, housing tenure—and building characteristics—like heating systems, size of the house, and age—drive a great deal of this variation.¹² The shares of electricity in household consumption per region in 2019 (before the rise of inflation) from the Eurostat HICP, s_c , capture this cross-country variability in the impact of higher electricity prices on household budgets. They should proxy for the visibility of energy prices to households in forming expectations of inflation, and they are likely exogenous with respect to the future expected inflation.

¹¹See, for instance, Känzig (2021) and Kilian and Zhou (2024).

¹²See, for instance, Krishnamurthy and Kriström (2015) and Longhi (2015).

Consider then a shift-share shock series, which multiplies the aggregate time-series variation in energy prices with the cross-sectional ex-ante variation in energy spending: $z_{c,t} = e_t s_c$. Insofar as cross-country differences in expected inflation may drive cross-country spending and electricity prices, but they do not affect EA aggregate demand for energy and prices, then this is a shock series to the price of energy. It should not be affected by reverse causality from expectations to demand for energy and its price.¹³

Going further, the electricity market in the EA has the following feature. The supply curve is at first approximately horizontal, as electricity is produced using renewable and nuclear sources, which have a large fixed cost but a low marginal cost. These sources are hard to expand or contract in the short run, so they are therefore almost always inframarginal, that are fully used until installed capacity. Afterwards, the supply curve slopes upwards. The marginal production of electricity uses oil, natural gas, and solid fossil fuels (like coal), with a competitive market switching between them. As a result, the price of electricity and of these energy sources usually, but not always, moves closely together.

Following a cut in the supply of natural gas from Russia, the upward-sloping section of the supply curve becomes steeper (or shifts left). Given the environmental and capacity constraints on expanding fossil fuels, oil prices become a proxy for the marginal cost of production of electricity in the EA. Känzig (2021) built shocks for oil supply expectations by measuring high-frequency changes in oil futures prices following OPEC production announcements, k_t . These shocks are plausibly exogenous in the sense that inflation expectations between 2020 and 2023 did not directly affect them. Using them leads to a second shift-share measure of energy shocks in Europe: $z_{c,t} = k_t s_c$. Both the shifter and the share are plausibly exogenous.

Finally, an increase in the production of electricity using renewables will shift the flat part of the supply curve for electricity to extend to the right, and so lower electricity prices. Using data from Ember, we measure the monthly change in total energy generated through wind in each region, $w_{c,t}$, plotted in panel (d) of figure 1. Since the marginal cost of producing electricity for installed turbines is very low, variations in wind shift the supply curve, and since they are mostly driven by exogenous fluctuations in the weather, they are not driven by changes in expected inflation. Therefore, $z_{c,t} = w_{c,t}$ provides a

¹³One concern (implausible to us) is that some households in 2019 foresaw the energy shock that was coming and adjusted their consumption of energy accordingly affecting the s_c . Appendix C considers two alternatives for the shares. First, the average expenditure shares over a longer period, between 2015 and 2019. Second, to purge from any quantity variation, the network cost of electricity for households in euro per KWh in 2019. This varies considerably across energy markets.

third alternative shock series for energy shocks.¹⁴

3 A flexible model of expectations

This section puts forward a model of expectations linking energy prices to expected inflation. The micro-foundations are relegated to appendix B, but they build on the main ingredients from the theoretical literature on inattention. Here, we present the reducedform that follows, which indicates how the variation in the data can answer our questions.

3.1 Components of expectations

To start, actual inflation depends mechanically on energy because it has a weight of ω on the consumption basket.¹⁵

Beyond this direct effect, energy prices provide a signal on how other prices will change, both because they change costs of production, and because they trigger responses by monetary policy. Let that information component be denoted by $x_{i,c,g,t}$, which may be different for each household in a country and a group depending on their attention to news.

Each group in a country has characteristics that persistently affect both their expectations, as well as how sensitive they are to individual signals. The former is already captured in $x_{i,c,g,t}$. The latter is captured by an extra term $\lambda_{c,g}^{\varepsilon} \varepsilon_{i,c,g,t}$, which can be correlated with the price of energy.

Finally, all other individual-group-country-time determinants of expectations that are orthogonal to energy prices are captured in the variable $u_{i,c,g,t}$.

All combined, expected inflation depends on energy prices directly, through information, and through sensitivity to information, and depends on other independent factors as well:

$$\pi^{e}_{i,c,g,t} = \omega e_{c,t} + x_{i,c,g,t} + \lambda^{\varepsilon}_{c,g} \varepsilon_{i,c,g,t} + u_{i,c,g,t}$$
(1)

¹⁴One concern might be that higher expected inflation could lead to building more wind turbines. Yet, installing this capacity takes time. Moreover, the correlation between our $w_{c,t}$ series and a monthly series for mean wind speed by region is high for most countries, especially for those where wind power is a large share of electricity production. This confirms that most of the variation is indeed exogenous.

¹⁵It is straightforward to allow this weight to be country specific, so that the regression described below will measure the average of these weights.

3.2 Inattention

The information in energy prices can be decomposed into a union-wide component e_t and what is specific to the region, $e_{c,t} - e_t$. If the household pays attention, it will put some weights on these two pieces of information that reflect their value (optimally or not), call them ϕ and ϕ^c , respectively. With rational expectations and imperfect information, we would have: $x_{i,c,g,t} = \phi e_t + \phi^c (e_{c,t} - e_t) + u_{i,c,g,t}^x$. The term $u_{i,c,g,t}^x$ absorbs all other information beyond energy prices (but which may be correlated with it) that is useful to forecast, including constants.¹⁶

However, only a share λ of respondents at that date are paying attention to these signals. The remainder, $1 - \lambda$ are either completely inattentive (so their individual *x* is zero) or partially so, only paying attention to their local conditions as a signal.¹⁷ The weight they put on these conditions is ϕ^a , which could be the optimal weight from the Kalman filter, or some sub-optimal weight. Either way, for these inattentive agents: $x_{i,c,g,t} = \phi^a e_{c,t} + u^x_{i,c,g,t}$.¹⁸

For inattentive agents, their signal is filtered through a noisy channel. Expectations deviate from the average of $x_{i,c,g,t}$ by an individual random error that reflects idiosyncratic noise. It is a general result in rational inattention that how much noise is in these signals depends on the costs of attention as well as on the marginal benefit of information. Under a linear-quadratic approximation to a rational inattention model, $\varepsilon_{i,c,g,t}$ is a standard normal variable and so $\lambda_{c,g}^{\varepsilon}$ is the cross-sectional standard deviation of these signals. This depends on group and country, because these have different marginal costs of attention. It also depends on energy prices because of diminishing returns to the value of knowing their precise value.

The appendix further shows that the interquartile range of forecasts $a_{c,g,t}$ is a statistic for this intensity of attention. Therefore, we can approximate: $\lambda_{c,g}^{\varepsilon}\varepsilon_{i,c,g,t} \approx \lambda^{\varepsilon}e_{c,t}a_{c,g,t} + u_{i,c,g,t}^{\varepsilon}$, where the last term is an individual-specific component associated with this noise.¹⁹

¹⁶For an early version of this model of rational expectations, see Muth (1961).

¹⁷As with the consumption baskets, it is also the case that we could allow this weight to be country-specific, and the regression estimate would be of the average attention parameter.

¹⁸This formulation nests the combined approaches of Lucas (1972) and Mankiw and Reis (2002), or more recently Angeletos and Lian (2016).

¹⁹This follows the formulation in Flynn and Sastry (2024) of the classic approach of Sims (2003).

3.3 An empirical specification

Combining all of the ingredients, summing over agents within a country-group, and grouping terms, gives the following model for observed expectations:

$$\sum_{i} \pi_{i,c,g,t}^{e} = (\omega + \lambda \phi^{c} + (1 - \lambda)\phi^{a})(e_{c,t} - e_{t}) + (\omega + \lambda \phi + (1 - \lambda)\phi^{a})e_{t} + (1 - \lambda)\lambda^{\varepsilon}e_{c,t}a_{c,g,t} + \sum_{i}(u_{i,c,g,t} + u_{i,c,g,t}^{x} + u_{i,c,g,t}^{\varepsilon}).$$
(2)

Starting with the last term, that sums over the u's, it is not independent of energy, nor it is zero when averaged over time. The term $u_{i,c,g,t}^x$ includes both a constant, associated say with the inflation target, as well as other time-varying variables that may be useful to forecast inflation, like past inflation or the state of monetary policy. Moreover, the group and country specific features of inattention in $u_{i,c,g,t}^{\varepsilon}$ would appear as group and country specific constants in this term. Finally, even outside of information, there are persistent differences in actual inflation across countries (e.g., due to Balassa-Samuelson effects) that make the $u_{i,c,g,t}$ not zero.

The other term in the second line shows the interaction between energy prices and a measure of the dispersion of expectations. A higher dispersion captures a higher cost of attention, which comes with more noise in individual signals. The inattention parameter λ^{ε} captures how sensitive the relative value of that attention is.

The top line shows the combined effect of energy prices on inflation expectations through: the direct impact on the price index (ω), the rational expectations information effect on making forecasts (ϕ , ϕ^c), and the limited information effect of local variables (ϕ^a). Inattention captured by λ mitigates the value of information.

If a regression includes time fixed effects, then those would absorb the second term, so the estimate would be: $\omega + \lambda \phi^c + (1 - \lambda)\phi^a$. Without those fixed effects, the coefficient on country energy prices would instead be $\omega + \lambda \phi + (1 - \lambda)\phi^a$. The second estimate is larger if $\phi > \phi^c$. This is likely the case, since aggregate energy prices are more relevant to forecast inflation than region-specific ones. A simple regression of actual inflation on e_t and $e_{c,t} - e_t$ in our sample period delivers an estimate of the first coefficient that is between 4.6 and 5.7 times larger than the second one, depending on the specification. Recalling that ϕ and ϕ^c were defined in terms of rational expectations, this suggests that ϕ is about five times larger than ϕ^c .

From a macroeconomic perspective, the regression without time fixed effects is plau-

sibly more relevant. Since energy markets have a strong global component, keeping the aggregate time-series variation would provide a more appropriate answer to the question stated in the introduction. Our baseline regression will therefore not have time fixed effects, but we present results with them as well, and discuss their connection to the relative sizes of ϕ and ϕ^c .

3.4 Baseline regression

We take equation (2) to the data by estimating the following unbalanced-panel regression:

$$\Delta^6 \pi^e_{i,c,g,t} = \beta \Delta^6 e_{c,t} + \gamma \Delta^6 e_{c,t} \times \Delta^6 a_{c,g,t} + \alpha_c + \eta_g + \theta^\pi \bar{\pi}_{c,t-6} + \rho \Delta^6 r_t + \varepsilon_{i,c,g,t}.$$
(3)

The operator Δ^h refers to the change in a variable relative to its value *h* months ago. Therefore $\Delta^6 \pi^e_{i,c,g,t} = \pi^e_{i,c,g,t} - \pi^e_{i,c,g,t-6}$, as long as a household answered the survey both in month t - 6 and again in month *t*. In turn, α_c are country fixed effects, η_g are group fixed effects, and θ^{π} and ρ are coefficients from controlling for past inflation ($\bar{\pi}$) and changes in ECB monetary policy (r_t). The two coefficients of interest are β and γ .

We take the theory to the data in 6-month first differences because there was a marked difference in the updating of average expected inflation across countries during the sample period of rising inflation. This may be due to different levels of trust in monetary policy across countries, or to country-specific characteristics affecting prices. First differences over time partly eliminate some of these differences across group-countries, with the remainder absorbed by the country and group fixed effects.²⁰

The controls for inflation and monetary policy that are suggested by the theory deal with the delayed effect of inflation on slow-moving expectations, and with the common monetary policy that responds to both energy prices and expected inflation. This baseline regression does not include time fixed effects, so they estimate the differential impact of energy prices on the expected inflation of two people both at the same time and across time. As discussed in the theory, we will also consider specifications with month fixed effects, which answer a slightly different question.²¹

²⁰Choosing h = 12 ensures that there is no overlap between the observation frequency and the forecast horizons, while choosing h = 1 maximizes the number of observations but introduces noise both in expectations and in energy prices, which are volatile and transient. We choose h = 6 as a compromise. Appendix C reports estimates with h = 1, 4, 12 as well.

²¹Appendix C discusses results with a full set of time-country-group joint fixed effects, to further isolate the role of the cross-regional variation.

Note that there is no variation in *i* in any of the right-hand side variables. These are seemingly unrelated regressions, which use the individual variation within country-group to sharpen the estimates of the common coefficients of interest. It is the cross-sectional *c*, *g* variation, the novelty in this paper, that sharpens the estimates of β and is crucial to identify γ on the effects of anchoring.

Finally, on the interpretation of the estimates, we multiply the left-hand side variable by 100, so that β measures the impact on expected inflation in basis points of a 1% increase in energy prices. Therefore, β answers our first question.

From a steady state where the anchor remains stable, γ measures by how many basis points more will 1-year ahead expected inflation rise with the increase in electricity prices if un-anchoring increased, as measured by a 1-percentage point higher interquartile range of 3-year ahead inflation expectations. This answers our second question. Given the group fixed effects, γ is identified from the change in expected inflation in one country relative to another where electricity prices rose by less and expectations were more anchored relative to the other country-groups. Coincidentally, the average disagreement across all households in 2023 was 1.05 percentage points higher than on average in 2021, so γ measures the approximate extra impact of an energy shock between these two years.

3.5 Energy supply shocks

The model is static. Making it dynamic would justify a similar specification to the one in equation (2), but the coefficients would now capture the impact of shocks to the energy prices on expectations. A focus on dynamics leads to further predictions on how the coefficients vary with the horizon.

The informativeness coefficients, (ϕ, ϕ^c, ϕ^a) should decline with the horizon. Energy shocks are often transitory, and they quickly lose forecasting power for inflation as the horizon increases. Instead, the inattention coefficient λ will tend to rise with the horizon approaching one. The more time elapses after the shock, the more households have learned about it. Therefore, the impact of energy shocks on expected inflation may rise or fall at first over the horizon, depending on which of the two effects is stronger. Eventually though, if the shock is transitory, this impact should die out.

Theory is more decisive on the effect of unanchoring. As the horizon rises, and more households learn about the shock, the noise around their signals will fall. Therefore, λ^{ε} falls with horizon, as does $1 - \lambda$, so the effect of the initial unanchoring dissipates over time.

We test these predictions by estimating a local projection in the panel of data for each horizon h = 1, ..., 24:

$$\pi^{e}_{c,g,t+h} = \beta^{h} z_{c,t} + \gamma^{h} z_{c,t} A_{c,g,t} + \sum_{p=1}^{P} \left(\tilde{\beta}^{h}_{p} z_{c,t-p} + \tilde{\gamma}^{h}_{p} z_{c,t-p} A_{c,g,t} + \psi^{h}_{p} \pi^{e}_{c,g,t-p} \right) \\ + \alpha^{h}_{c} + \eta^{h}_{g} + \theta^{h} \bar{\pi}_{c,t} + \rho^{h} r_{t} + \phi^{h} + \varepsilon_{c,g,t+h}$$
(4)

This measures the impact on average expected inflation in *h* months of an energy shock in the current month. We include the shock and the expectations in the last *P* = 2 months as a control, although the results are insensitive to this choice. The dummy variable $A_{c,g,t}$ captures whether unanchoring was above average for that country-group. Therefore, β^h is the impact when expectations unanchor by less, while $\beta^h + \gamma^h$ is the impact when they unanchor by more. As before, and for the same reasons, we include country fixed effects α_c^h and group fixed effects η_g^h at each horizon, and control for past inflation with coefficient θ^h and the policy rate with coefficient ϕ^h . Since the left-hand side variable is in levels, we include a horizon intercept ϕ^h .

Theory predicts that β^h may rise over *h* temporarily, as inattention beats informativeness, but eventually will fall, while γ^h will decline towards zero as unanchoring becomes less important as time elapses. Note that β^h and γ^h do not answer the two first questions posed in the introduction, but two related ones: by how much does expected inflation over the next year *gradually* increase on average *after a 1-standard deviation supply shock to energy*? By how much more does the *supply shock gradually* increase inflation expectations when those expectations are less well anchored? The difference is in the italicized parts, replacing energy prices with supply shocks and asking how the response changes over time.

The shift to focus on supply shocks, when combined with the cross-sectional identification, goes further in dealing with the confounding factors from other aggregate variables, since most of them work through aggregated demand raising demand for energy goods and so energy prices. Moreover, these are shocks, not instruments. Their impact on expected inflation may work through multiple channels that we care about, aside from isolating the channel that goes solely through the price of electricity.

4 Results: energy prices and expected inflation

This section presents the estimated impact of energy prices on expected inflation.

4.1 Baseline

The first column of Table 1 reports the results from estimating equation (3). A 1% increase in electricity prices raises expected inflation by 1.40bp if there is no change in anchoring. However, if disagreement increases by as much as the difference between 2021 and 2023, then the higher electricity prices add an extra 0.60bp effect, for a total effect of 2bp. Both effects are statistically significant.

The fit of the regression is low, as expected given that no explanatory variable captures the household variation in expected inflation. The second column instead pools observations within country-group, by replacing the left-hand side variable with $\Delta^6 \pi^e_{c,g,t} = \Delta^6 \sum_i \pi^e_{i,c,g,t} / I_{c,g,t}$, the change in the average expected inflation within a country-group. The R^2 dramatically rises, as expected. The effect without unanchoring stays roughly the same, at 1.17bp, while the impact of unanchoring falls to 0.20bp. Both remain significant.

The third column uses as the measure of unanchoring the distance of 3-year expected inflation from target. The effect of higher electricity prices with no change in anchoring is similar, at 1.22bp. Since this measure of unanchoring increased by 76bp between 2021 and 2023, its coefficient now implies that unanchoring contributed to an extra 1.98bp increase in expected inflation following a 1% rise in electricity prices, a much stronger effect than in the baseline.

The next two columns explore the role of the cross country-group variation in driving the results. Column four shows the results using only country, but no group, variation by aggregating across the groups, thus replacing $a_{c,g,t}$ by $a_{c,t}$. The impact without unanchoring is slightly larger, while the extra boost from unanchoring is much larger with a point estimate of 1.50bp. With less identifying variation, the confidence bands are wider.

In the other direction, column five includes country-group fixed effects to ascertain whether there is a bias from systematic differences in the way groups within countries changed their expectations during this time. It seems not to be the case, as the estimates are very close to the baseline.

The sixth and final column includes month fixed effects. This soaks much of the variability leaving only the variation across 11 countries and 8 groups to estimate the coefficients, making it hard to pin down the effect of anchoring, which now has wide confi-

Revision of expectation	(1)	(2)	(3)	(4)	(5)	(6)
Change in electricity prices	1.404***	1.167***	1.222***	1.531***	1.397***	0.372**
	(0.296)	(0.103)	(0.229)	(0.329)	(0.294)	(0.181)
Change in electricity prices	0.596***	0.199***	2.609***	1.499***	0.617***	0.146
× Unanchoring	(0.171)	(0.061)	(0.466)	(0.374)	(0.173)	(0.089)
Average past inflation	0.004	-0.025***	-0.001	0.009	0.005	0.004
	(0.028)	(0.009)	(0.025)	(0.027)	(0.028)	(0.079)
ECB deposit rate change	-0.436*** (0.119)	-0.449*** (0.031)	-0.442*** (0.113)	-0.438*** (0.118)	-0.437*** (0.119)	
Observations R^2 Country & group fixed effects Month fixed effects Country-group fixed effects	362756 0.016 Yes No No	2472 0.343 Yes No No	362756 0.018 Yes No No	362756 0.016 Yes No No	362756 0.016 Yes No Yes	362756 0.032 Yes Yes No

Table 1: The impact of electricity prices on expected inflation

Note: This table presents estimates of the regression in equation (3): $\Delta^6 \pi^e_{i,c,g,t} = \beta \Delta^6 e_{c,t} + \gamma \Delta^6 e_{c,t} \times \Delta^6 a_{c,g,t} + \alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \rho \Delta^6 r_t + \varepsilon_{i,c,g,t}$. Column (1) has the baseline estimates, (2) uses the average $\pi^e_{c,g,t}$ as the dependent variable, (3) uses as measure of unanchoring the deviation of long-run expected inflation from target, (4) uses anchoring at the country level only $a_{c,t}$, (5) includes country-group fixed effects, and (6) includes time fixed effects. In parentheses are standard errors clustered by month for the regressions using individual expectations.

dence bands.²² More interestingly, as predicted by the theory, the estimated coefficient on the price of energy is smaller.

How large are our estimates? A simple way to judge this is to estimate equation (3) but with actual inflation, as opposed to expected, on the left-hand side. Across specifications, the estimates are on average 6.5 times higher (see table A3 in the appendix). They are also 3-4 times higher than the weight of energy in the HICP basket. Expected inflation responds significantly less than actual inflation to electricity prices.

Going back to the theory, this is consistent with significant inattention. Households choose how much attention to devote to energy to forecast inflation, and this turns out to be little. Households are not overly sensitive to energy prices. Rather, they are less sensitive than what rational expectations would predict.

Moreover, the theory predicted that the estimate with fixed effects would be about 5 times smaller than the one without. In the data, it is about 3 times smaller, consistent with

²²Appendix C reproduces table 1 using always month fixed effects and confirms that the estimates are less precise, since there is less variation to pin them down, and lower.

the relative contributions of aggregate and region-specific components of energy prices.

4.2 Robustness

Appendix C shows estimates for several alternative specifications to explore the robustness of the results.

First, we consider alternative compositions of the panel to understand the role of the cross-sectional variation in the data. Table A4 considers a balanced panel of only six countries, weights observations by the number of respondents in the country-group, or uses median as opposed to mean expected inflation. These make little difference. Similarly, different interactions of fixed effects in table A5 confirm the role played by the cross-sectional variation in pinning down our estimates.

As for the time-series variation, estimating equation (3) separately for each country gives a set of $\{\beta_c, \gamma_c\}$ estimates that only use the variation in anchoring across groups, and so is close to a time-series regression. Confirming the importance of the country-group variation, this results in very imprecise estimates that are widely different across countries (table A6). Table A7 instead includes time fixed effects across all the baseline regressions. This confirms that estimates are smaller, as predicted by theory.

Turning to alternative measures of the variables, table A8 varies horizon *h*, by using 1-month, 4-month, and 12-month changes in expected inflation and electricity prices. This makes little difference.

For the measures of energy prices, we consider three alternatives: the consumer price index for energy as opposed to electricity, a measure of wholesale electricity prices, and a regulatory-funded public project's measure of electricity prices in capital cities. Appendix A describes their sources, and that they are all positively correlated, although sometimes not strongly so, again reflecting the difference across regional and national markets. Table A9 shows that the link between energy prices and expected inflation is robust to using the different measures.

Table A9 also shows that including a control for the squared price of energy does not change the results. It could be that sharp changes in energy prices have a large impact on expected inflation even for unchanged disagreement in expectations, and our anchoring measure was proxying for this. That is not the case. Table A10 uses instead the change in electricity price inflation as opposed to its price level, in case of concerns for stationarity of energy price inflation. The estimates are harder to interpret but remain significant.

Turning to anchoring, table A11 we also include the measure of anchoring by itself at

the same time as its interaction, to deal with some possible bias from omitted variables, but the results barely change.

Finally, in table A12, we instead calculate Huber-White standard errors, Driscoll-Kray standard errors, as well as clustered standard errors per demographic group and two-way clustered standard errors. They confirm the baseline results.

4.3 United States data and estimates

The FRB New York Survey of Consumer Expectations provides US household inflation expectations $\pi_{i,c,g,t}^e$ from June of 2013 onwards. It only covers approximately 1,300 respondents, across the 50 US states, so that each group-state (*c*, *g*) cell often only has a few respondents. Our measures of anchoring are therefore imprecise, and often impossible to calculate. Boldly, only when there are less than 5 respondents within a group, do we exclude a measure of $a_{c,g,t}$ and proceed to estimate our baseline regression in the unbalanced panel. For state-level electricity prices we use residential retail electricity prices from the US Energy Information Administration.

Table 2 presents the estimates. As expected, given the noise in measuring anchoring, all of the estimated coefficients on this variable are statistically insignificant and have wide confidence intervals. The US data do not allow us to answer the second question.

Turning to the first question, the US results are broadly consistent with those for the EU. The baseline estimate in the first column is that a 1% increase in electricity prices raises expected inflation by 1.80bp, compared with 1.40bp for the EU. This is robust to using the average expectation as the dependent variable (second column) or to the alternative measure of unanchoring (column three). Again, time fixed effects leads to a smaller estimate, which is now 1/6th of the size of the previous one, still suggesting a similar ratio between the relative informativeness of aggregate and local prices in the theory.

Column five instead changes the measure of energy prices from electricity to log national retail gasoline prices, calculated by the Energy Information Administration, while column six uses national oil prices for West Texas Intermediate (WTI). The impact of gasoline prices turns out to be similar to that of electricity prices. This suggests that, in comparing our baseline results with those from the literature before us, the different measure of energy prices is not the source of the difference. Using oil prices though, which are arguably less visible to the consumer than gas at the pump, leads to a coefficient that is half as large.

In appendix D, we show results using instead the Michigan survey of consumer expec-

	(1)	(2)	(3)	(4)	(5)	(6)
Change in energy prices	1.804**	1.942***	1.939**	0.300	1.690***	0.864***
	(0.740)	(0.721)	(0.743)	(1.049)	(0.301)	(0.220)
Change in energy prices \times Unanchoring	-0.024	0.058	0.766	0.002	0.062	0.043
	(0.132)	(0.100)	(0.478)	(0.137)	(0.086)	(0.049)
Average past inflation	0.002	-0.094	0.005	-0.003	-0.064	-0.067
	(0.085)	(0.061)	(0.085)	(0.097)	(0.077)	(0.081)
Change in FFR	0.047 (0.397)	-0.058 (0.408)	0.033 (0.401)		-0.169 (0.343)	-0.160 (0.421)
Observations R^2 Country & group fixed effects Month fixed effects	17903 0.016 Yes No	7100 0.008 Yes No	17903 0.017 Yes No	17903 0.022 Yes Yes	17907 0.018 Yes No	17907 0.017 Yes No

 Table 2: The impact of energy prices on expected inflation in the US Fed SCE

Note: This table presents estimates of the regression in equation (3): $\Delta^6 \pi^e_{i,c,g,t} = \beta \Delta^6 e_{c,t} + \gamma \Delta^6 e_{c,t} \times \Delta^6 a_{c,g,t} + \alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \varepsilon_{i,c,g,t}$ for the US SCE. Columns 1–4 show estimates for state-level electricity prices. Column (1) has the baseline estimates, (2) uses the average $\pi^e_{c,g,t}$ as the dependent variable, (3) uses as measure of unanchoring the deviation of long-run expected inflation from target, and (4) includes time fixed effects. Columns (5) and (6) respectively use the national gas and oil price instead of regional electricity prices. Past inflation is computed using the state-level CPI from Hazell et al. (2022). We exclude all individuals part of state-demographic groups with less than 5 members in the month. In parentheses are standard errors clustered by month for the regressions using individual expectations.

tations. Its main virtue is that it covers a much longer sample, starting in 1978. However, it has many limitations. First, it splits the respondents into only four large US regions. Even though we can use the variation over socio-economic groups g as before, there is much less variability over regions c, constraining our empirical strategy to answer the first question. Second, the sample of individuals i is even smaller, covering 500 to 700 households per wave. Even over only 4 regions, disagreement is calculated over groups that half of the times have fewer than 50 respondents, and sometimes as few as 4. It is impossible to answer the second question with much precision. Third, the longer time-series span also means that any estimates rely more on time-series variation, so the concerns with omitted aggregate variables are stronger.

With all these caveats in mind, table A13 in the appendix D shows that a 1% rise in US electricity prices raises expected inflation by 2.41 to 3.33bp, significantly more than in the Euro area but also with wider confidence bands. The effects of the (poorly measured) unanchoring series are imprecise and unstable across specifications.

5 Results: energy shocks and expected inflation

This section presents estimates of the impact of energy supply shocks on expected inflation.

5.1 **Baseline regressions**

Table 3 shows the estimated impact on expected inflation of an energy price shock, by simply replacing energy prices $_{c,t}$ with energy shock z_c , t in regression equation (3). The numerical answers are not directly comparable to those in table 1, since one standard deviation does not match a 1% price increase. As each shock series is in different units, we standardize them, so that β and γ now measure the impact on expected inflation of a one-standard deviation energy shock and we can compare across shocks.²³

The first column still uses electricity prices per country and month. The only difference from the first column in table 1 is that the energy price series is now standardized. Insofar as these estimates were dominated by the unexpected supply shocks from the invasion of Ukraine, this estimate may still mostly reflect a supply shock. The other three columns though use the three shock series that arguably clean out demand effects better.

The first, in the second column, is the shift-share shock series with exogenous energy expenditure shares. The effect of a shock on expected inflation if there is no unanchoring is almost four times larger, while if there is unanchoring, the effect is almost twice larger. This is consistent with the use of exogenous shares dealing with the reverse causality that would be biasing the coefficients downwards in the first column. The third column uses exogenous time-series variation in oil prices. The impact of the energy shock remains large, but unanchoring no longer plays a role. Finally, the fourth column uses exogenous time-series variation in wind electricity. Both effects now go to zero.²⁴

5.2 Local projections

Figure 2 shows the dynamic effects from the local projections following each of the four energy shocks in one month. In black-bold are pooled estimates that leave out the anchor-

²³Since our approach to build instruments for supply shocks relies on the features of the EU electricity market, it cannot be applied to the US.

²⁴Anticipating the results in the next section, when we raise the horizon h to 12 months, then the impact of and oil-driven energy shock almost doubles to 0.595, and the effect of unanchoring becomes 0.120 and statistically significant.

Revision of expectation	(1)	(2)	(3)	(4)
Energy price shock	0.185***	0.613***	0.339***	0.044
	(0.060)	(0.061)	(0.102)	(0.100)
Energy price shock	0.244***	0.138***	-0.002	-0.042
× Unanchoring	(0.031)	(0.029)	(0.062)	(0.076)
Average past inflation	-0.025	0.081***	-0.079	-0.051*
	(0.025)	(0.021)	(0.086)	(0.027)
ECB deposit rate change	-0.352***	-0.423***	-0.103	-0.370**
	(0.117)	(0.061)	(0.228)	(0.142)
Observations R^2	362756	362756	305037	362224
	0.018	0.027	0.015	0.012

Table 3: The impact of energy shocks on expected inflation

Note: This table presents estimates of the regression equation $\Delta^h \pi^e_{i,c,g,t} = \beta \Delta^h z_{c,t} + \gamma \Delta^h z_{c,t} \times \Delta^h a_{c,g,t} + \alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \rho \Delta^h r_t + \varepsilon_{i,c,g,t}$ where the first four columns use different measures of $z_{c,t}$. The energy shocks are, in order: (1) the *h*-month change in HICP electricity prices by country, (2) the *h*-month change in EA-wide HICP electricity times country-specific electricity expenditure weights in 2019, (3) OPEC supply shocks to oil prices cumulated over *h* months times country-specific expenditure weights in 2019, and (4) the *h*-month change in wind-source electricity generation, all standardised to increase electricity prices. In parentheses are standard errors clustered by month.

ing interaction term, with their confidence bands in the appendix C. The other two series and their confidence bands show the estimates with below and above average unanchoring.

Across the first three specification, the impact builds up with time, reaching between 5bp and 45bp twelve months later. Wind is the exception, with smaller estimates that peak after 4 months. After 12 months (not shown), all the estimates quickly approach zero.

These results are consistent with theory. It suggests that the impact of slow learning and gradual attention is stronger than that of the depreciation of the informativeness of the shock.

Also consistent with theory is the impact of anchoring. For all the shocks with the exception of wind, more unanchored expectations lead to a larger impact of energy prices on expected inflation. Depending on the horizon considered, higher than average unanchoring can as much as double this impact. Moreover, the difference between anchored and unanchored becomes negligible once h is high, just as predicted by theory.



Figure 2: Impulse response of expected inflation to a shock in energy prices

(a) Country electricity prices (b) EA electricity prices with country shares

Note: Local projection of average expected inflation within a region and group on a 1-month energy price shock, controlling for past inflation, the policy rate, country and group fixed effects, pooled across states (thick black line), when unanchoring in the first 6 months is higher (red dashed line) or lower (blue solid line) than average for the country and demographic group. The shocks are scaled by their standard deviation to increase energy prices. The shock in panel (a) is the change in electricity price by country and time. The shock in panel (b) is the time-varying EA-wide electricity price change times the country-varying expenditure shares. The shock in panel (c) is time-varying oil OPEC supply shocks times the country-varying expenditure shares. The shock in panel (d) is to the country-time contribution of wind to the production of electricity. Standard errors are clustered by country.

6 The contribution of energy price to the 2021-23 changes in expected inflation

Armed with these estimates, we investigate how much did energy prices and unanchoring contribute to the sudden rise in expected inflation in 2021-22.

6.1 How much of the increase in expected inflation in 2021-22 was due to higher energy prices?

Between May 2021 (when inflation was on target) and one year later, expected inflation on average across all the households, groups and countries increased by 2.9 percentage points. Aggregating the fitted values from our baseline equation (3), which explains expected inflation using past inflation and energy prices, predicted expected inflation would have risen by a meagre 0.53 percentage points, as shown in figure 3.

Moreover, most of this increase is explained by the rise in past inflation. The R^2 of a partial regression isolating the contribution of energy prices alone to these predicted values is 0.39. It falls to 0.24 if we focus on the six major countries during the whole sample period, and this is already starting from only 0.53/2.9 explained. The predicted increase in expected inflation due to energy prices is negligible.²⁵

The conclusion is that energy prices are important for inflation expectations but, by themselves, they fall well short of explaining the movements in expected inflation during the inflation disaster.

6.2 How sensitive was expected inflation to electricity prices during 2021-23?

Figure 4 uses the estimates in table 1 to plot, at each date in time, the impact of a doubling of electricity prices over the following 6 months. That is, it plots a 3rd-order centered moving average of $(\beta + \gamma \Delta^6 a_t) \ln(2)$, where the time variation comes from the smoothed unanchoring, averaged across countries and groups.

The estimates show that EA expected inflation was significantly more sensitive to energy prices at the start of 2022 than it was at the start of the sample. The scar of the

²⁵For the US, energy prices also explain little of the variation in overall expected inflation, with our regression predicting less than one quarter of the observed increase between March of 2021 and 2022, and with partial R^{2} 's from energy prices ranging between 0.01 and 0.24.

Figure 3: The contribution of electricity prices to expectation revisions



Note: The figure plots the survey-weighted average of actual revisions of expected inflation and the corresponding prediction based on equation (3), over the following six months. The energy prediction series shows the counterfactual expectation revisions due to changes in energy prices and anchoring alone, so including only the β and γ terms.

Figure 4: The time-varying impact of electricity prices on expected inflation



Note: The figure plots the predicted effect on average expected inflation from doubling electricity prices over the following 6 months as a function of the extent of unanchoring over the same period, using the coefficients in the first column of table 1 in red and in the third column in green.

inflation disaster is noticeable. Reassuringly, the re-anchoring of inflation expectations that came with the tightening of monetary policy and the fall in inflation in 2023 have reduced the impact of energy prices today to their pre-disaster level.²⁶

7 Conclusion

Ever since the 1970s, when large oil price shocks came with a sharp and persistent rise in inflation, economists have been studying the connection between these two variables. An important, but still poorly understood, channel is through inflation expectations. An often-repeated fact is that household expectations of inflation and energy prices are strongly correlated.²⁷ Sometimes, this is used to assert that this channel is strong, and other times to dismiss expectations data through the same "see through principle" that justifies dismissing energy shocks. If energy prices matter for expected inflation, how much do they matter?

This paper answered this question following in the footsteps of a wave of research in empirical macroeconomics that has used cross-regional variation within a currency union to make progress on identification. We used the theory of expectations to show how crosssectional variation, with or without time-series variation, can identify the role of energy prices on expected inflation both through their informativeness and through household's inattention to them. Taking advantage of the recently-released household survey of expectations in the EA that has many more respondents identified by country and group, and of the large variability in energy prices across Europe in the 2020-23 period, we provided new estimates of the impact of energy prices on expectations. Further, we used the specific features of the electricity market in Europe and the cross-country variation they induce to build new exogenous shocks to energy prices.

We found that energy prices matter more and for longer for expected inflation than previous estimates. At the same time, they matter less than they likely would under rational expectations. Households are inattentive with respect to this piece of information, rather than excessively sensitive, and the average expectation therefore adjust sluggishly to shocks. We found that the impact of energy prices is larger when inflation expectations

²⁶As part of the energy cycle, anchoring and the sensitivity of expectations will fluctuate. Flynn and Sastry (2024) incorporate a model of attention similar to ours it in a business-cycle framework, and note that this will lead firms to under- and over-produce, depending on whether energy prices are high or low, creating wedges. Energy shocks will then generate endogenous attention wedges that will appear as markup shocks in a Phillips curve.

²⁷And yet, in the 1970s, US inflation expectations rose well before the oil price shocks (Reis, 2021).

are unanchored, providing empirical justification foe theories of price-level determinacy, and for the long-held belief of central bankers.

The energy shocks of 2021-23 explain a small share of the rise in expected inflation. Something else was afoot, perhaps loose monetary policy. Once policy tightened, inflation expectations re-anchored so that, by the end of 2023, the impact of energy price shocks dropped back to what it was at the start of the sample. This may have helped keep inflation expectations unchanged when there were significant shifts in the price of energy.

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Appendix

A Data: additional information

Our data on inflation expectations comes from the ECB, and was downloaded on 6 February 2024. It ends in December of 2023, and starts in April of 2020 for six countries— Belgium, France, Germany, Italy, the Netherlands, and Spain—and in April of 2022 for another five—Austria, Finland, Greece, Ireland, and Portugal. We censor the individual response if individual point forecasts for inflation exceed 20% in absolute value to ensure robustness to outliers.

Table A1 provides additional information per country-group, with the averages over time of: the number of respondents per group, expected inflation, disagreement, and the average 6-month change in expected inflation. This makes clear that there is significant variation in the cross-section, which our estimates rely on.

Figures A1, A2, A3, and A4 complement the table by showing plots of that variation per group for each of the 6 major countries over time for: average expected inflation, dispersion of expectations, anchoring measured by disagreement over time, and anchoring measured as distance from target.

Turning to energy, our data for energy prices from HICP suffers from revisions to the methods to calculate them in the Netherlands in June of 2023. We use their research series to have a consistent series throughout our sample. There was also a change in the methods used for the HICP in Spain from January of 2023 onwards, but there is no research series available.

We also use three alternative series for energy prices. They are: the HICP energy price index that includes all energy prices, not just electricity; wholesale electricity prices from the European Network of Transmission System Operators for Electricity (ENTSO-E) collected by Ember; and the household energy price index (HEPI) from https://www.energypriceindex.com, commissioned by VaasaETT and funded by Energie-Control Austria and the Hungarian Energy and Public Utility Regulatory Authority MEKH, copyright 2024 VaasaETT Ltd. Their respective correlations with our HIPC series are in table A2.

The electricity expenditure shares from the HICP s_c are in figure A5, while the exogenous oil price shocks are from Känzig (2021). The data on wind speeds, used to check the correlation with our wind electricity generation series, are sourced from Visual Crossing. We average the daily mean wind speed by EA country and month.

One might be worried that expenditure shares on electricity are correlated with other variables persistently related to inflation expectations. Figure A6 shows that during our sample there is no significant relation between expenditure shares and inflation expectations directly, either across the sample or by country and year. The correlation between average expectations and electricity expenditure shares over the sample is 0.10 and statistically insignificant.

Finally, figure A7 plots actual inflation during this period. This figure shows the importance of controlling for country fixed effects as well as for the level of inflation in the regression.

B Expectations with limited information and inattention

A household chooses expected inflation π^e with an objective function that depends on other relevant state variables including aggregate (\bar{e}) and local (e). That objective function is $\mathbb{E}[\bar{V}(\pi^e, \bar{e}, e, .)]$, where the missing attribute captures the random variables over which the expectation is taken. This objective is concave and differentiable. We omit all known constants and deterministic parts, since they play no useful role.

A fraction λ of agents form rational expectations. They are attentive, so they simply maximize this objective. Their optimal forecast is the solution $x(\bar{e}, e, .)$ to the equation $\mathbb{E}(\partial \bar{V}(\pi^e, \bar{e}, e, .)/\partial \pi^e)(x(\bar{e}, e, .)) = 0$. A linear approximation of this optimality condition (or quadratic approximation of the objective function) delivers: $x(\bar{e}, e, .) \approx \phi \bar{e} + \phi^c e$. The two weights come from the well-known least-squares regression formulae.

A fraction $1 - \lambda$ are inattentive. They have incomplete information, (potentially) observing only *e*. Their objective function is then to maximize: $V(\pi^e, e) \equiv \mathbb{E}_{\bar{e}} [\mathbb{E} [\bar{V}(\pi^e, \bar{e}, e, .)]]$ where they must take expectations over the unknown aggregate energy prices as well.

Moreover, these agents have limited information, which prevent them from observing e perfectly. Rather, each of them observes energy prices with a noise, which in turn makes her optimal choice noisy as well. As is standard in the literature on inattention, we model this as the agent choosing a stochastic decision rule $p(\pi^e|e)$, taking into account that in the map from energy prices to her expectation, there will be a noise created by her inattention. The agent faces the constraint that the function $p(\pi^e|e)$ is everywhere non-negative and it integrates to one over all the actions.

Her expected payoff is:

$$\mathbb{E}_{e}\left[\int \left(V(\pi^{e}, e) - \bar{\lambda}\log\left(p(\pi^{e}|e)\right)\right) p(\pi^{e}|e)d\pi^{e}\right].$$
(A1)

which takes expectations over the unknown *e*, as well as over the noise induced by the noisy signal (in the integral). The second term inside the integral is the cost of paying attention. It is written here in terms of the entropy of the decision rule, following Flynn and Sastry (2024)'s formulation. They modify the cost function from the classic Sims (2003) formulation to depend on the entropy of the decision function, as opposed to the mutual information between prior and posterior, and so eliminate the influence of the prior on the final solution. A crucial parameter is $\bar{\lambda}$: the marginal cost of an extra bit of attention.

If $\bar{\lambda} = 0$, then the imperfectly informed inattentive agent forms her expectation according to x(e), which is the solution to: $(\partial V(\pi^e, e)/\partial \pi^e)(x(e), e) = 0$. A linear approximation of this is $x(e) \approx \phi^a e$. It is well-known that, if *e* is Gaussian, then ϕ^a will just be the optimal gain from the Kalman filter.

Using the implicit function theorem:

$$x'(e) = -\frac{\left(\frac{\partial^2 V(\pi^e, e)}{\partial \pi^e \partial e}\right)(x(e), e)}{\left(\frac{\partial^2 V(\pi^e, e)}{\partial (\pi^e)^2}\right)(x(e), e)}$$
(A2)

It then follows that a quadratic approximation of the objective function around x(e) is:

$$V(\pi^{e}, e) \approx V(x(e), e) + 0.5 \left[(\partial^{2} V(\pi^{e}, e) / \partial(\pi^{e})^{2})(x(e), e) \right] (\pi^{e} - x(e))^{2}$$

$$\propto \left(\frac{v(e)}{x'(e)} \right) (\pi^{e} - x(e))^{2}$$
(A3)

where we define $v(e) = -(\partial^2 V(\pi^e, e)/\partial \pi^e \partial e)(x(e), e)$.

Letting *e* have a density f(e), the optimization problem has the Lagrangian:

$$\mathcal{L} = \int_{e} \int_{\pi}^{e} \left(\left(v(e) / x'(e) \right) \left(\pi^{e} - x(e) \right)^{2} - \bar{\lambda} \log \left(p(\pi^{e}|e) \right) + \kappa(\pi^{e}, e) \right) p(\pi^{e}|e) d\pi^{e} f(e) de + \int_{e} \gamma(e) \left(\int_{\pi}^{e} p(\pi^{e}|e) d\pi^{e} - 1 \right) f(e) de.$$
(A4)

The $\kappa(\pi^e, e)$ are the Lagrange multipliers for each choice and state so that their probability is non-negative. The $\gamma(e)$ are the Lagrange multipliers so that, at every state, the choice

probabilities integrate to 1.

The first-order condition for optimality is:

$$\left(v(e)/x'(e)\right)\left(\pi^e - x(e)\right)^2 + \kappa(\pi^e, e) + \gamma(e) = \lambda \log\left(p(\pi^e|e)\right) + \bar{\lambda}.$$
 (A5)

Integrating over π^e and using the constraint that $\int_{\pi}^{e} p(\pi^e|e)d\pi^e = 1$, this optimality condition becomes:

$$p(\pi^{e}|e) = \frac{\exp\left(\frac{(\pi^{e} - x(e))^{2}}{\left|\bar{\lambda}x'(e)/v(e)\right|}\right)}{\int_{\pi}^{e} \exp\left(\frac{(\pi^{e} - x(e))^{2}}{\left|\bar{\lambda}x'(e)/v(e)\right|}\right) d\pi^{e}}.$$
(A6)

From this it follows that π^e follows a normal distribution, with mean x(e) and with variance $|\bar{\lambda}x'(e)/v(e)|$.

In other words, the expectation of the inattentive agent is:

$$\pi^{e} = x(e) + \underbrace{\sqrt{\left|\frac{\bar{\lambda}x'(e)}{v(e)}\right|}}_{\equiv \lambda^{\varepsilon}(e)} \varepsilon, \tag{A7}$$

where ε has a standard normal distribution.

Intuitively, the larger is the cost of attention, $\bar{\lambda}$, the less attention she pays, and so the larger are the errors she makes $\lambda^{\varepsilon}(e)$. In the other direction, the larger is the impact of errors from inattention on her well-being, captured by a lower $\bar{x}'(e)/v(e)$, the more attention she will pay leading to a lower $\lambda^{\varepsilon}(e)$.

Now, going back to the linear solution for x(e), this delivers $\pi^e = \phi^a e + \lambda^{\varepsilon}(e)\varepsilon$ just as in the text. However, $\lambda^{\varepsilon}(e)$ depends on $\bar{x}'(e)/v(e)$, which depends on e. There is a relevant second-order term there, which leads to an interaction effect of attention with energy prices.

The standard deviation of expectations across agents who each make an idiosyncratic error is $\lambda^{\varepsilon}(e)$. In turn the interquartile range of a standard normal distribution is 1.34898. Therefore the interquartile range of π^{e} across the agents is:

$$a(e) = 1.34898 \sqrt{\left|\bar{\lambda}x'(e)/v(e)\right|} \quad \Rightarrow \quad x'(e) = \left(\frac{v(e)}{2\bar{\lambda}}\right) a(e)^2. \tag{A8}$$

More unanchoring is associated with a larger response of inflation expectations to energy prices. The intuition is that when expectations are very sensitive to shocks, then the mis-

takes in forming those expectations must not be so costly. Therefore, she is less attentive, and so there is more unanchoring.

But then, a linear approximation is $\lambda^{\varepsilon}(e) \approx \lambda^{\varepsilon} e_{c,t} a_{c,g,t}$, just as we wrote in the text.

C Alternative specifications

This appendix shows alternative specifications. They complement the baseline results, and inform what drives the variation, as explained in the text.

Table A3 replaces expected inflation with actual inflation in the baseline specification. The estimates are much larger, showing that there is inattention, as opposed to excess sensitivity.

Table A4 restricts the sample to a balanced panel of 6 countries, pools the individual observations via the median as opposed to the average, or weights the country-group averages by their respective number of respondents. The main inferences on β are relatively robust to these different specifications. At the same time, they highlight the importance of taking disagreement into account when investigating micro data on expected inflation.

Table A5 adds different interactions of fixed effects to the baseline regression with time fixed effects, using either country-group, country-time, or group-time fixed effects, each for individual and mean expectations. Results are similar to the version in column 6 of table 1 using only country, group and time effects separately, except for electricity prices without unanchoring when adding country-time fixed effects, since electricity prices only vary on this level.

Table A6 shows the regression equation estimated separately for each country. The estimates vary significantly across countries showing the importance of exploiting this cross-country variation.

Table A7 reproduces table 1 but using month fixed effects throughout. The estimates for β are of similar magnitude as the last column in table 1. The effect of unanchoring has wide confidence bands, as expected, since anchoring is imprecisely measured and there are only 11 countries with different energy prices, and 8 groups, on which the estimation is based on. The coefficient is significantly positive when using the distance from target as its measure. The difference from the baseline estimates may be because there were omitted time-series variables in this short sample that drove both electricity prices and expected inflation up, biasing estimates up. Or, it may instead show that our baseline estimates further capture the macro impact of the higher energy prices relative to these which leave it out because it is absorbed by the time fixed effects.

Table A8 compares the results across choices of the revision horizon h. The data is much more noisy so, as expected, with h = 1 the R^2 falls and the standard errors rise. At the same time, in size and sign, the estimates remain similar. With h = 12, as opposed to 6 months, on the one hand, some of the effect may reverse with the horizon, as the estimate is a little lower at 1.13bp. On the other hand, because now we consider a 12-month change in anchoring as well, the impact of this prolonged unanchoring is larger at 0.81bp.

Table A9 reproduces the first and second columns of table 1, but replaces the energy estimates with the three alternatives we discussed above. Interestingly, wholesale prices do not seem to be salient in the sense of moving expected inflation as much. The two measures of prices paid by consumers give similar results to our baseline case. In turn including squared energy prices as a separate control makes little difference.

Table A10 replaces energy prices with energy inflation.

Table A11 includes anchoring as a separate regressor.

Table A12 repeats table 1 but now lists three alternatives to account for estimation uncertainty: standard errors with Huber-White adjustment for heteroskedasticity, clustering per demographic group, and Driscoll-Kraay standard errors accounting for serial correlation. The errors rise, but the two key estimates of interest remain statistically significant at conventional significance levels.

Figure A8 shows the impact of exogenous shocks on expected inflation with error bands, omitting the anchoring dummy variable. In the first two rows, effects are, as expected, in between the ones in figure 2, and statistically significant. The figure also shows, in the bottom row, the impact of the oil shift-share, but now using the average expenditure shares between 2015-19, or the network cost of electricity paid by households in 2019. The effects are very similar.

D US estimates using the Michigan data

Table A13 shows the results of estimating equation (3) on the Michigan data for gas price changes. A 1% rise in gasoline prices raises expected inflation by 2.80–3.99bp, significantly more than in the Euro area, while the effects of the (poorly measured) unanchoring are not statistically distinguishable from zero. This last conclusion is not robust though, as slight changes in the specification (like the choice of h) lead to large changes on the coefficient on unanchoring. For instance, column two simply lags the unanchoring vari-

able, and its extra boost rises to a large and statistically significant coefficient of 0.49bp. Column three further confirms this by using the alternative measure of anchoring based on the distance from target. The coefficient on anchoring is now quite large, but very imprecise, while the impact of oil prices falls by one third to 2.80bp.

Column four replicates the specification of Coibion and Gorodnichenko (2015) with our longer sample and slightly different treatment of outliers in the data. Our estimate is close to theirs. This involve using oil as measure of energy prices. Columns five and six replicate the baseline regression using gas at the pump and oil prices.

Count	ry Group	Number of respondents	Inflation expectation	Dis- agreement	6-month t revision	Coun	try Group	Number of respondents	Inflation expectation	Dis- agreement	6-month revision
AT	1	210	5.66	4.90	-1.07	FR	1	273	2.98	4.45	-0.14
AT	2	143	5.12	4.47	-1.02	FR	2	154	2.83	3.88	0.08
AT	3	75	5.48	3.86	-0.93	FR	3	443	3.25	4.09	0.10
AT	4	79	5.50	2.95	-0.41	FR	4	489	3.30	3.67	0.06
AT	5	268	5.41	5.75	-1.37	FR	5	377	3.13	4 62	-0.09
AT	6	126	5.16	5.00	-1.62	FR	6	117	3.14	4.61	0.02
AT	7	85	5.52	5.69	-1.17	FR	7	540	3.51	4.62	0.07
AT	8	78	4.63	5.35	-0.97	FR	8	373	3.49	4.11	-0.18
BE	1	148	3.59	4.40	-0.03	IE	1	94	4.93	6.31	-1.93
BE	2	74	3.66	4.13	0.05	IE	2	38	4.02	5.94	-1.88
BE	3	131	3.69	3.95	0.03	IE	3	132	5.57	4.54	-1.15
BE	4	157	3.31	2.84	0.06	IE	4	120	5.34	4.80	-1.28
BE	5	182	4.11	5.24	-0.08	IE	5	163	5.36	8.03	-1.45
BE	6	59	4.17	3.89	-0.07	IE	6	49	4.62	6.30	-1.57
BE	7	159	4.00	4.20	0.21	IE	7	219	5.37	6.87	-1.30
BE	8	125	3.95	4.19	0.04	IE	8	171	5.51	5.88	-1.25
DE	1	419	3.44	4.10	0.15	IT	1	488	4.17	5.72	0.03
DE	2	199	2.81	3.63	0.04	IT	2	240	4.23	4.92	0.01
DE	3	348	3.18	4.04	0.31	IT	3	308	3.94	5.26	0.19
DE	4	421	3.16	3.72	0.16	IT	4	324	4.01	4.35	0.07
DE	5	495	3.46	4.52	0.06	IT	5	636	4.57	6.73	-0.04
DE	6	201	3.10	4.01	0.22	IT	6	195	4.87	6.50	0.05
DE	7	306	3.09	3.97	0.22	IT	7	392	4.16	5.33	-0.03
DE	8	266	3.18	3.99	0.11	IT	8	268	4.38	5.26	-0.13
GR	1	137	6.32	10.00	-0.24	NL	1	161	3.63	3.43	-0.03
GR	2	42	7.03	8.83	0.17	NL	2	80	3.84	2.81	0.03
GR	3	163	8.27	11.28	0.07	NL	3	88	3.44	2.82	-0.08
GR	4	170	6.41	9.72	-0.05	NL	4	147	3.58	2.22	0.22
GR	5	148	7.14	10.09	-0.44	NL	5	230	3.99	3.98	-0.03
GR	6	45	6.53	8.49	0.06	NL	6	75	3.84	3.20	0.04
GR	7	204	6.88	9.76	-0.23	NL	7	113	3.55	3.72	0.01
GR	8	124	6.89	9.48	-0.14	NL	8	103	3.76	3.30	-0.01
ES	1	372	3.55	5.23	0.17	PT	1	188	5.22	7.04	-1.01
ES	2	168	3.07	4.28	0.35	PT	2	80	5.45	6.22	-1.26
ES	3	340	3.40	4.34	0.09	PT	3	117	5.04	5.50	-0.79
ES	4	487	3.51	3.40	0.17	PT	4	159	4.74	4.59	-1.27
ES	5	435	3.71	5.90	0.34	PT	5	169	4.92	7.66	-1.36
ES	6	115	4.00	5.71	0.12	PT	6	46	6.00	6.06	-1.19
ES	7	466	3.69	5.52	0.11	PT	7	205	5.24	6.81	-1.02
ES	8	364	3.69	4.69	0.18	PT	8	151	5.49	5.63	-0.88
FI	1	189	4.78	4.92	-1.31						
FI	2	81	4.08	4.53	-1.19						
FI	3	111	4.72	4.80	-1.24						
FI	4	133	4.48	3.77	-1.21						
FI	5	187	4.79	5.44	-1.39						
FI	6	84	5.01	4.76	-1.34						
FI	7	177	5.52	4.78	-1.59						
FI	8	119	4.56	4.33	-1.33						

Table A1: Descriptive statistics by country and group

Note: The table shows average values by country and demographic group across survey waves. Groups are split by: Male (1,2,3,4) or female (5,6,7,8); college education (3,4,7,8) or below (1,2,5,6); and income bracket above 60th percentile (2,4,6,8) or below (1,3,5,7).

	HICP electricity	HICP energy	Wholesale electricity price	HEPI index
HICP electricity	1.00			
HICP energy	0.60***	1.00		
Wholesale electricity price	0.37***	0.63***	1.00	
HEPI index	0.59***	0.78***	0.54^{***}	1.00

Table A2: Correlation of energy price measures

Note: This table shows estimated correlations between the four different energy price measures used for the EA, calculated in a pooled cross-country panel.

	A	ctual inflatio	on	Expected inflation		
	(1)	(2)	(3)	(4)	(5)	(6)
Change in electricity prices	10.000*** (0.641)	10.164*** (0.639)	6.524*** (0.506)	1.523*** (0.228)	1.602*** (0.226)	1.238*** (0.221)
Change in electricity prices \times Unanchoring		2.046** (0.835)	1.037* (0.597)		0.986*** (0.295)	0.797*** (0.261)
Average past inflation			-0.629*** (0.044)			-0.018 (0.019)
ECB deposit rate change			0.100 (0.148)			-0.457*** (0.065)
Observations R^2	309 0.514	309 0.523	309 0.760	309 0.319	309 0.344	309 0.495

Table A3: Results for changes in actual and expected inflation

Note: This table shows estimates of equation (3) with variation only across countries and time, to compare estimates for changes in actual inflation, $\Delta^6 \pi_{c,t}$, to those for changes in inflation expectations, $\Delta^6 \pi_{c,t}^e$ as dependent variable. All regressions include country fixed effects.



Figure A1: Variation in expected inflation by major EA country

Note: The figure plots the average expected inflation 12-months ahead by country and by demographic group. Groups are defined as follows: male (1,2,3,4) or female (5,6,7,8); college education (3,4,7,8) or below (1,2,5,6); and income bracket above 60th percentile (2,4,6,8) or below (1,3,5,7).



Figure A2: Variation in expectations (1-year SD) by major EA country

Note: The figure plots the standard deviation of expected inflation one year ahead within country and demographic group. Groups are defined as follows: male (1,2,3,4) or female (5,6,7,8); college education (3,4,7,8) or below (1,2,5,6); and income bracket above 60th percentile (2,4,6,8) or below (1,3,5,7).



Figure A3: Variation in anchoring (3-year IQR) by major EA country

Note: The figure plots the average inter-quartile range of expected inflation three years ahead within country and demographic group. Groups are defined as follows: male (1,2,3,4) or female (5,6,7,8); college education (3,4,7,8) or below (1,2,5,6); and income bracket above 60th percentile (2,4,6,8) or below (1,3,5,7).



Figure A4: Variation in anchoring (distance to target) by major EA country

Note: The figure plots the average absolute distance from the inflation target of expected inflation three years ahead within country and demographic group. Groups are defined as follows: male (1,2,3,4) or female (5,6,7,8); college education (3,4,7,8) or below (1,2,5,6); and income bracket above 60th percentile (2,4,6,8) or below (1,3,5,7).



Figure A5: Electricity expenditure shares by country

Note: The figure plots the weight of HICP electricity in the HICP by country and year during the presample.



Figure A6: Electricity expenditure shares and average expectations

Note: The figure plots the weight of HICP electricity in the HICP and average inflation expectations by country over the sample. Panel a) plots sample averages by country, while panel b) plots annual averages by country.





Note: The figure plots HICP 12-month inflation for the EA as a whole and for the 11 countries in our sample.

	Balanced panel	Weighted mean	Mee	dian
	(1)	(2)	(3)	(4)
Change in electricity prices	1.402*** (0.305)	1.127*** (0.097)	0.733*** (0.118)	0.705*** (0.118)
Change in electricity prices \times Unanchoring (Disagreement)	0.643*** (0.171)	0.409*** (0.063)	0.226*** (0.069)	
Change in electricity prices \times Unanchoring (Target distance)				0.899*** (0.175)
Average past inflation	0.009 (0.030)	0.004 (0.009)	-0.106*** (0.010)	-0.108*** (0.010)
ECB deposit rate change	-0.444*** (0.126)	-0.444*** (0.030)	-0.283*** (0.035)	-0.286*** (0.035)
Observations R^2	322987 0.014	2472 0.287	2472 0.288	2472 0.292

Table A4:	Alternative	panel c	composition	and	weighting
		P			···

Note: This table shows estimates of equation (3) using alternative panel composition or aggregation. In column (1) we estimate the baseline regression but restrict the sample to a balanced panel of 6 countries. Column (2) weights the country-group averages by their respective number of respondents. Columns (3) and (4) show results for median instead of mean expectations for the baseline with each anchoring measure.

	(1)	(2)	(3)	(4)	(5)
Change in electricity prices	0.372** (0.181)	0.386** (0.182)	0.193** (0.094)	0.327* (0.173)	0.368** (0.182)
Change in electricity prices \times Unanchoring	0.146 (0.089)	0.140 (0.093)	-0.013 (0.050)	0.758*** (0.260)	0.145 (0.087)
Average past inflation	0.004 (0.079)	0.002 (0.079)	-0.049** (0.023)	-0.007 (0.080)	0.004 (0.078)
Observations R^2	362756 0.032	362756 0.034	2472 0.573	362756 0.032	362756 0.032
Country & group fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Group-month fixed effects	No	Yes	No	No	No
Country-group fixed effects	No	No	No	No	Yes

Table A5:	Baseline	results	with	different	fixed	effects
	Dubenne	rebuild	AATCEL	amercin	IIACU	circub

Note: This table shows estimates of equation (3) adding different time fixed effects and further fixed effect combinations. Column (1) includes time fixed effects, column (2) adds group-time fixed effects, and column (3) shows results for average expectations within country-group with time fixed effects. Columns (4) repeat column (1) but uses the average absolute distance from target as anchoring measure. Column (5) adds country-group fixed effects to the specification in column (1).

	AT	BE	DE	ES	FI	FR	GR	IE	IT	NL	PT
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Change in electricity prices	0.204	2.410***	2.596*	0.896	1.391	5.457	-0.951	-0.886	2.570***	0.307	1.133
	(1.111)	(0.452)	(1.415)	(0.709)	(1.199)	(5.389)	(4.271)	(3.172)	(0.372)	(0.787)	(1.582)
Change in electricity prices \times Unanchoring	-0.176	0.483**	4.302***	0.511*	-0.385	11.650***	0.113	-0.195	0.238*	-0.292	-0.406
	(0.309)	(0.218)	(1.011)	(0.253)	(0.332)	(1.009)	(0.202)	(0.195)	(0.124)	(0.222)	(0.363)
Average past inflation	-0.340**	-0.036	0.046	0.115**	-0.337**	-0.342***	-0.120	-0.589*	0.214***	-0.253***	-0.207
	(0.124)	(0.055)	(0.042)	(0.048)	(0.127)	(0.106)	(0.291)	(0.326)	(0.060)	(0.059)	(0.127)
ECB deposit rate change	-1.341***	-0.204	-0.546**	-0.685**	-1.420***	0.573***	-1.059*	-1.686***	-1.175***	-0.379*	-1.066
	(0.440)	(0.196)	(0.203)	(0.313)	(0.229)	(0.136)	(0.578)	(0.382)	(0.177)	(0.212)	(0.802)
Observations R^2	9473	25618	68611	66437	10034	71166	4738	6614	66480	24675	8910
	0.016	0.040	0.022	0.011	0.019	0.028	0.010	0.026	0.032	0.052	0.018

Table A6: Baseline results by country

Note: This table shows estimates of equation (3) separately by country.

	(1)	(2)	(3)	(4)	(5)
Change in electricity prices	0.372**	0.193**	0.327*	0.395**	0.368**
	(0.181)	(0.094)	(0.173)	(0.185)	(0.182)
Change in electricity prices \times Unanchoring	0.146	-0.013	0.758***	-0.056	0.145
	(0.089)	(0.050)	(0.260)	(0.191)	(0.087)
Average past inflation	0.004	-0.049**	-0.007	0.007	0.004
	(0.079)	(0.023)	(0.080)	(0.079)	(0.078)
Observations R^2	362756	2472	362756	362756	362756
	0.032	0.573	0.032	0.032	0.032
Country & group fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Country-group fixed effects	No	No	No	No	Yes

Table A7: Baseline results with month fixed effects

Note: This table re-estimates table 1 of the regression in equation (3), adding month fixed effects in every specification. Column (1) has the baseline estimates, (2) uses the average $\pi_{c,g,t}^e$ as the dependent variable, (3) uses as measure of unanchoring the deviation of long-run expected inflation from target, (4) uses anchoring at the country level only $a_{c,t}$, (5) includes country-group fixed effects. In parentheses are standard errors clustered by month for the regressions using individual expectations.

	1-month changes		4-month changes		12-month changes	
	(1)	(2)	(3)	(4)	(5)	(6)
Change in electricity prices	0.963**	0.602***	1.298***	1.100***	1.133***	0.879***
	(0.407)	(0.175)	(0.279)	(0.112)	(0.216)	(0.110)
Change in electricity prices \times Unanchoring	0.255	-0.169	0.544***	0.318***	0.810***	0.446***
	(0.454)	(0.126)	(0.148)	(0.069)	(0.137)	(0.051)
Average past inflation	-0.013	-0.018***	-0.005	-0.032***	-0.063	-0.016
	(0.012)	(0.005)	(0.028)	(0.007)	(0.049)	(0.022)
ECB deposit rate change	0.001	0.002	-0.241*	-0.216***	-0.665***	-0.918***
	(0.052)	(0.017)	(0.127)	(0.025)	(0.128)	(0.054)
Observations R^2	518748	2912	414988	2648	237269	1944
	0.001	0.022	0.007	0.197	0.043	0.625

Table A8: Results for h-month changes in all variables

Note: Columns (1), (3) and (5) show results for individual expectations, $\Delta^h \pi^e_{i,c,g,t}$, while columns (2), (4) and (6) show results for average expectations within country and group, $\Delta^h \pi^e_{c,g,t}$.

	HICP energy		Wholesale prices		HEPI index		HICP electricity squared	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Change in energy prices	4.243***	3.555***	0.138	0.375***	2.130***	1.758***	1.344***	1.144***
	(0.500)	(0.151)	(0.252)	(0.051)	(0.264)	(0.085)	(0.260)	(0.103)
Change in energy prices \times Unanchoring	1.252***	0.636***	0.220*	0.100***	0.305**	0.169***	0.540***	0.165***
	(0.221)	(0.086)	(0.121)	(0.024)	(0.150)	(0.050)	(0.154)	(0.061)
Change in electricity prices, squared							1.156 (0.801)	0.853*** (0.283)
Average past inflation	0.016	-0.006	-0.060	-0.081***	0.019	-0.021**	0.006	-0.023**
	(0.023)	(0.008)	(0.038)	(0.012)	(0.030)	(0.010)	(0.028)	(0.009)
ECB deposit rate change	-0.206**	-0.181***	-0.270	-0.131***	-0.356***	-0.277***	-0.481***	-0.491***
	(0.081)	(0.029)	(0.237)	(0.042)	(0.104)	(0.032)	(0.137)	(0.033)
Observations R^2	362756	2472	330729	2112	344597	2296	362756	2472
	0.024	0.446	0.013	0.334	0.021	0.438	0.016	0.345

Table A9: Alternative measures of energy prices

Note: This table re-estimates the first two columns of table 1 using alternative measures of energy prices. The first two columns replace the HICP electricity index, with the HICP energy index, the next two with the wholesale electricity price index, and columns (5) and (6) with the household energy price index. The last two columns show results for the HICP electricity index, adding the squared log change.

	(1)	(2)	(3)	(4)	(5)	(6)
Change in electricity inflation	0.200**	0.125***	0.197***	0.209**	0.198**	-0.066
	(0.077)	(0.022)	(0.072)	(0.079)	(0.077)	(0.041)
Change in electricity inflation × Unanchoring	0.048	0.029**	0.226**	0.023	0.051	0.005
	(0.043)	(0.015)	(0.110)	(0.118)	(0.046)	(0.023)
Average past inflation	-0.020	-0.074***	-0.027	-0.017	-0.018	-0.185
	(0.048)	(0.016)	(0.048)	(0.050)	(0.048)	(0.149)
ECB deposit rate change	-0.431**	-0.416***	-0.406**	-0.445***	-0.435***	3.774**
	(0.159)	(0.044)	(0.158)	(0.162)	(0.160)	(1.524)
Observations	241379	1408	241379	241379	241379	241379
R^2	0.020	0.459	0.020	0.020	0.020	0.039
Country & group fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Month fixed effects	No	No	No	No	No	Yes
Country-group fixed effects	No	No	No	No	Yes	No

Table A10: Results for electricity inflation rate change

Note: This table shows estimates of equation (3), replacing the change in electricity prices with the change in the year-on-year inflation rate in electricity prices, $\Delta^6 \pi^e_{c,t}$

	(1)	(2)	(3)
Change in electricity prices	1.548*** (0.358)	1.327*** (0.242)	1.002*** (0.185)
Unanchoring (Disagreement)		0.354*** (0.035)	
Change in electricity prices \times Unanchoring (Disagreement)		0.290** (0.117)	
Unanchoring (Target distance)			1.016*** (0.067)
Change in electricity prices \times Unanchoring (Target distance)			0.917*** (0.331)
Average past inflation	0.007 (0.029)	0.015 (0.023)	0.040** (0.019)
ECB deposit rate change	-0.458*** (0.122)	-0.406*** (0.097)	-0.502*** (0.079)
Observations R^2	362756 0.015	362756 0.023	362756 0.028

Table A11: Alternative specification of anchoring

Note: This table shows estimates of equation (3) using alternative specifications of anchoring. Column (1) excludes anchoring, while (2) and (3) include the respective anchoring measures as a separate regressor in addition to the interaction term.

	Huber-White	Group clustering	Two-way clustering	Driscoll-Kraay	
	(1)	(2)	(3)	(4)	
Change in electricity prices	1.404***	1.404***	1.404**	1.404***	
	(0.064)	(0.124)	(0.488)	(0.453)	
Change in electricity prices \times Unanchoring	0.596***	0.596***	0.596**	0.596**	
	(0.046)	(0.166)	(0.267)	(0.240)	
Average past inflation	0.004	0.004	0.004	0.004	
	(0.006)	(0.017)	(0.076)	(0.045)	
ECB deposit rate change	-0.436***	-0.436***	-0.436	-0.436**	
	(0.019)	(0.045)	(0.272)	(0.190)	
Observations R^2	362756	362756	362756	362756	
	0.016	0.016	0.016	0.016	

Table A12: Results with different types of standard errors

Note: This table re-estimates the first column of table 1 using different types of approaches to calculate the standard errors. Two-way clustering is applied by month and country.



Figure A8: Impulse response of expected inflation to a shock to energy prices

(a) Country electricity prices

(b) EA electricity prices with country shares

Note: Local projection of average expected inflation within a region and group on 3-month cumulated energy price shock, controlling for inflation, country and group fixed effects. The shocks are scaled by their standard deviation and the standard errors are clustered by country. Panels (a) to (d) show the confidence bands corresponding to the pooled estimates in figure 2. Panels (e) and (f) investigate the robustness of the oil series by using alternative variables to measure the shares.

	(1)	(2)	(3)	(4)	(5)	(6)
Change in energy prices	3.075*** (0.712)	3.331*** (0.141)	2.409*** (0.722)	1.980*** (0.231)	4.210*** (0.325)	2.297*** (0.274)
Change in energy prices \times Unanchoring	0.209 (0.210)	0.114** (0.044)	1.589** (0.754)		0.077 (0.092)	0.078 (0.065)
Average past inflation	0.036 (0.036)	0.124*** (0.007)	0.109*** (0.033)		-0.067*** (0.024)	-0.060** (0.024)
Change in FFR	-0.126 (0.107)	-0.047*** (0.013)	-0.580*** (0.095)		-0.126** (0.049)	-0.077 (0.049)
Observations R^2 Country & group fixed effects Month fixed effects	44650 0.003 Yes No	8380 0.116 Yes No	24597 0.011 Yes No	89144 0.011 No No	59205 0.024 Yes No	65129 0.017 Yes No

Table A13: The impact of energy prices on expected inflation in the US Michigan survey

Note: This table presents estimates of the regression in equation (3): $\Delta^6 \pi^e_{i,c,g,t} = \beta \Delta^6 e_{c,t} + \gamma \Delta^6 e_{c,t} \times \Delta^6 a_{c,g,t} + \alpha_c + \eta_g + \theta \bar{\pi}_{c,t-6} + \rho \Delta^6 r_t + \varepsilon_{i,c,g,t}$ for the US. Columns 1–4 show estimates for regional electricity prices. Column (1) has the baseline estimates, (2) uses the average $\pi^e_{c,g,t}$ as the dependent variable, and (3) uses as measure of unanchoring the deviation of long-run expected inflation from target. Column (4) replicates the result of Coibion and Gorodnichenko (2015) with wholesale oil prices for our updated sample and censoring procedure: $\Delta^6 \pi^e_{i,t} = \beta \Delta^6 e_t + \alpha + \varepsilon_{i,t}$. Columns (5) and (6) respectively use the national gas and oil price instead of regional electricity prices in our baseline specification. Regional electricity prices are constructed as within-region unweighted averages of state-level prices. Past inflation is computed using the regional CPI from the BLS, which coincides with the MSC regions used except for the inclusion of Guam, Puerto Rico, and the US Virgin Islands. In parentheses are standard errors clustered by month for the regressions using individual expectations.