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Do Abnormal Weather Shocks Create an Inflationary Effect?

Evidence from GCC Countries

Oguzhan Cepni
Abdulla Budebes
Khalifa Alhosani

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Do Abnormal Weather Shocks Create an Inflationary Effect? Evidence from GCC Countries[‡]

Oguzhan Cepni[*†] Abdulla Budebes[*] Khalifa Alhosani[*]

Abstract

This paper examines how abnormal weather shocks affect inflation dynamics in the Gulf Cooperation Council (GCC) countries. We construct a comprehensive monthly indicator of abnormal weather conditions, capturing unexpected fluctuations in temperature, precipitation, and wind speed, and estimate their effects on headline inflation and its key sub-components using a panel local projections framework. The results indicate that local weather shocks have no statistically significant contemporaneous effect on headline inflation, but are associated with delayed food-price effects over the medium term. These effects are concentrated in extreme and clustered weather realizations rather than isolated one-off anomalies. Weather shocks in major supplier countries exert larger and more persistent effects on GCC food inflation than domestic weather shocks, with both the direction and the volatility of external weather conditions constituting distinct transmission channels. We further document important asymmetries: food inflation responds mainly to adverse external climate shocks, while benign realizations have little effect, and, contrary to the heat-driven mechanism emphasized in the literature, unseasonably cool local temperatures are more inflationary in the GCC than unseasonably hot ones. These findings are consistent with ongoing policy efforts across GCC economies to diversify food import sources, strengthen supply-chain resilience, and enhance preparedness for climate-related external shocks.

Keywords: Climate risk, Inflation, Trade linkages, Weather anomalies, Local projections.

JEL Codes: C23, E31, F14, Q54

[*]Central Bank of the United Arab Emirates

[†]Corresponding author. Email: oguzhan.cepni@cbuae.gov.ae

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1 Introduction

In recent years, the intensification of climate risks has become a critical global concern, with extreme weather events occurring with increasing frequency and severity (AghaKouchak et al., 2020). These climate anomalies, ranging from heatwaves and heavy precipitation to powerful windstorms, pose significant challenges to economic stability worldwide. Understanding the multifaceted implications of these shocks is crucial for policymakers, businesses, and individuals alike, as it can inform proactive strategies for mitigation and adaptation. The economic ramifications are particularly pronounced in inflation rates, as unpredictable weather patterns disrupt agricultural production, supply chains, and market dynamics. Furthermore, the global interconnectedness of economies amplifies these effects, as disruptions in one region can have ripple effects across global supply chains, influencing prices and inflation rates in distant markets. Understanding the relationship between climate risks and inflation is thus essential for effective policy-making.

In this paper, we focus on the Gulf Cooperation Council (GCC) countries. While these economies are widely recognized for their resilience and their strategic role in global energy markets, they are also experiencing the impacts of climate variability. Their distinctive economic structures and climatic conditions therefore make the GCC countries a particularly informative setting for examining how abnormal weather patterns affect inflation dynamics. To this end, we first construct a comprehensive measure of abnormal weather shocks, isolating unpredictable fluctuations in temperature, precipitation, and wind speed from seasonal and predictable patterns. We then relate this measure to inflation and its sub-components (food, housing, hospitality, transport, clothing) within the GCC countries using a panel local projections framework, which allows us to assess both the immediate and medium-term impacts of such shocks on price levels[1].

Given the GCC's heavy reliance on imported food products, we also construct a global climate risk measure weighted by import partner shares[2]. This enables us to investigate how food prices within the GCC react to weather shocks occurring in major food-

[1] These estimates should be interpreted as reduced-form evidence on the dynamic pass-through of abnormal weather shocks to observed inflation outcomes, and thus as reflecting a partial-equilibrium perspective. While some indirect effects may be embedded in the data to the extent that they materialize within the estimation horizon, our framework is not a structural stock-flow or general-equilibrium model and therefore does not separately identify the full set of climate-sensitive mechanisms, such as wage adjustment, fiscal responses, sectoral reallocation, energy demand effects, or external-balance feedbacks, that may also influence headline inflation.

[2] Given the GCC's structurally open food markets and reliance on diversified international supply chains, we also construct a global climate-risk measure weighted by food-import partner shares. Regional estimates suggest that GCC countries import a large share of food consumption, although exposures vary across countries and product categories. https://www.strategyand.pwc.com/m1/en/articles/2020/how-gcc-countries-can-ensure-their-food-security.html

exporting regions, capturing the transmission of external climate risks through trade linkages. Moreover, we show that not only the direction but also the volatility of weather conditions in supplier countries matters: heightened weather unpredictability in food-exporting regions generates short-to-medium-term food inflationary pressures in the GCC, underscoring the role of supply uncertainty as a distinct transmission channel.

Motivated by growing evidence that the macroeconomic effects of weather shocks can be nonlinear and asymmetric (Kim et al., 2022; Beirne et al., 2024; Ciccarelli et al., 2024; Liao et al., 2024), we also examine whether the inflationary consequences of climate risk depend on the sign of the shock. Specifically, we decompose global climate risk into adverse and benign components and show that food inflation in the GCC responds primarily to adverse external shocks, whereas below-normal realizations have little effect. In addition, we document a GCC-specific asymmetry in temperature anomalies: unlike much of the literature that emphasizes heat-driven food inflation (Parker, 2018; Mukherjee and Ouattara, 2021), unseasonably cool local temperatures are more inflationary in the GCC, consistent with the region's adaptation to high baseline heat and the role of seasonal demand conditions.

The economic ramifications of natural disasters have been extensively explored in recent literature, highlighting the significant, often detrimental effects of natural hazards like floods, droughts, and windstorms on sustainable economic growth. Studies such as those by Noy (2009), Strobl (2011), and Fomby et al. (2013) show that these events generally depress economic activity in the short term, particularly in developing economies. The impact of these natural disasters is traditionally perceived as a supply shock, impeding economic activity and escalating prices. However, recent studies into asymmetric economic disruptions, as discussed by Batten (2018) and Ciccarelli and Marotta (2024), suggest that these events might also trigger what is termed a 'Keynesian supply shock', affecting demand across various sectors and exerting downward pressure on both activity and prices.

While the influence of natural disasters on economic output is well-established, the effect on inflation has received less attention. Parker (2018) analyze the inflationary effects of natural hazards across 212 economies and find that while natural disasters tend to have a more pronounced inflationary impact in developing economies, their effect in advanced economies is more limited and often temporary. Mukherjee and Ouattara (2021) show that temperature shocks lead to inflationary pressures, often persistent, through a panel VAR analysis. This contrasts with Faccia et al. (2021), who provide further insights by studying how extreme temperatures affect inflation. They find that hot summers increase food prices in the short term but have an insignificant or even negative impact on various price indices over the medium term, highlighting the complex and sometimes contradictory nature of climate impacts on inflation. Kim et al. (2022) utilize a smooth transition VAR to investigate the macroeconomic impacts of extreme weather in the United States, finding that while extreme weather generally influences inflation, the effects of extreme temperatures alone are less significant.

The broader literature on climate change and its economic impacts indicates that temperature increases can significantly affect labor productivity and output, particularly in heat-exposed sectors (Acevedo et al., 2020). Studies such as those by Dell et al. (2012) and Colacito et al. (2019) demonstrate that higher temperatures can depress economic growth rates and reduce productivity, with varying impacts across different regions and sectors. As Faccia et al. (2021) and Kim et al. (2022) suggest, these effects are not uniform and can lead to different inflationary or deflationary outcomes depending on the specific economic context and the nature of the temperature shocks. Overall, the literature emphasizes the importance of considering both short-term and long-term impacts of natural disasters and temperature changes on economic activity and inflation, highlighting the complex interaction between climate change and macroeconomic outcomes.

Our paper contributes to the growing literature on climate risk and inflation in several ways. First, we construct a comprehensive monthly measure of abnormal weather shocks and estimate their dynamic effects on headline and disaggregated CPI in the GCC using a panel local projections framework (Jordà, 2005). Our findings show that while local weather shocks have limited contemporaneous effects, they generate delayed and persistent inflationary pressures at the headline level, with the most pass-through operating through food prices (and, at longer horizons, clothing), whereas other components exhibit weaker and often statistically insignificant responses. Importantly, these effects exhibit strong nonlinear properties: the inflationary pass-through is concentrated in extreme weather realizations (above the 75th percentile of the climate risk distribution), and is driven almost entirely by clustered multi-month episodes of extreme weather rather than isolated one-off anomalies. This distinction has direct policy relevance, as it implies that sustained spells of abnormal weather, which climate projections suggest will become more frequent, pose a qualitatively different inflation risk than transient weather events. Second, we go beyond domestic climate effects by examining international trade linkages in the transmission of weather shocks. In contrast to earlier studies that consider only local climate impacts, we introduce a trade-weighted global climate risk measure to capture weather anomalies in key food-exporting partner countries. Our results show that external weather shocks in supplier regions have a far stronger and more persistent influence on GCC food inflation than local weather does. We further show that the volatility of weather conditions in supplier countries, not only their direction, constitutes a distinct source of imported food inflation risk, as heightened weather unpredictability in exporting regions raises supply uncertainty and generates precautionary price pressures that transmit to GCC food prices within a few months. This contribution fills a gap in the literature by highlighting the cross-border propagation of climate shocks through supply chains, and it emphasizes the policy need for diversifying import sources and strengthening food security against global climate risks[3]. Third, we document important asymmetric behavior: food inflation responds asymmetrically to adverse versus benign external climate-risk realizations, and temperature anomalies display a GCC-specific asymmetry in which unusually cool spells are more inflationary than additional heat, a pattern that differs from the standard heat-driven food inflation mechanism emphasized in much of the existing evidence (Parker, 2018; Mukherjee and Ouattara, 2021; Faccia et al., 2021) and is consistent with the broader view that weather shocks can have state-dependent macroeconomic effects (Kim et al., 2022; Ciccarelli et al., 2024).

The paper is organized as follows. In Section 2, we provide a detailed description of the data sources and variables used in our analysis. Section 3 outlines the methodology employed to assess the impact of abnormal weather shocks on inflation in the GCC countries. Section 4 presents the empirical findings of our analysis, including an examination of nonlinear effects and the role of clustered weather extremes. Section 5 extends the analysis by examining the transmission of external weather shocks through trade linkages and exploring asymmetric effects of global climate risk and temperature anomalies. Section 6 concludes.

2 Data

2.1 Weather Variables and the Construction of Climate Risk Measure

We utilize comprehensive weather data obtained from the National Oceanic and Atmospheric Administration (NOAA). The dataset covers the GCC countries: Saudi Arabia, United Arab Emirates (UAE), Qatar, Kuwait, Oman, and Bahrain. The meteorological data includes measurements of temperature, precipitation, and wind speed. Tempera-

[3]Crucially, the transmission of external climate risks is also relevant for monetary and financial stability analysis, particularly in highly open, trade-integrated economies where imported goods account for a large share of the consumption basket. Because such shocks can raise imported inflation, they are a useful input when assessing the effective monetary stance alongside domestic cyclical conditions and external factors such as the real effective exchange rate. Consistent with NGFS (2024), which documents that the physical impacts of climate change can affect inflation dynamics, this reinforces the value of monitoring climate-related price pressures as part of a comprehensive assessment of macroeconomic conditions.

ture is recorded as the daily average between 7 AM and 7 PM local time, expressed in Fahrenheit. Precipitation data captures the total daily accumulation of rain, snow, sleet, or hail. Wind speed is represented as the average daily speed in knots, excluding gusts.

To analyze the impact of weather on inflation, following Choi et al. (2020), we decompose weather-related variables into three components: a predictable (long-run mean), a seasonal (calendar-month) component, and an abnormal (unexpected) component. This decomposition allows us to isolate abnormal weather fluctuations, which are hypothesized to have the most significant impact on inflation.

For each country i and month t, each realized weather variable W_{it} is decomposed as

$$W_{it} = W_{it}^{M} + W_{it}^{D} + W_{it}^{A}, \tag{1}$$

where W_{it} denotes a weather variable, namely temperature ($Temp_{it}$), precipitation ($Precip_{it}$), or wind speed ($Wind_{it}$). Let $m(t) \in \{1,\ldots,12\}$ denote the calendar month corresponding to period t.

The predictable component W_{it}^{M} is defined as the trailing 10-year (120-month) average based on months prior to t,

$$W_{it}^{M} = \frac{1}{120}\sum_{s=1}^{120} W_{i,t-s}. \tag{2}$$

Next, we define the average weather condition for the same calendar month over the previous 10 years as

$$\bar{W}_{i,m(t)} = \frac{1}{10}\sum_{k=1}^{10} W_{i,t-12k}. \tag{3}$$

The seasonal component is then given by

$$W_{it}^{D} = \bar{W}_{i,m(t)} - W_{it}^{M}, \tag{4}$$

which captures systematic differences between calendar months and the long-run mean. Finally, the abnormal component is defined as the residual,

$$W_{it}^{A} = W_{it} - \bar{W}_{i,m(t)} = W_{it} - \left(W_{it}^{M} + W_{it}^{D}\right), \tag{5}$$

representing unexpected deviations from typical weather conditions in that calendar month, such as unseasonal heatwaves or unusually strong storms, that are most likely to generate economic effects.

We then construct a composite climate risk measure ($CRisk_{it}$) by taking an equally weighted average of the standardized abnormal deviations in temperature, precipitation, and wind speed. Specifically, each abnormal component W_{it}^{A} is standardized by subtracting its sample mean and dividing by its sample standard deviation:

$$\widetilde{W}_{it}^{A} = \frac{W_{it}^{A} - \bar{\mu}_{W^A}}{\bar{\sigma}_{W^A}}, \tag{6}$$

yielding a z-score with zero mean and unit variance for each of the three weather variables ($W \in \{Temp, Precip, Wind\}$). This standardization ensures that temperature, precipitation, and wind speed contribute equally to the composite index despite differences in their original units and scales. The composite measure is then defined as the equally weighted average of these z-scores:

$$CRisk_{it} = \frac{\widetilde{Temp}_{it}^{A} + \widetilde{Precip}_{it}^{A} + \widetilde{Wind}_{it}^{A}}{3}, \tag{7}$$

where $\widetilde{Temp}_{it}^{A}$, $\widetilde{Precip}_{it}^{A}$, and $\widetilde{Wind}_{it}^{A}$ are the standardized abnormal deviations as defined in Equation (6). This measure serves as an aggregate indicator of the risk posed by abnormal weather patterns. Values of $CRisk_{it}$ close to zero reflect weather conditions that are close to historical norms.

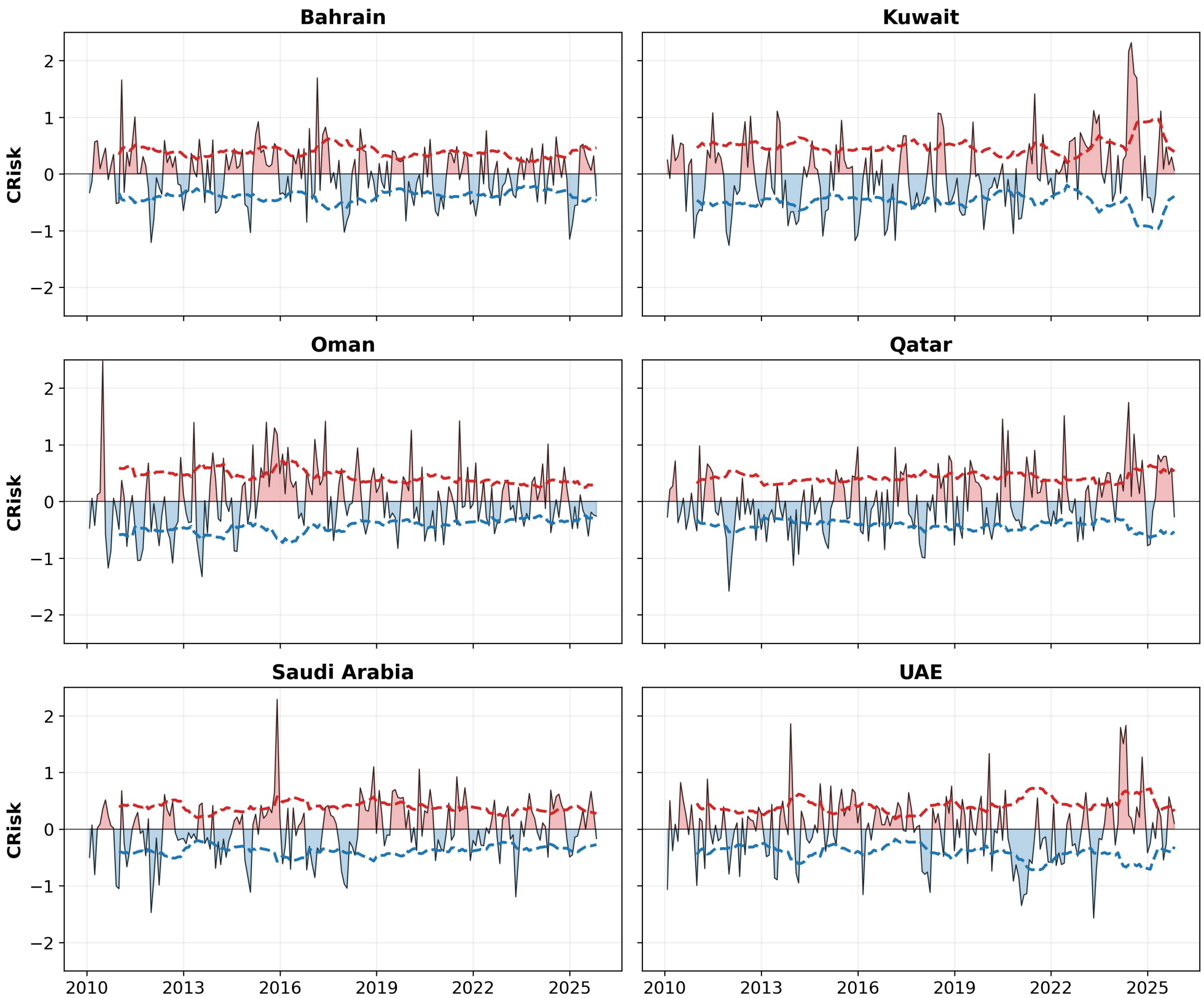
Figure 1 shows the $CRisk$ measure for each GCC country. All six series fluctuate around zero by construction, but the amplitude of anomalies varies considerably over time and across countries. The rolling intensity envelope reveals a heterogeneous pattern. Overall, the dispersion of local weather anomalies appears to have increased in the latter half of the sample compared to the earlier period, suggesting a shift toward more volatile domestic weather conditions across the GCC.

2.2 Inflation and its Sub-components

Our analysis investigates the impact of weather shocks on inflation and its sub-components using monthly Consumer Price Index (CPI) data spanning from January 2010 to October 2025 for each of the GCC countries.[4] The CPI serves as a comprehensive measure of inflation, tracking changes in the prices of a basket of goods and services consumed by households. In addition to overall inflation, we focus on key sub-components: food, housing, hospitality, transport and clothing.

[4]Although the inflation sample begins in January 2010, the construction of the abnormal weather component W_{it}^{A} requires a trailing 10-year window of weather observations for the same calendar month (Equation 3). The underlying meteorological data therefore extend back to January 2000, ensuring that $CRisk_{i,t}$ is well defined from the start of the estimation sample.

Figure 1: Evolution of *CRisk* measure across GCC countries



Notes: Each panel shows the monthly *CRisk* measure for a GCC country. Red (blue) shading denotes positive (negative) realizations. The dashed envelope plots the 12-month rolling mean of the absolute value, indicating the intensity of weather anomalies over time.

Table 1 reports the approximate CPI basket weights for these five categories across the six GCC countries. The weights vary considerably, reflecting differences in household expenditure patterns, demographic composition, subsidy regimes, and the relative importance of the expatriate population. Housing commands the largest share in every GCC country, ranging from approximately 21% in Qatar to 35% in the UAE, consistent with the large share of renting households in expatriate-heavy Gulf economies. Food weights exhibit a nearly two-to-one spread, from around 12% in the UAE to approximately 23% in Oman, implying that a given food-price shock translates into a substantially larger headline CPI impact in Oman or Saudi Arabia than in the UAE or Qatar. Transport carries an outsized weight in Qatar (19%) and Oman (15%), while hospitality (restaurants and hotels) ranges from about 3% in Kuwait to 8% in Qatar. Clothing accounts for a relatively modest 4 - 8% across the region. These cross-country differences in basket composition imply that an equivalent weather-induced movement in food prices, for instance, will translate into a larger headline CPI impact in Oman or Saudi Arabia than in the UAE or Qatar. While country fixed effects control for persistent cross-country level differences in inflation, they do not account for this form of slope heterogeneity. Accordingly, our panel estimates should be interpreted as average effects across GCC economies. To provide a more granular picture, we also estimate the effects of weather shocks on individual CPI sub-components separately, which helps abstract from cross-country differences in headline basket weights when interpreting category-specific responses.

Table 1: CPI basket weights for selected sub-components (% of total)

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE
Food	16	17	23	13	19	12
Housing	24	33	27	21	26	35
Hospitality	5	3	6	8	6	5
Transport	10	8	15	19	13	13
Clothing	5	8	6	7	4	5
Sum of five	60	69	77	68	68	70

Notes: Approximate CPI basket weights based on the most recent available household expenditure surveys and national statistical office publications. Base years differ across countries: Bahrain (2019), Kuwait (2013), Oman (2018), Qatar (2018), Saudi Arabia (2023), and UAE (2021). Figures are rounded to the nearest integer.

The housing CPI encompasses the cost of renting, utility expenses such as electricity and water, and other dwelling-related services. The hospitality CPI primarily tracks changes in the prices of hotel accommodations, restaurants, and catering services. Collectively, the five sub-components account for approximately 60–77% of the total CPI basket depending on the country, providing broad coverage of the expenditure categories most likely to be affected by weather-related disruptions. The inflation data are sourced from national statistical offices.

3 Methodology

We utilize panel local projections, as introduced by Jordà (2005), to assess both the immediate and medium-term effects of abnormal weather shocks on inflation in the GCC countries. This approach offers a flexible alternative to traditional methods like vector autoregressive (VAR) models, particularly in evaluating how the impact of weather shocks varies based on other factors through the inclusion of interaction terms.

Drawing on the substantial body of literature that explores the economic impact of weather shocks (Felbermayr and Gröschl, 2014; Faccia et al., 2021), we treat variations in our composite climate risk measure ($CRisk_{i,t}$) within GCC countries as exogenous, incorporating both country-specific and time-specific fixed effects. The country-specific fixed effects are intended to account for invariant factors that do not change over time, such as geographical latitude, which could otherwise influence the results. Time-specific fixed effects are used to control for phenomena that affect all countries simultaneously but are unrelated to climate, such as global economic downturns or sharp swings in commodity prices[5].

To analyze how inflation and its sub-components in GCC countries react to these weather shocks, we estimate the following panel local projections model:

$$\ln(P_{i,t+h}) - \ln(P_{i,t-1}) = \beta_1^h CRisk_{i,t} + \sum_{n=1}^{12} \gamma_n^h \Delta \ln(P_{i,t-n}) + \alpha_i^h + \theta_t^h + \varepsilon_{i,t}^h \tag{8}$$

where $P_{i,t}$ denotes the price index for country i in period t. The specification is estimated separately for each price measure: headline CPI and the five sub-components (food, housing, hospitality, transport, and clothing). The dependent variable is the cumulative growth rate $P_{i,t}$ between the periods $t+h$ and $t-1$, measured as the difference in the natural logarithms of $P_{i,t}$. The model adjusts for both country-specific α_i^h and time-specific θ_t^h fixed effects, as well as for the inertia inherent in inflation rates through lagged terms. This formulation estimates the conditional dynamic response of inflation to abnormal weather deviations, after controlling for country fixed effects, time fixed effects, and lagged inflation. We include 12 lags of monthly inflation to control for inertia in price dynamics.[6] Standard errors are double-clustered by time and country to account

[5]Our objective is therefore to recover the reduced-form dynamic response of inflation to abnormal weather shocks while minimizing confounding from persistent cross-country differences and common time effects. The resulting estimates should be interpreted as non-structural evidence on the pass-through of weather shocks to observed prices. They do not arise from a stock-flow or general-equilibrium model and therefore do not separately identify broader climate-sensitive channels, including wages, fiscal responses, trade reallocation, energy demand, or other economy-wide feedbacks that may also affect headline inflation.

[6]The choice of 12 lags reflects the monthly frequency of the data and captures a full seasonal cycle of inflation persistence, which is particularly relevant in the GCC where several CPI components exhibit pronounced seasonal patterns (e.g., food prices during Ramadan, hospitality during peak tourism months). This lag length is standard in the climate–inflation literature employing monthly local projections (Faccia et al., 2021; Mukherjee and Ouattara, 2021) and is sufficiently long to purge residual serial correlation from

for potential cross-sectional and temporal dependencies in the data. Analyzing the impact of weather events across different GCC countries necessitates a detailed examination of individual sub-components of consumer prices, as the influence of weather shocks can differ markedly between sub-components, which might lead to a nuanced impact on the overall CPI, as underscored by Parker (2018).

4 Empirical Findings

In this analysis, we differentiate between the short-term and medium-term effects of weather shocks on inflation and its sub-components. The distinction is crucial for policymakers, particularly central banks, as they typically respond to medium-term inflationary pressures rather than short-term fluctuations. This is because policy actions often have a lagged effect, and reacting to transient price changes can create unnecessary volatility (Faccia et al., 2021).

4.1 Short-term Impacts

We begin by examining the short-term effects of weather shocks on inflation and its main sub-components. As shown in Table 2, local weather shocks measured by *CRisk* do not have a statistically significant immediate effect on headline inflation or on the sub-components of housing, hospitality, transportation, and clothing at either horizon. The only statistically significant contemporaneous impact is observed on food prices, which increase by 0.12 percentage points at horizon 0. This suggests that abnormal weather events, even those occurring locally, can disrupt food supply chains and lead to immediate but transitory price pressures. The effect dissipates by horizon 1, indicating that the food supply chain adapts relatively quickly to local weather disruptions.

Table 2 also reports the short-term effects of local temperature anomalies ($\widetilde{Temp}^{A}$), which we include separately given the central role of temperature in the climate–inflation literature. The results are broadly consistent with the composite *CRisk* measure: temperature anomalies do not generate statistically significant contemporaneous effects on headline inflation or most sub-components. This motivates the decomposition into positive and negative temperature shocks in Section 5.4, where we show that the aggregate insignificance masks an important asymmetry between hot and cold anomalies.

The contemporaneous rise in food price inflation can be attributed to disruptions in supply chains caused by abnormal weather conditions. Perishable goods like fresh

the projection errors. Results are robust to alternative lag lengths of 6 and 8 months.

produce are especially vulnerable to such disruptions, which can quickly lead to higher prices in grocery stores. Additionally, even imported food can be affected by local weather conditions, as extreme temperatures can increase storage costs, which are often passed on to consumers (Barrett, 2010; Wheeler and Von Braun, 2013). Furthermore, although GCC countries are primarily dependent on imported food, there is still some local production, particularly in sectors like dairy, poultry, and certain fruits and vegetables. Adverse weather conditions can harm these local production capacities by damaging crops or livestock, reducing the local supply.

Table 2: Short-term impact of weather shocks on inflation and its sub-components

	Headline	Food	Housing	Hospitality	Transportation	Clothing
Horizon 0						
$CRisk$	-0.005	0.115**	-0.046	0.028	-0.062	0.017
	(0.024)	(0.052)	(0.059)	(0.044)	(0.186)	(0.073)
$\widetilde{Temp}^A$	-0.006	-0.032	0.003	-0.009	-0.025	0.021
	(0.017)	(0.021)	(0.047)	(0.023)	(0.165)	(0.039)
Observations	1058	993	993	993	993	993
R^2	0.11	0.25	0.11	0.06	0.12	0.01
Horizon 1						
$CRisk$	-0.011	-0.087	0.004	0.027	-0.201	0.020
	(0.048)	(0.085)	(0.154)	(0.083)	(0.258)	(0.178)
$\widetilde{Temp}^A$	-0.007	-0.052	0.007	-0.007	-0.119	0.013
	(0.032)	(0.050)	(0.117)	(0.037)	(0.220)	(0.063)
Observations	1052	987	987	987	987	987
R^2	0.16	0.34	0.15	0.09	0.16	0.01

Notes: This table presents the short-term impacts of weather shocks on headline inflation and its sub-components. Horizon h denotes the cumulative response h months after the shock, with Horizon 0 corresponding to the contemporaneous effect. The $CRisk$ and $\widetilde{Temp}^A$ rows report coefficients from separate regressions. Standard errors, double-clustered by time and country, are in parentheses. The difference in observation counts between headline CPI (1,058) and the sub-components (993) reflects missing sub-component index data in the early sample for Kuwait and Saudi Arabia; these gaps also propagate through the 12 lagged inflation controls. ***, **, * denote significance at 1, 5, and 10% levels.

Overall, the short-term evidence indicates that the contemporaneous inflationary effects of local weather shocks in the GCC are limited in both magnitude and persistence, consistent with the region's heavy reliance on imported food and its well-developed cold-chain infrastructure. The more substantive and policy-relevant effects emerge over the medium term, as we document in the following subsection.

4.2 Medium-term Impacts

Figure 2 reports the impulse responses of headline inflation and its main sub-components to an abnormal weather shock in the GCC. Overall, the responses reveal clear medium-term dynamics and substantial heterogeneity across CPI categories, suggesting that weather shocks propagate through multiple channels and affect some sectors more than others.

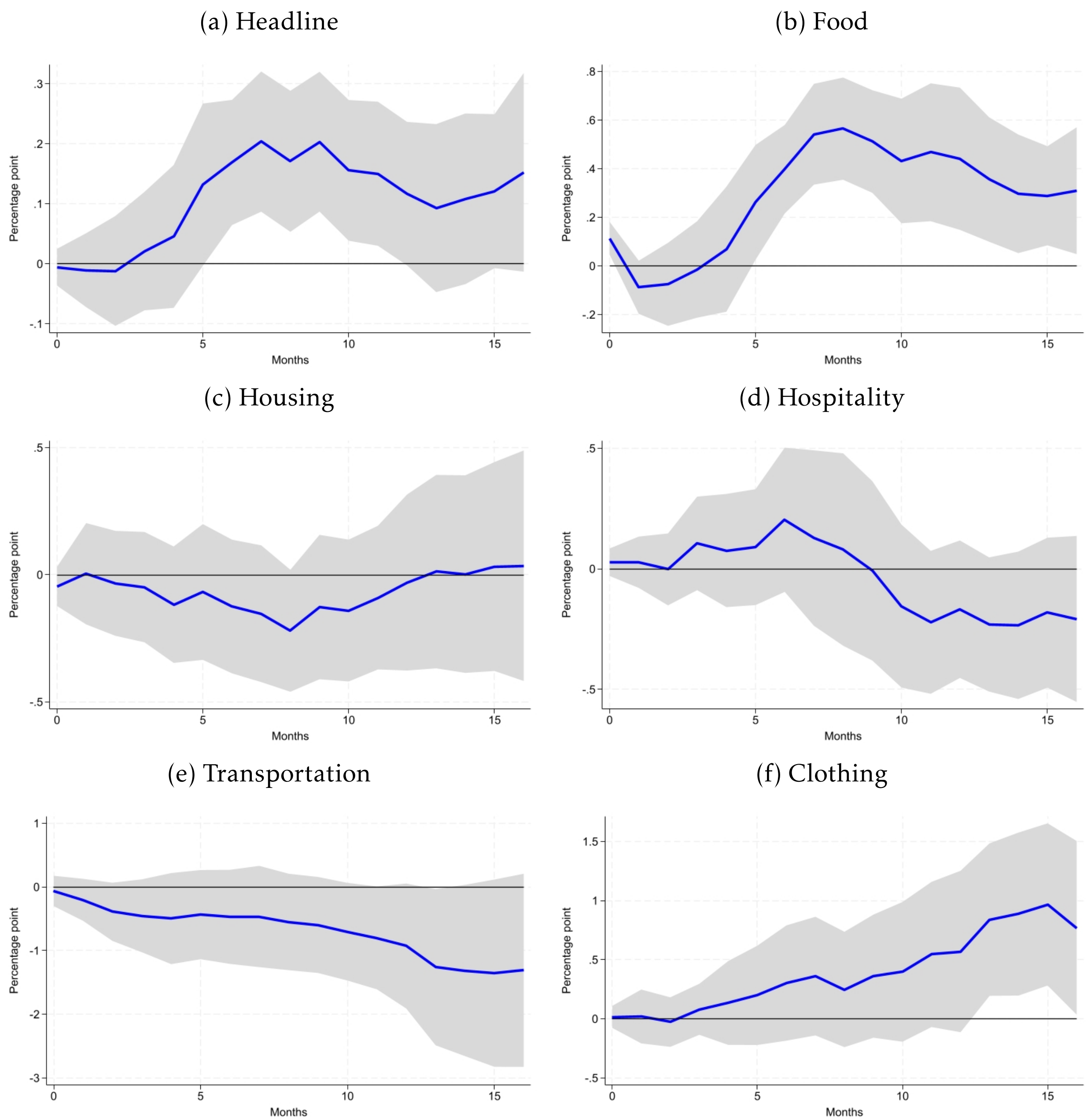
Figure 2a shows that headline CPI inflation reacts with a delay. Following a small and short-lived initial response, the effect turns positive and becomes statistically significant in the medium term, peaking around 7–9 months after the shock. Thereafter, the response gradually declines but remains positive over most of the horizon, indicating that abnormal weather shocks can generate persistent headline inflationary pressures rather than purely transitory movements. This delayed pattern is consistent with sluggish pass-through mechanisms, such as gradual adjustment in distribution costs, contracts, and retail pricing, and with the notion that weather shocks can affect inflation through both direct supply disruptions and slower-moving second-round effects (Parker, 2018; Faccia et al., 2021).

Figure 2b shows a pronounced and persistent response of food inflation. After a brief initial dip, food CPI inflation rises sharply from about months 4–5 onward and peaks in the medium term (around 7–8 months), remaining elevated for an extended period. This pattern aligns with the broader evidence that weather anomalies can be inflationary for food prices via supply-side disruptions and higher costs along the food supply chain (Mukherjee and Ouattara, 2021; Faccia et al., 2021). Importantly, despite the GCC's high reliance on imported food, the results suggest that local abnormal weather conditions can still matter for food inflation through channels such as storage and refrigeration costs, domestic transportation and distribution frictions, and the small but non-negligible role of local production for selected items (e.g., dairy, poultry, and some vegetables) [7].

Figure 2c illustrates the effect of abnormal weather shocks on housing prices in the GCC, which captures changes in rents, utility expenses, and other dwelling-related costs. The point estimate is negative over the medium term but remains statistically insignificant at all horizons, indicating that idiosyncratic weather anomalies are not a meaningful driver of housing inflation in the region. This is consistent with the institutional features of GCC housing markets: rents are typically preset in yearly contracts, utility prices are often regulated or subsidized, and the built environment is designed to accommodate

[7] In supplementary analysis reported in Appendix, we examine whether media attention to climate change moderates the pass-through of weather shocks to prices. When we interact lagged country-level climate news coverage (sourced from Bloomberg) with $CRisk_{i,t}$, the interaction term is negative and statistically significant for food inflation at horizon 0, suggesting that the contemporaneous pass-through of abnormal weather shocks to food prices is weaker in periods of heightened media salience.

Figure 2: Impact of abnormal weather shocks on inflation and its sub-components over the medium term



Notes: Impulse responses to abnormal weather anomalies using the baseline specification. Shaded areas represent 90% confidence intervals.

the region's climate, limiting the scope for short- to medium-run weather fluctuations to affect housing costs.

Figure 2d shows that hospitality inflation exhibits a non-monotonic response. The point estimate is mildly positive in the early horizons, but the effect subsequently declines, turns negative around the second half of the horizon, and remains below zero thereafter. This pattern is consistent with the idea that weather shocks can trigger both cost-push and demand-side mechanisms. While short-run disruptions may temporarily raise operating costs, adverse weather conditions can later reduce mobility and discretionary spending on tourism and leisure activities, generating a demand-driven disinflationary effect in hospitality-related prices.

Figure 2e denotes the effect of abnormal weather shocks on transportation CPI. While there appears to be a persistent decrease in transportation CPI following a weather shock, the effect is not statistically significant. In the GCC context, if an abnormal weather event reduces travel activity (for instance, heavy rains flooding roads or extreme heat discouraging driving), there may be a drop in demand for transportation services and fuel. With fuel prices in many GCC countries partly administered or subsidized, short-run fluctuations might be contained, but over a longer horizon some adjustments or lower usage costs could translate into the index.

Furthermore, Figure 2f reveals a positive reaction of clothing CPI to weather shocks, where the response becomes statistically significant after twelve months. This suggests that certain abnormal weather events could lead to price increases in the clothing sector.

Taken together, the medium-term evidence shows that abnormal weather shocks exert statistically significant and persistent effects on headline inflation in the GCC. The transmission is strongest through food prices, while responses across other CPI components are more uneven. This heterogeneity underscores the need to look beyond headline inflation and examine sub-indices when evaluating the inflationary consequences of climate-related disturbances. The results support the view that climate-induced relative price changes can feed into medium-term inflation, particularly when shocks are sufficiently persistent to affect expectations or propagate through production and cost networks (Pankratz and Schiller, 2024).

4.3 Nonlinear Effects and Clustered Extremes

The baseline specification treats the climate risk measure as entering linearly, implying that all abnormal weather deviations, regardless of their magnitude, have a proportional effect on inflation. However, it is plausible that only sufficiently large anomalies generate meaningful economic disruptions, while moderate deviations are absorbed by existing buffers and adaptive capacity. To investigate this nonlinearity, we decompose $CRisk_{i,t}$ into extreme and moderate components using the 75th percentile of the pooled distribution as the threshold. Specifically, we define $CRisk_{i,t}^{Extreme} = CRisk_{i,t} \cdot \mathbf{1}(CRisk_{i,t} > q_{75})$ and

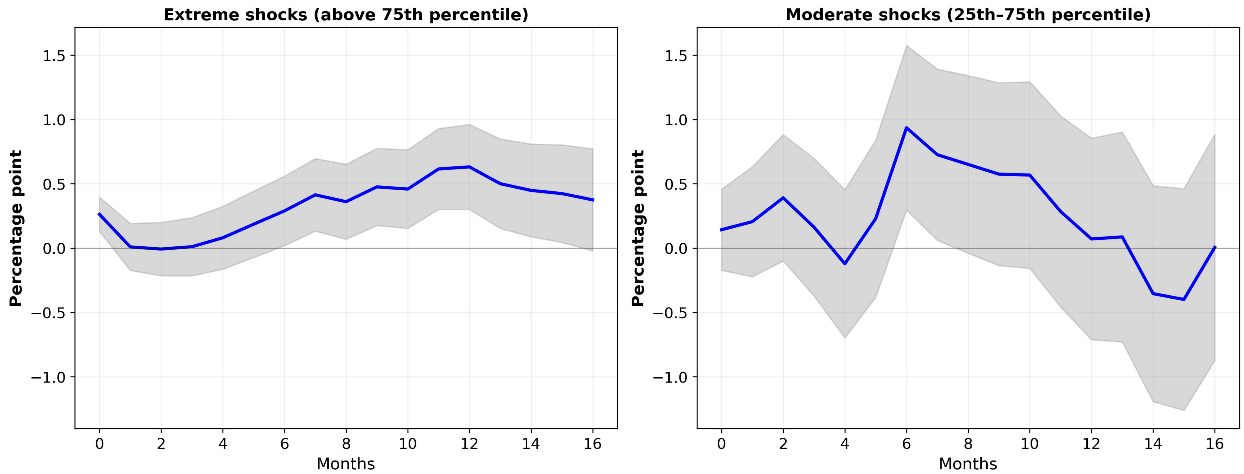
$CRisk_{i,t}^{Moderate} = CRisk_{i,t} \cdot \mathbf{1}(q_{25} \leq CRisk_{i,t} \leq q_{75})$, and re-estimate the panel local projections specification with both components included simultaneously.

Figure 3 reports the results. Extreme weather shocks above the 75th percentile generate statistically significant and persistent effects on food inflation, with the response building gradually and peaking at approximately 0.63 percentage points around 12 months after the shock. In contrast, moderate shocks between the 25th and 75th percentiles produce statistically insignificant responses at nearly all horizons. This confirms that the inflationary effects of local weather anomalies are concentrated in the upper tail of the distribution, consistent with the view that only sufficiently large deviations from seasonal norms generate meaningful supply disruptions.

We further investigate whether the persistence of extreme weather matters by distinguishing between clustered and isolated extremes. A clustered extreme is defined as a month in which $CRisk_{i,t}$ exceeds the 75th percentile and at least one of the two preceding months also exceeds this threshold; an isolated extreme is a month above the 75th percentile with neither of the two prior months exceeding it. This decomposition captures the intuition that consecutive months of abnormal weather are more likely to overwhelm adaptive capacity and generate persistent supply-chain disruptions than one-off events.

Figure 4 presents the impulse responses. The contrast is stark: clustered extremes generate a large, persistent, and highly significant increase in food inflation that builds steadily over the horizon, peaking at approximately 1.05 percentage points at 12 months. Isolated single-month extremes, by contrast, generate a significant contemporaneous response but one that dissipates quickly and remains statistically insignificant at all subsequent horizons, suggesting that one-off weather anomalies can temporarily disrupt food prices but lack the persistence needed to generate sustained inflationary pressure. Clustered extremes, on the other hand, produce a response that builds steadily over time, consistent with the cumulative nature of supply-chain disruptions when abnormal conditions persist across multiple months. This finding underscores that the inflationary consequences of abnormal weather in the GCC are driven not by occasional one-off anomalies but by sustained episodes of extreme conditions, which are more likely to disrupt agricultural supply chains, strain storage and logistics infrastructure, and trigger precautionary pricing behavior.

Figure 3: Nonlinear effects: extreme vs. moderate weather shocks on food inflation



Notes: Impulse responses of food inflation to extreme ($CRisk > q_{75}$, left) and moderate ($q_{25} \leq CRisk \leq q_{75}$, right) weather shocks. Shaded areas represent 90% confidence intervals.

Figure 4: Clustered vs. isolated extreme weather shocks on food inflation

Notes: Impulse responses of food inflation to clustered extremes (2+ consecutive months above the 75th percentile, left) and isolated extremes (single month above the 75th percentile, right). Shaded areas represent 90% confidence intervals.

5 Additional Analyses

5.1 The Influence of External Weather Shocks on Food Inflation

Given that GCC countries import a large proportion of their food products from abroad, it is plausible that abnormal weather shocks occurring in their import partners could significantly impact food prices within the GCC. These shocks could affect food production and prices in the exporting countries, which would then be transmitted to the GCC through higher import costs. Therefore, to understand the transmission mechanisms of global weather shocks to the GCC food inflation, it is essential to examine the impact of weather shocks in major importing partners. By exploring this relationship, we can better understand the indirect pathways through which climatic events abroad impact domestic food prices. This understanding is important for formulating effective policy responses and enhancing the resilience of the food supply chain in the GCC against external climatic shocks.

In this context, to investigate the impact of weather shocks in food-exporting countries on the food CPI in the GCC, we utilize yearly food product import data from the World Bank. For each year, we identify the top 10 import partners for each GCC country individually. Because the composition of the top 10 partners can change from year to year, reflecting shifts in trade relationships, supply conditions, and sourcing strategies, the set of partner countries entering the index is time-varying. We then employ Equation (7) to calculate the $CRisk_{jt}$ measure for each of these import partners. Subsequently, to obtain an aggregated measure of external weather risk, we compute import share-weighted averages of the $CRisk_{jt}$ measures of the top 10 import partners for each GCC country, which we denote as the "Global CRisk" ($GCRisk_{it}$) measure.

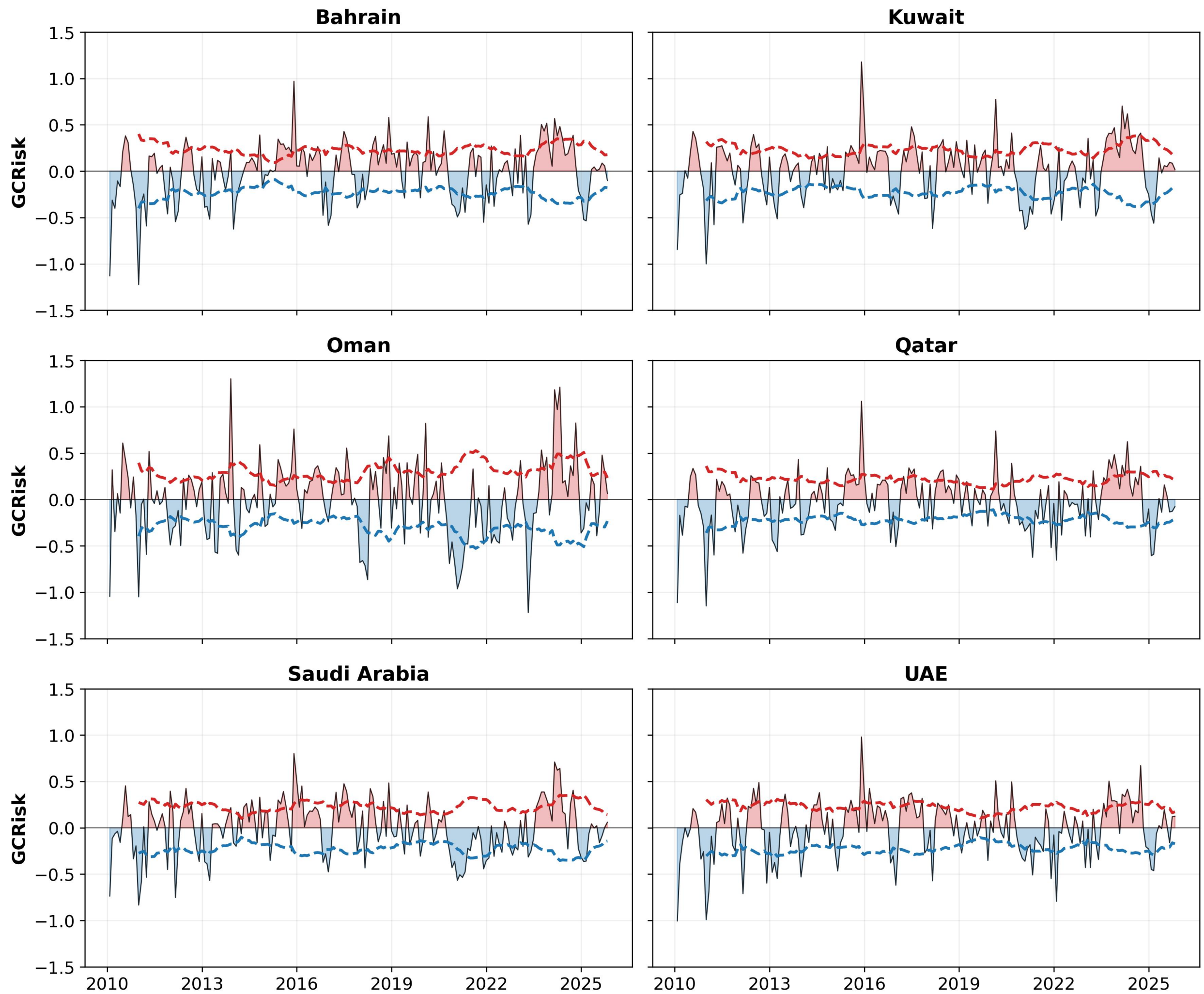
The Global CRisk measure is calculated as follows:

$$GCRisk_{i,t} = \sum_{j \in \mathcal{J}_{i,t}} \omega_{i,j,t} \cdot CRisk_{j,t} \tag{9}$$

where $\mathcal{J}_{i,t}$ denotes the set of top 10 food-import partners of GCC country i in year t, $\omega_{i,j,t}$ is the import share of partner country j for GCC country i in year t, and $CRisk_{j,t}$ represents the climate risk measure for partner country j in month t. This weighted average approach allows us to quantify the aggregate climate risk from the primary import partners, providing insights into the potential transmission of external weather shocks to food inflation in the GCC region. We then replace the $CRisk_{j,t}$ measure in Equation (8) with the newly calculated $GCRisk_{i,t}$ measure to understand how abnormal weather patterns in import partner countries affect the food CPI in the GCC region.

Figure 5 presents the trade-weighted global climate risk measure, $GCRisk$. Because this index aggregates weather anomalies across the top 10 food-exporting partners of each GCC country, the diversification across geographies produces a smoother series. Across most GCC countries, the intensity envelope for $GCRisk$ remains broadly stable, suggesting that the trade-weighted exposure to external weather risk has not exhibited a clear secular trend over the sample period, though episodic surges are becoming more

Figure 5: Evolution of global climate risk (*GCRisk*) across GCC countries



Notes: Each panel shows the trade-weighted global climate risk measure (*GCRisk*) for a GCC country. Red (blue) shading denotes positive (negative) realizations. The dashed envelope plots the 12-month rolling mean of the absolute value.

frequent in recent years. This pattern underscores that even without a monotonic trend, the recurrence of extreme external weather events can generate meaningful and repeated inflationary impulses through the import channel.

Panel A of Table 3 illustrates the significant impact of the *GCRisk* measure on food inflation in the short term. The results show that the contemporaneous effect of the *GCRisk* measure on the food CPI is four times larger than the impact of local abnormal weather shocks. Furthermore, the *GCRisk* measure leads to a 0.68 percentage point increase in food prices in the subsequent month, highlighting the influence of external climate risks on food inflation in GCC countries. Panel B of Table 3 further supports these findings by demonstrating that the impact of the *GCRisk* measure remains highly significant even when controlling for the local *CRisk* measure. This finding indicates that global climatic conditions in key import partner countries play a critical role in shaping inflationary trends in food prices in the GCC, thereby highlighting the importance of incorporating global climate risks into economic forecasts and policy planning in the region.

Table 3: Short-term impact of global weather shocks on food inflation

Panel A			
	Horizon 0	Horizon 1	Horizon 2
GCRisk	0.427 **	0.681***	0.326**
	(0.199)	(0.237)	(0.154)
Observations	993	987	981
R^2	0.24	0.34	0.37

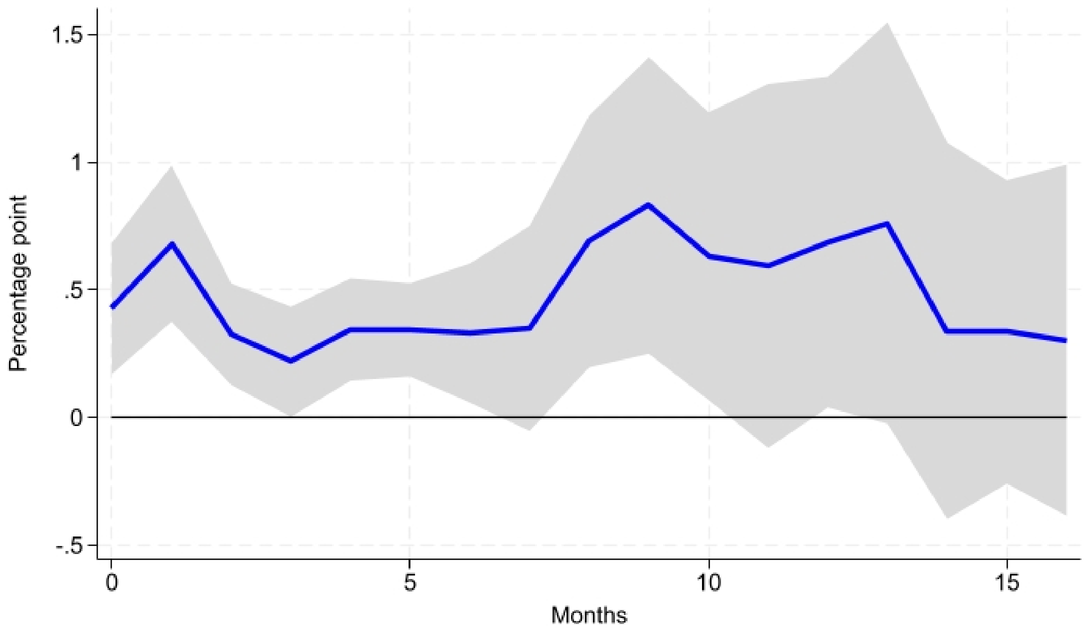
Panel B			
	Horizon 0	Horizon 1	Horizon 2
GCRisk	0.458**	0.665***	0.311**
	(0.201)	(0.229)	(0.151)
CRisk	0.129**	-0.066	-0.065
	(0.061)	(0.105)	(0.144)
Observations	993	987	981
R^2	0.25	0.35	0.38

Notes: This table presents the impact of global weather shocks, measured by our global climate risk measure (*GCRisk*), on food inflation within the GCC countries. Horizon *h* denotes the cumulative response *h* months after the shock, with Horizon 0 corresponding to the contemporaneous effect. The coefficients for *GCRisk* and local climate risk (*CRisk*) are reported for three different horizons (0, 1, and 2 months) following the weather shock. Standard errors, double-clustered by time and country, are shown in parentheses. Panel A illustrates the standalone effects of *GCRisk*, while Panel B includes both *GCRisk* and *CRisk* to capture both global and local effects simultaneously. ***, **, * denote significance at 1, 5, and 10% levels.

When we examine the medium-term impacts of global abnormal weather shocks on food inflation in GCC countries, as presented in Figure 6, the effects are not only highly significant but also persistent. The impulse response function illustrates a clear and sustained positive impact on food inflation, with the effect becoming again statistically significant around the seventh month after the initial shock and persisting through nearly the full 12-month horizon. The peak impact, reaching almost 0.83 percentage point increase in food inflation, occurs around nine months after the shock[8]. Unlike the transient

[8]As a robustness check, we re-estimate the joint specification in Panel B of Table 3 using 6 and 8 lags of monthly inflation instead of 12. The results are virtually unchanged: the peak *GCRisk* effect is 0.81

Figure 6: Impact of global abnormal weather shocks on food inflation over the medium term



Notes: Impulse responses to external weather anomalies using the baseline specification. Shaded areas represent 90% confidence intervals.

effects of local weather shocks, the $GCRisk_{it}$ measure exhibits a lasting impact, suggesting that adverse weather conditions in major food-exporting regions can lead to prolonged price pressures in the GCC.[9] This finding highlights the importance of developing strategies to mitigate these risks and enhance food security in the region[10].

percentage points with 6 lags, and 0.84 with 8 lags, all occurring at horizon 9. The short-term coefficients at horizons 0–2 are similarly stable across specifications. This confirms that the findings are not sensitive to the choice of lag length for the inflation inertia controls.

[9]As a robustness check, we re-estimate the specification using a constant set of trade partners, defined as those appearing among the top 10 food-import partners in every year of the sample, with import weights re-normalized to sum to one. The number of constant partners varies by country: Bahrain (7), Kuwait (6), UAE (6), Saudi Arabia (5), Oman (3), and Qatar (3). The constant-partner *GCRisk* generates a statistically significant positive food inflation response over horizons 2–6, peaking at 0.62 percentage points at $h = 4$, confirming that the weather-to-inflation transmission channel operates through a stable core of supplier countries and is not driven by time-varying partner composition (see Figure A.1 in the Appendix).

[10]To illustrate the potential gains from reducing import dependence, we consider a simple counterfactual in which the share of imported food in total food consumption is compressed from approximately 85% to 50%. Under the assumption that the pass-through elasticity remains unchanged, scaling the $GCRisk_{i,t}$ measure by the ratio of the hypothetical to actual import shares ($0.50/0.85 \approx 0.59$) implies that the estimated peak medium-term effect of external weather shocks on food inflation would decline from approximately 0.83 pps to around 0.49 pps. Conversely, increasing the share of locally sourced food would elevate the region's exposure to domestic abnormal weather shocks (*CRisk*). Given our finding that local shocks currently have smaller and more transient effects on food prices compared to global shocks, successful import

To gauge the economic significance of these estimates, it is useful to express them relative to average food inflation in the GCC. Over the sample period, year-on-year food inflation averages approximately 2.3 percentage points (pp) across the six countries. The contemporaneous *GCRisk* effect of about 0.46 pp thus represents roughly one-fifth of average annual food inflation, while the peak cumulative effect of approximately 0.83 pp at nine months corresponds to nearly 36% of the annual average. These magnitudes indicate that external weather shocks are not merely statistically significant but also economically meaningful relative to the typical scale of food price movements in the region.

To further illustrate the economic significance of our findings, Figure 7 presents realized food inflation alongside a climate-purged counterfactual for the GCC. The solid blue line plots realized food inflation, averaged across the six GCC countries and smoothed with a 12-month moving average, while the dashed red line shows the counterfactual path that removes the estimated contributions of both local and global abnormal weather shocks.[11] The counterfactual thus captures all non-weather drivers of food prices and provides an illustrative fitted decomposition that removes the estimated contemporaneous contribution of local and external weather anomalies.

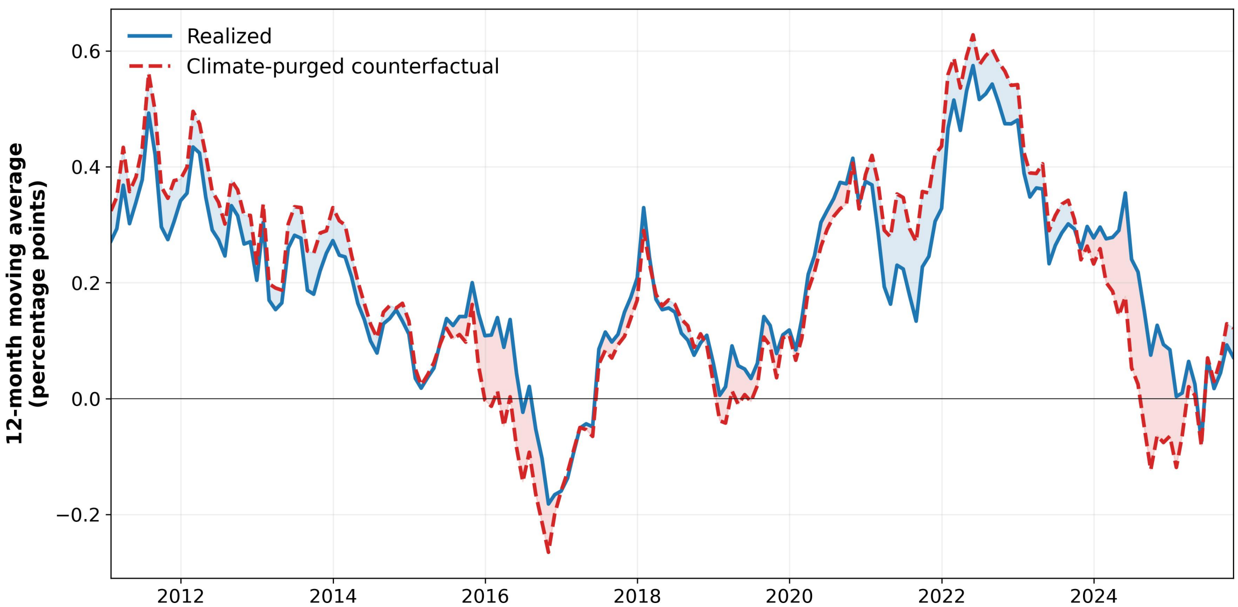
The gap between the two lines reflects the size of the weather-attributable gap, which varies markedly over time, with some notable episodes. During 2016–2017, realized food inflation ran above the counterfactual, indicating that adverse weather conditions added to food-price pressures during a period when food inflation was otherwise declining. The gap also widens in the most recent part of the sample, when realized food inflation runs somewhat above the climate-purged path. Episodes of this kind illustrate that, although abnormal weather is not the primary driver of food inflation on average, it can be a visible contributor in particular periods.

These results speak directly to the food-security agendas currently pursued across GCC countries, which increasingly treat high import dependence as an exposure that food security strategies seek to manage in the face of global supply disruptions and climate-related risks. A common pillar of these national strategies is import diversification, i.e., reducing reliance on a narrow set of suppliers by expanding the number and geographic spread of sourcing partners and logistics routes, often complemented by strategic reserves and longer-term contracting arrangements. Such policy priorities are consistent with our empirical evidence: because food inflation in the GCC responds

substitution combined with climate-resilient domestic agriculture could systematically lower the overall climate-sensitivity of GCC food inflation.

[11] The counterfactual is constructed by subtracting the fitted weather component, $\hat{\beta}_{CRisk} \cdot CRisk_{i,t} + \hat{\beta}_{GCRisk} \cdot GCRisk_{i,t}$, from observed monthly food inflation at each country-month observation, using the coefficients from the joint specification in Panel B of Table 3.

Figure 7: Realized vs. climate-purged food inflation (GCC average)



Notes: This figure shows realized food inflation (solid blue) and a climate-purged counterfactual (dashed red) that removes the estimated contributions of local (*CRisk*) and global (*GCRisk*) weather shocks, averaged across GCC countries (12-month moving average).

strongly to weather shocks in supplier regions, diversifying import sources (particularly across climate-resilient geographies) can help reduce the pass-through of external climate shocks into domestic food prices.[12]

Beyond food security, these findings are relevant for the broader macroeconomic monitoring undertaken by GCC central banks. To the extent that weather shocks in major supplier countries pass through to domestic food prices, they contribute to imported inflation, which is one of several factors informing the assessment of real financing conditions.

[12]See, for example, the UAE National Food Security Strategy 2051 (https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/environment-and-energy/national-food-security-strategy-2051); Qatar's National Food Security Strategy 2030 and related policy documents emphasizing partnerships, trade diversification, and storage reserves (https://www.gco.gov.qa/en/media-centre/top-news/prime-minister-launches-the-national-food-security-strategy-2030/; Bahrain's emphasis on diversifying food supply chains (https://www.bahrain.bh/wps/portal/en/BNP/ExploreBahrain/FoodSafetyAndSecurity); Kuwait's initiatives stressing diversification of food sources (https://www.kuna.net.kw/ArticleDetails.aspx?id=3160640&language=en); and Saudi Arabia's outward-facing approach to strengthening food security through global supply-chain investments (https://www.mfat.govt.nz/assets/Trade-General/Trade-Market-reports/Saudi-Arabia-Food-Security-Strategy-January-2024.pdf and Oman's Vision 2040 food security priority, complemented by the National Nutrition Strategy 2020–2030 introduced by the Ministry of Health, which emphasizes improving nutrition outcomes and strengthening food supply resilience (https://www.oman2040.om/priority/12?lang=en).

Persistent imported inflation can also influence the real effective exchange rate (REER), a standard consideration in monitoring external conditions for highly open economies. Consistent with NGFS (2024), which finds that physical climate shocks can have persistent effects on inflation, these channels reinforce the case for incorporating climate-related price pressures into regular macroeconomic surveillance. More recently, NGFS (2026) notes that climate-related risks can bear on a range of central bank functions, including reserve management, adding a further dimension to the physical-risk channels relevant for monetary and financial stability frameworks globally.

5.2 The Role of Weather Volatility in Supplier Countries

The preceding analysis examines how the level of abnormal weather conditions in food-exporting partner countries affects food inflation in the GCC. However, the increasing unpredictability of weather patterns, even absent a shift in the mean, may itself generate inflationary pressures by raising uncertainty about agricultural supply conditions, complicating harvest planning, and disrupting logistics in key food-exporting regions (Adam and Kaur Matta, 2025). To investigate this channel, we construct a measure of weather volatility in supplier countries and estimate its dynamic effects on GCC food inflation.

We proxy the weather volatility of each import partner j in month t by the squared climate risk measure:

$$Vol_{j,t} = \left(CRisk_{j,t}\right)^2, \tag{10}$$

which captures the intensity of weather anomalies regardless of their sign: both unusually adverse and unusually benign weather conditions in a given month produce high values of $Vol_{j,t}$, while months with weather close to historical norms yield values near zero.[13]

We then aggregate partner-level volatility into a trade-weighted global measure:

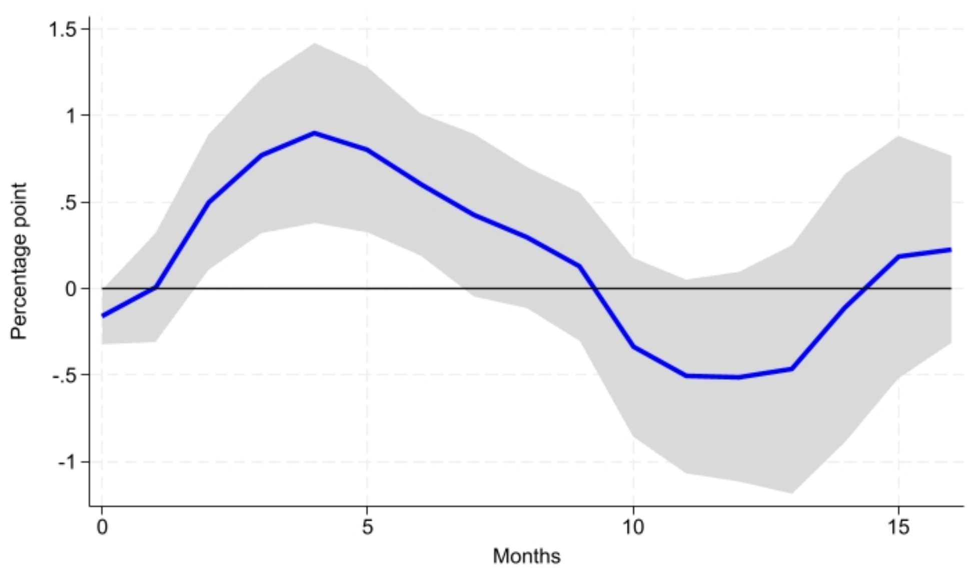
$$GCRiskVol_{i,t} = \sum_{j\in\mathcal{J}_{i,t}} \omega_{i,j,t} \cdot Vol_{j,t} = \sum_{j\in\mathcal{J}_{i,t}} \omega_{i,j,t} \cdot \left(CRisk_{j,t}\right)^2, \tag{11}$$

[13]This approach is analogous to the use of squared returns as a proxy for realized variance in financial economics. Squaring also avoids cancellation between positive and negative anomalies that can arise when averaging the level of *CRisk* across partner countries. While more sophisticated measures of distributional risk, such as recursively estimated higher moments or shape parameters from extreme value distributions, could in principle capture additional features of weather uncertainty, they would require fitting distributions to rolling windows of observations, introducing tuning parameters and reducing temporal resolution. Given our relatively short panel and the need to preserve monthly variation for the local projections framework, the squared anomaly provides a parsimonious and model-free proxy that is sufficient for testing whether the unpredictability of weather conditions, as opposed to their direction, constitutes a distinct inflationary channel.

where, as before, $\mathcal{J}_{i,t}$ denotes the set of top 10 food-import partners and $\omega_{i,j,t}$ denotes the import share of partner country j for GCC country i. By computing volatility at the individual partner level before aggregating, this measure preserves the idiosyncratic weather uncertainty in each supplier region, rather than measuring the volatility of an already-averaged index.[14] We then estimate the panel local projections specification in Equation (8) with $GCRiskVol_{i,t}$ as the shock variable and food CPI as the dependent variable.

Figure 8 reports the impulse response of food inflation to a shock in external weather volatility. The response is positive and statistically significant from approximately months 2 through 7, peaking at around months 3–4 with an estimated magnitude of nearly one percentage point. This indicates that heightened weather unpredictability in major food-exporting regions generates short- to medium-term inflationary pressures on food prices in the GCC, even after controlling for the direction of weather anomalies captured by the level-based $GCRisk$ measure.

Figure 8: Impact of weather volatility in supplier countries on GCC food inflation



Notes: Impulse responses to external weather anomalies using the baseline specification. Shaded areas represent 90% confidence intervals.

The timing of the response is consistent with the structure of agricultural supply chains. Weather volatility in exporting regions raises uncertainty about crop yields and

[14] Constructing volatility from the aggregate $GCRisk_{i,t}$ would mechanically smooth out idiosyncratic partner-level variation through diversification, and would also be contaminated by discrete jumps arising from annual changes in import weights and partner composition.

harvest outcomes, which can lead to precautionary behavior by producers and traders, including forward contracting at higher prices, reduced export commitments, and inventory hoarding, that pushes up international food prices within a few months (Adenäuer et al., 2023). These cost increases are subsequently transmitted to GCC food inflation through import channels, consistent with the 2–4 month lag observed in the impulse response. Beyond the peak, the response gradually declines and turns mildly negative around months 10–13, though this reversal is not statistically significant at conventional levels. This pattern may reflect a partial correction as the initial uncertainty dissipates: once actual harvest outcomes are realized and supply conditions become clearer, the precautionary price premia embedded in earlier months can unwind, generating a modest mean-reversion in food prices.

These findings complement the level-based results in Section 5.1 and highlight that the unpredictability of weather conditions in supplier countries, not only their direction, constitutes a distinct source of imported food inflation risk for the GCC. From a policy perspective, this reinforces the case for strategies that buffer against supply uncertainty, such as strategic food reserves, longer-term procurement contracts, and diversification of import sources across geographies with uncorrelated weather patterns.

5.3 Asymmetric effects of external climate risk on food inflation

A growing literature suggests that the macroeconomic and price effects of weather shocks can be asymmetric, with adverse realizations generating stronger and more persistent inflationary pressures than favorable realizations (Parker, 2018; Faccia et al., 2021; Ciccarelli et al., 2024; Falck and Schulte, 2025). This asymmetry is particularly plausible for food prices, as negative weather anomalies in major food-exporting regions can reduce agricultural supply and disrupt logistics, thereby raising global food prices and transmitting inflation to import-dependent economies (Wheeler and Von Braun, 2013; Mukherjee and Ouattara, 2021).

To allow for asymmetric transmission of external weather shocks, we decompose the global climate risk index into its positive and negative components:

$$GCRisk_{it}^{+} = \max(GCRisk_{it}, 0), \qquad GCRisk_{it}^{-} = -\min(GCRisk_{it}, 0), \tag{12}$$

so that $GCRisk_{it}^{+} \geq 0$ and $GCRisk_{it}^{-} \geq 0$ measure, respectively, the magnitude of positive and negative realizations of global climate risk.[15]

[15] By construction, $GCRisk_{it} = GCRisk_{it}^{+} - GCRisk_{it}^{-}$. The transformation in (12) facilitates a direct comparison of the effects associated with positive versus negative realizations of external climate risk.

We then re-estimate the panel local projections specification in (8) for food prices by replacing $GCRisk_{it}$ with $(GCRisk^{+}_{it}, GCRisk^{-}_{it})$:

$$\ln\left(P^{Food}_{i,t+h}\right) - \ln(P^{Food}_{i,t-1}) = \beta^{h}_{+} GCRisk^{+}_{i,t} + \beta^{h}_{-} GCRisk^{-}_{i,t} + \sum_{n=1}^{12} \gamma^{h}_{n} \Delta \ln\left(P^{Food}_{i,t-n}\right) + \alpha^{h}_{i} + \theta^{h}_{t} + \varepsilon^{h}_{i,t}, \quad (13)$$

where α^h_i and θ^h_t denote country and time fixed effects. Standard errors are double-clustered by country and time.

Figure 9 displays the impulse responses of food inflation in GCC countries to the asymmetric components of external climate risk. Panel (a) shows that adverse global climate-risk shocks, captured by the positive component $(GCRisk^{+}_{it})$ lead to a large and persistent increase in food inflation. The response becomes pronounced shortly after the shock, peaks at around four months with an estimated magnitude of approximately one percentage point, and remains elevated over subsequent horizons. In contrast, Panel (b) reports the response of food inflation to below-normal realizations, represented by the negative component $(GCRisk^{-}_{it})$. These impulse responses are small and statistically insignificant at all horizons, indicating that improvements in global weather conditions do not generate meaningful impact on food prices in the GCC. Overall, the results reveal a clear asymmetry in the transmission of external climate risk: adverse climate shocks significantly raise food inflation, whereas benign climate shocks have no discernible effect.

This asymmetric pattern is economically intuitive for import-dependent countries. Positive global climate-risk realizations can proxy adverse conditions in key supplier regions (e.g. severe droughts or crop-damaging weather events), which can reduce effective supply and raise export prices, thereby passing through to domestic food inflation in the GCC via trade linkages (Wheeler and Von Braun, 2013; Parker, 2018). Conversely, negative realizations need not translate into similarly a dis-inflationary effects because food prices may exhibit downward rigidity, storage, and contracting frictions that limit the extent to which favorable supply conditions reduce import prices.[16]

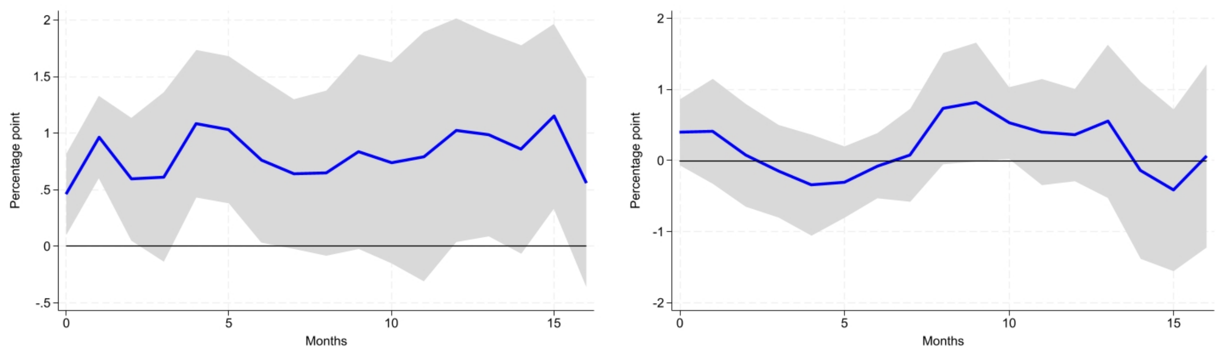
5.4 Hot versus cold temperature anomalies in the GCC

A large body of evidence emphasizes that unusually high temperatures tend to be inflationary, especially for food, because heat stress can reduce agricultural yields, raise production costs, and amplify supply-side pressures (Parker, 2018; Mukherjee and Ouat-

[16]This mechanism is consistent with the broader evidence that the inflationary effects of weather shocks depend on shock direction and the presence of nonlinear adjustment dynamics (Faccia et al., 2021; Kim et al., 2022).

Figure 9: Asymmetric impact of global climate risk on food inflation

(a) Positive component ($GCRisk^{+}$) (b) Negative component ($GCRisk^{-}$)



Notes: Impulse responses of food inflation to the negative and positive components of global climate risk using the specification in (13). Shaded areas represent 90% confidence intervals.

tara, 2021; Faccia et al., 2021). However, the GCC provides a different setting: local agricultural production is limited, food is largely imported, and economic activity and infrastructure are adapted to persistently high baseline temperatures. These features imply that the inflation response to temperature anomalies may be state-dependent and potentially asymmetric, consistent with recent work highlighting nonlinear macroeconomic effects of weather shocks (Faccia et al., 2021; Kim et al., 2022; Ciccarelli et al., 2024; Falck and Schulte, 2025).

In particular, the cooler season in the GCC typically coincides with the peak tourism calendar and a rise in outdoor activities and events, which boosts demand for hotels, restaurants, and related services. When unusually low temperatures occur during these periods, they may further intensify outdoor consumption and visitor spending, thereby exerting additional demand-side pressure on food-away-from-home and hospitality prices. This demand amplification provides a plausible channel through which negative temperature anomalies might generate stronger inflationary effects than positive temperature anomalies in the GCC context.

To investigate this asymmetry, we decompose the abnormal temperature component, $Temp_{it}^{A}$, into positive and negative parts:

$$PTEMP_{it} = \max\Big(Temp_{it}^{A}, 0\Big), \qquad NTEMP_{it} = -\min\Big(Temp_{it}^{A}, 0\Big), \tag{14}$$

so that $PTEMP_{it} \geq 0$ measures the magnitude of abnormally *high* temperatures, while $NTEMP_{it} \geq 0$ measures the magnitude of abnormally *low* temperatures. We then estimate a panel local projections specification analogous to (8):

$$\ln(P_{i,t+h}) - \ln(P_{i,t-1}) = \beta_+^h PTEMP_{i,t} + \beta_-^h NTEMP_{i,t} + \sum_{n=1}^{12} \gamma_n^h \Delta \ln(P_{i,t-n}) + \alpha_i^h + \theta_t^h + \varepsilon_{i,t}^h, \quad (15)$$

where $P_{i,t}$ denotes the CPI (headline) or a CPI sub-component (food and hospitality), α_i^h and θ_t^h are country and time fixed effects, and standard errors are double-clustered by country and time.

Figure 10 reports the impulse responses to positive and negative temperature anomalies.[17] Across outcomes, the responses indicate that abnormally low temperatures ($NTEMP$) generate stronger inflationary effects than abnormally high temperatures ($PTEMP$). For headline CPI (top row), a negative temperature shock pushes up overall inflation noticeably, whereas a positive shock's impact is much more modest. The IRF indicates that a cold shock leads headline CPI inflation to increase gradually, becoming significantly positive after a few months and peaking roughly within 6–9 months. The effect then persists for about a year before fading out. In contrast, a hot shock yields only a very mild increase (on the order of a few basis points) or no clear effect on headline inflation; any slight upward movement builds slowly and lacks statistical significance in the medium term. In short, headline inflation in the GCC rises in response to abnormal cold spells, while it shows little response to abnormal heat.

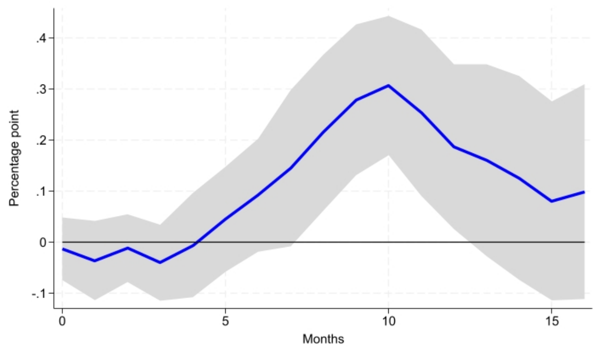
For food inflation (middle row), an $NTEMP$ shock triggers a sharp rise in food CPI inflation that is both larger in magnitude and more persistent than the effect of a $PTEMP$ shock. The IRF for food prices shows that after a brief initial dip, a cold shock leads to significantly higher food inflation after five months and remains elevated for around a year. For example, food inflation increases and peaks several months after the cold shock (with the response on the order of a few tenths of a percentage point) and stays positive for 10–12 months before gradually dissipating. In contrast, a positive temperature shock yields a much more muted response: food inflation either barely rises or even initially declines, and any increase is short-lived.

A similar asymmetry appears for the hospitality CPI (bottom row). Negative temperature shocks lead to a more pronounced and longer-lasting increase in hospitality prices, whereas positive shocks have only transient or negligible effects. Following an $NTEMP$ shock, hospitality inflation tends to rise after a short lag and can remain elevated for several quarters. This suggests that unexpected cold spells put upward pressure on costs

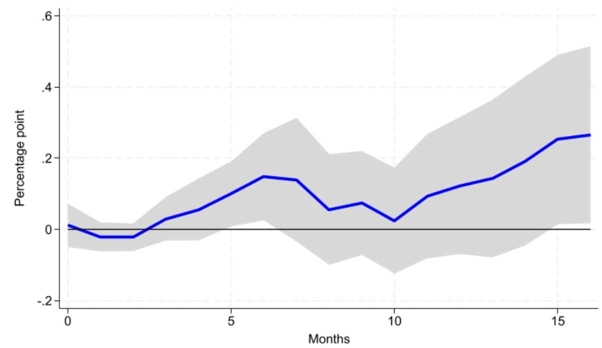
[17] The corresponding coefficient estimates with standard errors for all horizons are reported in Table A.2 in the Appendix.

Figure 10: Asymmetric effects of abnormal temperature shocks on inflation in the GCC

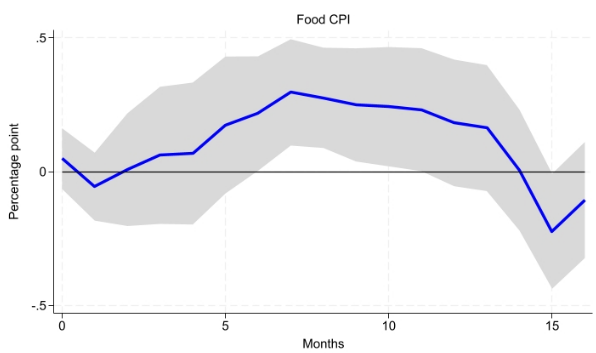
(a) Headline CPI: $NTEMP$



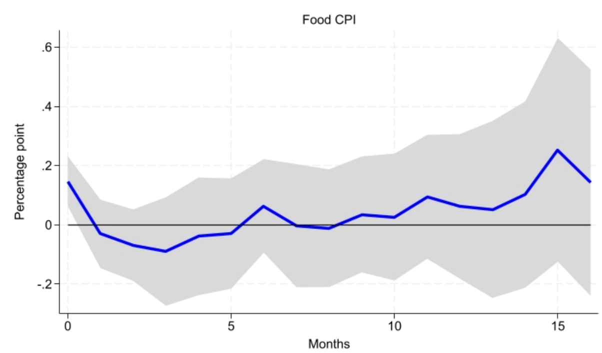
(b) Headline CPI: $PTEMP$



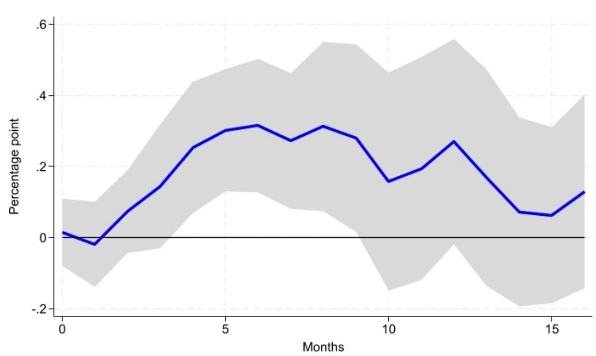
(c) Food CPI: $NTEMP$



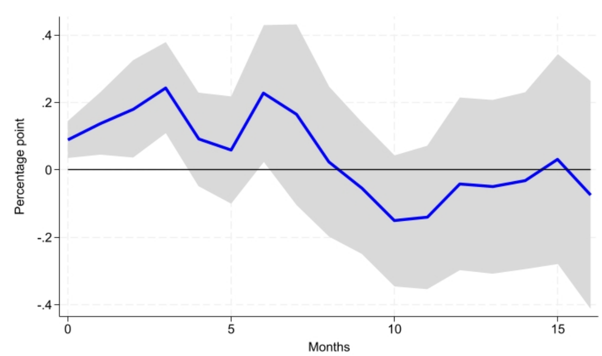
(d) Food CPI: $PTEMP$



(e) Hospitality CPI: $NTEMP$



(f) Hospitality CPI: $PTEMP$



Notes: Impulse responses from the panel local projections in (15). Shaded areas represent 90% confidence intervals.

or prices in sectors like hotels, restaurants, and leisure services. By contrast, the IRF for a $PTEMP$ shock in hospitality shows at most a small uptick in prices that reverses in the following months. In fact, after an initial mild increase, the hospitality CPI response to a hot-weather shock turns downward, implying any effect is short-term and possibly even offset by subsequent price adjustments (for instance, tourism demand may soften in extreme heat, tempering price growth).

These findings stand in contrast to the typical "heat-driven" inflation mechanism emphasized in the literature (Mukherjee and Ouattara, 2021; Faccia et al., 2021), and highlight that the temperature–inflation relationship is highly context-dependent. In the GCC, the conventional agricultural supply channel is relatively weak due to limited domestic crop production and heavy reliance on imports, and the marginal disruptive effect of additional heat may be attenuated by adaptation (e.g., cooling infrastructure and operational adjustments). By contrast, unseasonably cool conditions are comparatively rarer and also occurring during periods of elevated tourism activity that can amplify demand pressures in food-related services and hospitality. Overall, the evidence suggests that in the GCC it is the negative tail of temperature anomalies (not the positive tail) that is more relevant for inflation dynamics, consistent with nonlinear and asymmetric macroeconomic responses to weather shocks documented elsewhere (Faccia et al., 2021; Kim et al., 2022; Ciccarelli et al., 2024).

6 Conclusion

This study underscores the multifaceted impacts of climate variability on inflation within the GCC countries. By constructing a comprehensive measure of abnormal weather shocks and analyzing its effects on inflation and its sub-components, we provide detailed insights into how these shocks influence inflation dynamics in the region. Our findings reveal that the delayed but significant impact of weather shocks on overall inflation, coupled with their varying effects on different price components, highlights the need for a nuanced approach to policymaking. Policymakers should not only focus on the immediate consequences of weather events but also consider their medium-term effects on specific sub-components, particularly food prices.

The results highlight the role of external weather shocks in food-price dynamics across the GCC. Because GCC food markets are closely integrated with global supply chains, weather developments in major supplier countries can affect domestic food prices through import channels. This underscores the importance of considering global dimensions of climate risk in economic forecasts and policy planning. Policymakers in the GCC should prioritize strategies that enhance the resilience of their food supply chains, such as strengthen trade facilitation, maintain resilient logistics and storage arrangements to reduce dependency on a limited number of supplier countries. The fact that food inflation responds more strongly to shocks originating in supplier regions provides empirical support for the emphasis placed in national food-security agendas on import diversification and supply-chain resilience. When inflation risks are transmitted through a concentrated set of import partners, even well-functioning domestic distribution systems remain exposed to climate volatility abroad. Diversifying sourcing across a broader set of partners, especially across geographies that are not simultaneously exposed to the same climate hazards, can reduce the probability that a single adverse event translates into a broad-based and persistent rise in domestic food prices. Additionally, investing in climate-smart agriculture and strengthening local production capacities can increase the resilience of food supply chains against external abnormal weather shocks.

It is also worth noting that the relatively modest contemporaneous effect of local weather shocks on food inflation documented in our baseline results partly reflects the very low share of domestically sourced food in GCC consumption baskets. With approximately 85% of food imported, only a small fraction of the food CPI basket is directly exposed to local weather conditions. Ideally, the specification for the impact of local abnormal weather events on food inflation would be refined by controlling for the country- and time-varying share of locally produced food in total food consumption. Such data are not systematically available at the monthly frequency required by our estimation framework, but this refinement represents an important avenue for future work, particularly given its forward-looking policy relevance. As GCC countries advance food security strategies that include expanding domestic production, the composition of climate exposure will evolve, with a somewhat larger role for domestic conditions alongside external ones. This is precisely why national strategies pair expanded local production with investment in climate-resilient agricultural technologies, such as controlled-environment agriculture, desalination-fed irrigation, and precision farming, so that greater self-sufficiency reinforces overall resilience.

Future research avenues also include exploring the long-term impacts of climate variability on other economic indicators such as employment, investment, and productivity in the GCC region. Additionally, examining the effectiveness of specific adaptation and mitigation strategies in reducing the economic vulnerabilities associated with climate risks would provide valuable insights for policymakers. Further studies could also investigate the differential impacts of climate risks across various socio-economic groups, helping to design targeted policies that protect the most vulnerable populations. Expanding the geographic scope to include other regions with similar economic structures could enhance the generalizability of the findings and contribute to a more comprehensive understanding of the global economic impacts of climate change.

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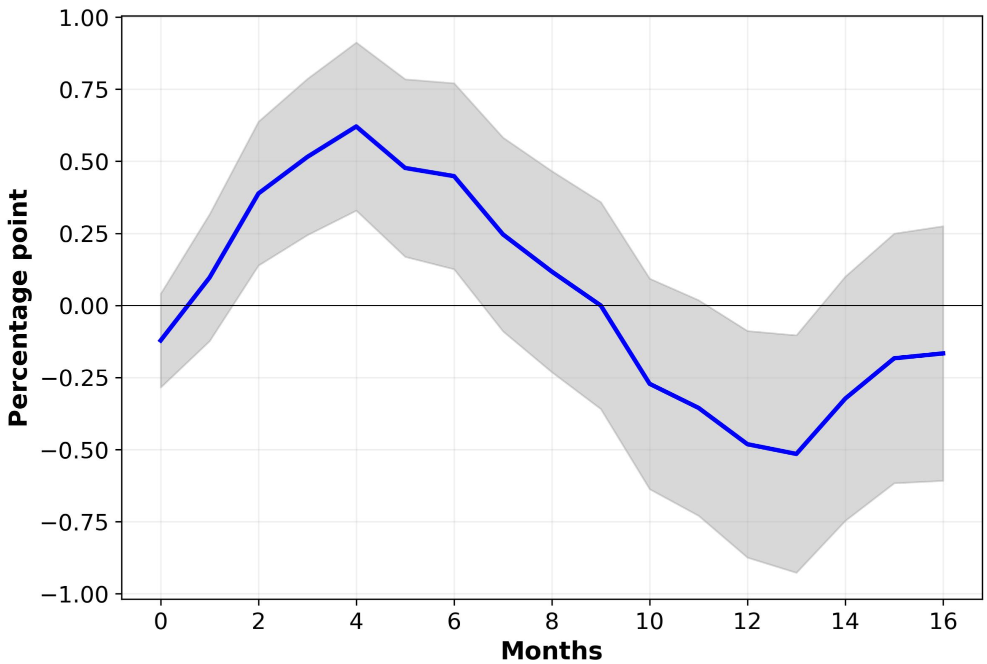
APPENDIX

A Additional Tables and Figures

Figure A.1: Robustness: impact of global weather shocks on food inflation using constant trade partners



Notes: Impulse response of food inflation to the constant-partner global climate risk measure ($GCRisk^{const}$), estimated jointly with local $CRisk$. The constant-partner set is defined as those appearing among the top 10 food-import partners in every year of the sample: Bahrain (7 partners), Kuwait (6), Oman (3), Qatar (3), Saudi Arabia (5), and UAE (6). Import weights are re-normalized to sum to one within each country's constant set. Shaded areas represent 90% confidence intervals.

Table A.1: Impact of media attention and climate risk on inflation sub-components

	Headline	Food	Housing	Hospitality	Transportation	Clothing
			Horizon 0			
CRisk	-0.011	0.011*	-0.061**	0.031	-0.061	0.021
	(0.024)	(0.006)	(0.027)	(0.038)	(0.190)	(0.078)
News(-1) X *CRisk*	-0.061***	-0.085**	-0.167***	-0.016	-0.012	-0.051**
	(0.023)	(0.041)	(0.017)	(0.017)	(0.078)	(0.023)
Observations	1058	993	993	993	993	993
R^2	0.11	0.28	0.12	0.06	0.11	0.01
			Horizon 1			
CRisk	-0.017	-0.088	-0.012	0.032	-0.202	0.036
	(0.049)	(0.094)	(0.145)	(0.078)	(0.271)	(0.184)
News(-1) X *CRisk*	-0.075**	-0.071	-0.172	-0.012	-0.019	-0.168***
	(0.033)	(0.073)	(0.071)	(0.044)	(0.129)	(0.036)
Observations	1052	987	987	987	987	987
R^2	0.16	0.38	0.16	0.10	0.16	0.01

Notes: The interaction term News(-1) × *CRisk* assesses whether lagged media attention to climate change moderates the inflation response to abnormal weather shocks. Standard errors, double-clustered by time and country, are in parentheses. ***, **, * denote significance at 1, 5, and 10% levels. Horizon h denotes the cumulative response h months after the shock, with Horizon 0 corresponding to the contemporaneous effect.

Table A.2: Asymmetric effects of abnormal temperature shocks on inflation: coefficient estimates

	Headline CPI		Food CPI		Hospitality CPI	
Horizon	$NTEMP$	$PTEMP$	$NTEMP$	$PTEMP$	$NTEMP$	$PTEMP$
0	−0.013	0.012	0.047	0.147**	−0.025	0.090*
	(0.037)	(0.029)	(0.079)	(0.062)	(0.076)	(0.049)
1	−0.036	−0.021	−0.058	−0.031	−0.080	0.138*
	(0.049)	(0.039)	(0.107)	(0.085)	(0.104)	(0.081)
2	−0.011	−0.022	0.004	−0.069	−0.007	0.181*
	(0.058)	(0.046)	(0.122)	(0.096)	(0.123)	(0.097)
3	−0.040	0.030	0.057	−0.091	0.036	0.244**
	(0.065)	(0.052)	(0.132)	(0.105)	(0.138)	(0.109)
4	−0.005	0.056	0.063	−0.040	0.213*	0.091
	(0.072)	(0.057)	(0.142)	(0.114)	(0.131)	(0.121)
5	0.045	0.100	0.169	−0.030	0.276*	0.059
	(0.077)	(0.062)	(0.150)	(0.121)	(0.163)	(0.130)
6	0.092	0.148*	0.211	0.063	0.216*	0.227
	(0.082)	(0.086)	(0.157)	(0.127)	(0.135)	(0.140)
7	0.145*	0.140	0.289*	−0.004	0.200*	0.164
	(0.087)	(0.093)	(0.164)	(0.133)	(0.144)	(0.147)
8	0.215**	0.056	0.269*	−0.012	0.301*	0.024
	(0.092)	(0.074)	(0.150)	(0.138)	(0.163)	(0.155)
9	0.279***	0.075	0.242*	0.034	0.303	−0.054
	(0.096)	(0.078)	(0.144)	(0.142)	(0.200)	(0.161)
10	0.307***	0.025	0.235*	0.025	0.223	−0.151
	(0.101)	(0.081)	(0.147)	(0.144)	(0.207)	(0.166)
11	0.254**	0.094	0.223	0.093	0.256	−0.141
	(0.105)	(0.085)	(0.182)	(0.148)	(0.212)	(0.171)
12	0.187*	0.124	0.173	0.061	0.288	−0.041
	(0.110)	(0.089)	(0.190)	(0.156)	(0.219)	(0.177)
13	0.161	0.143	0.154	0.051	0.190	−0.050
	(0.115)	(0.094)	(0.198)	(0.162)	(0.227)	(0.184)
14	0.126	0.193**	−0.002	0.101	0.087	−0.032
	(0.119)	(0.097)	(0.203)	(0.167)	(0.236)	(0.192)
15	0.081	0.253**	−0.230	0.252	0.051	0.032
	(0.122)	(0.100)	(0.207)	(0.170)	(0.244)	(0.199)
16	0.099	0.266**	−0.114	0.142	0.163	−0.074
	(0.126)	(0.104)	(0.211)	(0.175)	(0.251)	(0.206)
Obs.	1,058–962		993–897		993–897	

Notes: Coefficient estimates from the panel local projections in (15), with $PTEMP$ and $NTEMP$ included simultaneously. Standard errors, double-clustered by time and country, are in parentheses. ***, **, * denote significance at 1, 5, and 10% levels. Horizon h denotes the cumulative response h months after the shock.

B The Role of Media Attention on Climate Risk

This appendix examines whether media attention to climate change moderates the inflationary impact of abnormal weather shocks. Building on the idea that information dissemination can shape economic behavior (Boykoff and Boykoff, 2004; Muth, 1961), we extend the baseline specification with an interaction between lagged country-level climate news coverage and the climate risk measure:

$$\begin{aligned}\ln(P_{i,t+h}) - \ln(P_{i,t-1}) = \beta_1^h CRisk_{i,t} + \delta_1^h News_{i,t-1} + \phi_1^h (News_{i,t-1} \times CRisk_{i,t}) \\ + \sum_{n=1}^{12} \gamma_n^h \Delta \ln(P_{i,t-n}) + \alpha_i^h + \theta_t^h + \varepsilon_{i,t}^h \end{aligned} \tag{A.1}$$

where $News_{i,t-1}$ denotes the country-level monthly share of Bloomberg articles providing global coverage with local reference to "Climate Change", that is, articles published anywhere in the world that reference climate-related risks in the context of country i, constructed by normalizing the article count by total article volume and lagging it by one month to limit contemporaneous overlap between media coverage and local weather realizations.[18]

Table A.1 reports the results. The interaction term $News_{i,t-1} \times CRisk_{i,t}$ is consistently negative across CPI components, indicating that greater media attention is associated with a weaker pass-through of weather shocks to prices. At horizon 0, this dampening effect is statistically significant for headline CPI, food, housing, and clothing inflation. At horizon 1, it remains significant for headline CPI and clothing. The result is particularly noteworthy for food prices, where the baseline *CRisk* coefficient is positive and significant: the negative interaction suggests that heightened climate news coverage attenuates the contemporaneous food-price response to abnormal weather.

[18] The article count is thus not restricted to domestic media outlets; it captures global Bloomberg coverage that references country i in a climate context. This design choice reflects the view that internationally sourced climate reporting can influence expectations and behavior of local economic agents, for instance through coverage of cross-border supply chain risks or foreign climate policy developments. The lag accounts for the possibility that media may report on the same local weather events captured by $CRisk_{i,t}$.

These estimates are consistent with the view that greater salience of climate risks encourages anticipatory adjustments by supply-chain participants, such as inventory management and supplier diversification, thereby limiting the extent to which weather shocks translate into consumer price increases. We note, however, that precisely identifying the channel through which media attention operates remains challenging, and we therefore present these findings as suggestive evidence. Ideally, the role of information in moderating the pass-through of weather shocks would be examined through the lens of inflation expectations, which represent the most direct channel through which climate awareness could influence pricing behavior. However, adequate survey-based or market-implied measures of inflation expectations are not systematically available across GCC countries at the frequency and coverage required by our estimation framework.