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The transition to renewables: dampening the impact of fossil fuel price shocks on local inflation.

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Abstract

This paper investigates the role of renewable energy adoption in mitigating the impact of international fossil fuel shocks on local inflation. We focus on Latin America and the Caribbean (LAC), a region that has the highest share of renewables in its electricity matrix, but with significant heterogeneities across countries and over time. Our findings reveal that the renewable adoption on electricity generation has had a dampening effect of international fossil fuel price shocks on local inflation. The findings underscore the positive externality of renewable energy investment and its potential to enhance economic stability. Results are robust to different speeds of renewables adoption and matrix composition.

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Keywords: Energy transition; Crude oil; Gas; Inflation; LAC.

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Code to download and organize the data as well as perform analyses and produce the figures is publicly available from https://github.com/magcornejo/renewableenergy_inflation.

1. Introduction

Fossil fuel prices are inherently volatile and prone to significant shocks. The empirical literature has extensively analyzed the vulnerability of economies to such price shocks. Fossil fuel price fluctuations have been shown to negatively impact real economic activity (Berument et al., 2010; Baz et al., 2021), the balance of payments (Lebrand et al., 2024), stock markets (Park and Ratti, 2008; Kilian, 2009a), inflation dynamics (Cheikh et al., 2023; Choi et al., 2018; Gelos and Ustyugova, 2017; Ha et al., 2023), inflation expectations (Kilian and Zhou, 2022), and monetary policy (Tiwari et al., 2024).

Fossil fuel price fluctuations generally exert direct upward pressure on global inflation by raising the energy cost component of price indices, including products closely linked to energy, such as gasoline, natural gas, and electricity. The challenge posed by inflation driven by such cost increases becomes particularly complex for economies heavily reliant on fossil fuels. In this study, we investigate the differentiated impact of fossil fuel price pass-through on inflation, conditioned by the share of renewable energy in national electricity matrices. This approach allows us to explore the heterogeneity in pass-through effects based on the degree of clean energy adoption across Latin American and Caribbean (LAC) countries.

Over the past two decades, two notable episodes of fossil fuel price volatility have occurred. First, the price surge of 2007–2008 was driven by strong demand confronting stagnating global production. Second, the COVID-19 pandemic led to a dramatic decline in fossil fuel demand, causing hydrocarbon prices to plummet—at times nearing zero in some markets—and resulting in reduced investments in the sector (Baffes et al., 2015; Kilian, 2014). This decline in investment, coupled with the Russia-Ukraine conflict, which significantly disrupted natural gas supply, triggered a sharp spike in hydrocarbon prices, particularly natural gas. These events underscore the historical volatility of fossil fuel prices. These price swings have had direct economic consequences globally. For example, the recent rise in fossil fuel prices increased the average cost of living in Europe by approximately 7% in 2022 (Ari et al., 2022).

The transition to renewable, energy-efficient, and low-carbon technologies is crucial for meeting the objectives of the Paris Agreement. While this transition has gained prominence only recently, the composition of the electricity matrix in Latin America and the Caribbean has historically been shaped by the region's natural endowments. Countries with abundant hydropower potential, such as Brazil and Colombia, have developed robust hydroelectric industries, making them some of the largest hydroelectric power producers globally. Additionally, the availability of fossil fuels, the need to ensure energy security, and concerns over volatile international hydrocarbon prices have influenced the region's electricity policy (Rubio and Tafunell, 2014). These factors have driven significant investment in both hydropower and biofuels, resulting in LAC having the highest proportion of renewable energy in its electricity matrix worldwide. However, this share varies considerably across countries and over time. This context presents a valuable opportunity to explore the economic impacts of renewable energy adoption in the region.

Assessing the externalities associated with renewable energy adoption is critical for informed policymaking. This study contributes to the empirical literature by evaluating whether the adoption of renewable electricity in LAC has mitigated the effects of fossil fuel price shocks on overall and energy-related inflation. By highlighting the price stability benefits of energy transition, this work underscores the importance of investing in renewable energy. Moreover, it deepens our understanding of the broader economic impacts of transitioning to a low-carbon economy, particularly regarding how this shift alters the channels through which oil and hydrocarbon price volatility affects economies.

To address these issues, we analyze how fossil fuel price shocks are transmitted to inflation in LAC countries. First, we estimate fuel-specific price, global supply, and demand shocks using a Structural Vector Autoregressive (SVAR) model. Second, we quantify the impact of these shocks on energy and headline inflation by estimating local projection-based impulse response functions (IRFs) within a state-dependent panel model. Specifically, we employ a smooth transition model with a logistic function to capture the shift between two regimes: a low renewable integration (LR) electricity matrix and a high renewable integration (HR) matrix. Our analysis is based on a panel dataset of 18 LAC countries, covering the period from January 2005 to December 2021 ($T = 204$).

Our results indicate that the pass-through effect of international crude oil prices on energy inflation is significantly higher in countries with greater reliance on fossil fuels in their electricity matrices compared to those with higher renewable energy integration. Among the various types of shocks, fuel-specific demand shocks and oil demand shocks have the most pronounced impact on inflation. Specifically, the cumulative impact of a one-standard-deviation crude oil price shock (an 11% monthly increase on average during the sample period) on energy inflation is approximately 0.1 percentage points over nine months in countries with a less renewable electricity matrix. This effect is seven times larger than in countries with high renewable energy integration. While the impact on headline inflation is significant, it is notably smaller than the effect on energy-related inflation.

Our analysis of natural gas prices indicates that global demand shocks are the most significant driver of price volatility, particularly for countries with a higher reliance on fossil fuels. While global supply and price shocks also impact natural gas prices, the differences in their effects across countries with varying levels of renewable energy integration are less pronounced. Notably, our results remain robust even when we adjust parameters such as the speed of regime transitions and the definition of the renewable energy matrix.

The paper is structured as follows. Section 2 introduces the relationship between international fossil fuel prices, inflation, and electricity matrices. Section 3 describes the data and methodology used to estimate the impact of fossil fuel price shocks on both headline and energy inflation, considering the level of renewable electricity generation. Section 4 discusses the main findings and tests the robustness of the results. Finally, Section 5 presents the discussions.

2. Literature review

This section delves into the arguments supporting the pass-through effect of international fossil fuel prices on inflation and the role of the electricity matrix in facilitating this transmission. It also discusses the intricate relationship between the energy sector and inflation, including possible asymmetries. In the following sections, this background sets the stage for defining the key variables needed to analyze pass-through effects.

2.1. The pass-through from oil prices to inflation

Fossil fuels play an important role in the global economy, serving as the most relevant energy source for economic activities. Consequently, any change in the price of these commodities has noteworthy implications for the economy as a whole. Empirical studies highlight the substantial impact of oil price fluctuations on inflation. Some studies focus on individual countries (Kilian, 2009a; Tiwari et al., 2019), while others analyze groups of countries to identify factors that may explain differences between groups in the effects of price shocks on inflation (Aharon et al., 2023; Choi et al., 2018; Gelos and Ustyugova, 2017; López-Villavicencio and Pourroy, 2019; Zakaria et al., 2021).

The impact of oil price shocks on inflation pass-through is heterogeneous and has likely evolved due to factors such as globalization, oil crises, development of oil substitutes, financial instability, real wage rigidities, shifts in institutional and technological structures, and the share of oil in production and consumption (Bachmeier and Cha, 2011; Blanchard and Gali, 2007; Ha et al., 2023). Tiwari et al. (2019) study the long-term relationship between oil prices and U.S. inflation from 1871 to 2018. The authors find that this relationship has changed over time, likely due to significant structural changes that have altered the role of fossil fuels relative to renewable fuels in the economy.

Empirical studies often employ the decomposition method pioneered by Kilian (2009a, 2019a) to ensure that pass-through estimates primarily capture exogenous drivers of fossil fuel price fluctuations. Oil real price shocks are structurally divided into oil supply, global demand, and oil-specific demand shocks. Oil supply shocks occur when global crude oil supplies are disrupted. Global demand shocks are caused by fluctuations in the overall demand for industrial goods due to changes in global economic activity. Meanwhile, oil-specific demand shocks stem from changes in the precautionary demand for crude oil, often driven by concerns about future oil supply availability. Kilian (2009a) shows that the implications of higher oil prices for U.S. real GDP and inflation rely on the underlying cause of the oil price increase.

The relationship between fossil fuel prices or component shocks and inflation has been extensively researched, resulting in diverse findings. A common approach to identifying key factors influencing the varying impacts of fossil fuel shocks across economies involves analyzing groups of countries. Choi et al. (2018) analyze 72 economies and do not find significant differences between advanced and developing economies. López-Villavicencio and Pourroy (2019) investigate the influence of inflation targeting on the pass-through of oil prices. Their findings suggest that countries adopting inflation targeting strategies experience a higher pass-through compared to non-inflation-targeting countries.

Recent studies have analyzed the pass-through of oil price shocks to inflation from regional perspectives. Bigerna (2024) examines the pass-through in the Middle East and North Africa (MENA) region, while Aharon et al. (2023) focus on five ASEAN countries and three East Asian countries. Both studies found significant asymmetry between oil prices and inflation. Zakaria et al. (2021) analyze the impact of global oil prices on inflation rates in South Asian countries using monthly data from 1980 to 2018, identifying significant oil price shock asymmetries in inflation.

2.2. Empirical evidence of the role of energy variables in driving inflation

Global energy commodity price shocks have a dual impact on final consumer prices: direct and indirect. Direct effects manifest as higher prices for energy goods used as final products such as electricity, natural gas, gasoline, LPG, and diesel. Indirectly, these shocks increase production costs for energy-intensive industries, which often pass on these costs to consumers through higher product or service prices. This ripple effect extends to industries like plastics, chemicals, fertilizers, heavy industries, and service sectors such as public transportation. However, many of these effects depend on producers' ability to pass on consumer cost increases and the market design of industries such as electricity. Additionally, wage demands in response to higher energy costs, often referred to as second-round effects, can further amplify the overall impact on consumers (Baba and Lee, 2022; Blanchard and Gali, 2007). The most immediate impact of fossil fuel price spikes is often felt through the energy component of inflation. For example, Kilian and Zhou (2022) highlight that 2021 energy price fluctuations primarily influenced headline inflation in the United States through the energy component of the Consumer Price Index, with only modest effects on core inflation.

Previous studies have used energy-related variables to explain differences in the pass-through of fossil fuel prices to inflation. Blanchard and Gali (2007) highlight that the share of oil in consumption and production may be a key factor in understanding the evolving impact of oil price shocks. Bachmeier and Cha (2011) complement prior work by showing that decreases in energy intensity and sensitivity to monetary policy account for the reduced impact of oil shocks from 1973-85 to 1986-2006. They attribute two-thirds of the reduced impact on core inflation to changes in energy intensity and one-third to monetary policy.

Choi et al. (2018) find that the share of transportation costs within the Consumer Price Index (CPI) basket is the most robust determinant of cross-country variations in inflation responses to oil price fluctuations. The authors attribute this to both a mechanical effect and indirect second-round effects. In contrast, other relevant factors, such as monetary policy, exhibit limited explanatory power in accounting for these differences. Similarly, Gelos and Ustyugova (2017) show that countries with higher oil intensities are more likely to experience stronger inflationary effects from fuel price shocks than countries with lower oil intensity.

Additionally, studies have explored the relationship between energy commodity import dependence and the pass-through of oil price shocks to inflation. Salisu et al. (2017)

and Ha et al. (2023) find that net oil-importing countries generally experience a more significant impact of oil price shocks on inflation compared to oil-exporting countries. A plausible cause of differences in the pass-through magnitude is the electricity matrix's composition. Ganapati et al. (2020) analyze how variations in energy input costs, particularly electricity, influence the welfare distribution between U.S. manufacturing producers and consumers. Leveraging the pre-deregulation structure of the electricity industry, where prices for industrial consumers were primarily dictated by the utility's fuel mix within monopolistic zones, they assess the impact of fuel input price shocks. Their findings indicate that approximately 70% of energy price-driven changes in input costs are passed through to consumers over the short- to medium-term, highlighting the substantial role of electricity structure in cost transmission mechanisms across industries.

The historical dependence on fossil fuel imports has played a pivotal role in adopting alternative electricity generation sources, such as hydropower. In Latin America, this shift was particularly pronounced. The escalating cost of oil in the 1970s made it increasingly unaffordable for many countries, prompting a transition to hydropower as a more viable energy source (Rubio and Tafunell, 2014). Other determinants of the cleanliness of the electricity matrix in some Latin American countries have been natural endowments, mainly hydroelectric potential, as well as energy demand and trade (Rubio and Folchi, 2012).

Building upon Kilian (2009a)'s decomposition analysis, energy variables have been identified as significant determinants of specific types of shocks. Peersman and Van Robays (2012) highlights that while oil and other energy forms play a less significant role in explaining differences arising from global or oil-specific demand shocks, oil's role is crucial in understanding asymmetries in the effects of exogenous oil supply shocks. Moreover, countries that have strengthened their net energy position over time have exhibited greater resilience to oil supply shocks compared to those with less favorable energy balances.

The electricity mix in Latin America and the Caribbean provides a valuable opportunity to examine the economic benefits of transitioning to renewable energy sources. This study specifically focuses on the electricity mix due to its greater variability across countries and over time compared to other measures, such as total energy supply. The primary source of variability in total energy supply is closely associated with developments in the electricity sector.

2.3. The role of the electricity matrix in fossil fuel price shock transmission

Overall, Latin America and the Caribbean has one of the lowest share of fossil fuels on energy matrices. Between 2015 and 2021, fossil fuels accounted for about 61% of the region's total primary energy supply: oil 36%, natural gas 27%, and coal 5% (OLADE, 2022). Substantial heterogeneity exists among the energy matrices of LAC countries. This variation is primarily due to differing dependence on hydropower and other renewable resources for electricity generation, which plays a crucial role in the region's energy diversity.

Electricity, a key vector for energy decarbonization (IEA, 2022; Perez-Arriaga et al., 2016), accounted for 17% of the Latin American and Caribbean (LAC) region's final energy consumption between 2005 and 2021. Projections suggest this share will exceed 25% by 2050 (IEA, 2023). Globally, Latin America and the Caribbean stands out for having one of the highest proportions of renewable energy in its electricity matrix, largely explained by its hydroelectric installed capacity. Nevertheless, there is notable heterogeneity across the region. For instance, countries like Costa Rica, Colombia, Panama, and Uruguay generate most of their electricity from renewable sources, while fossil fuels play a significant role in electricity generation in countries such as Bolivia, Chile, Mexico, and Jamaica. Even in regions with a predominantly renewable electricity matrix, fossil fuel prices can still exert some influence on these markets. For example, thermal plants often set marginal electricity prices during peak demand or periods of low hydropower availability (e.g., El Niño) in many LAC countries (OLADE, 2022). However, this impact is typically limited in duration and has a limited impact on average wholesale prices.

Natural gas, oil, and their derivatives are the primary inputs for thermal electricity generation in Latin America and the Caribbean. While distinct, the natural gas, oil, and electricity markets exhibit significant interdependencies due to geographical, temporal, and technological factors. These interconnections give rise to unique price formation mechanisms. A vertical relationship exists where hydrocarbons serve as inputs for electricity generation. While a horizontal relationship arises from the substitutability of different fuels in meeting energy demand. Furthermore, the co-production of certain fossil fuels, such as associated natural gas and oil, creates additional linkages between their respective prices. Electricity generation systems offer fuel substitution flexibility, primarily determined by merit order dispatch. Power plants often switch between fuels, providing short-term adaptability to price fluctuations. However, when all available generation capacity is utilized during peak demand periods, the scope for fuel substitution is limited.

The extent to which fossil fuel prices influence electricity prices depends on the composition of the electricity generation mix and the design of the electricity market. Regions with a higher proportion of fossil fuel-based generation tend to exhibit a stronger correlation between electricity and fossil fuel prices (Balza et al., 2024a). For instance, Zakeri et al. (2023) find that coal and natural gas plants were the primary price-setters in the European electricity market during the 2015-2021 period, especially in regions with a higher share of fossil fuels. The growing integration of renewable energy sources has gradually reduced the influence of fossil fuels on electricity prices.

The potential inflationary impact of rising fossil fuel prices due to the electricity matrix may be challenging to quantify. The intricate nature of electricity pricing mechanisms in the Latin America and Caribbean region can constrain the pass-through of these costs to electricity tariffs. The region's electricity markets exhibit significant diversity, shaped by diverse institutional and regulatory frameworks. While transmission and distribution are generally regulated, the degree of liberalization in wholesale electricity markets varies across countries. For example, Brazil and Colombia have relatively liberalized markets for large consumers, whereas most LAC countries rely on regulated tariffs to pass generation costs to final consumers. Consequently, the mechanisms through which fossil fuel costs are reflected in electricity tariffs are both complex and varied, depending on the structure of wholesale markets and regulatory frameworks.

The transmission of international oil and gas price shocks to electricity prices is influenced by the relationship between international and domestic energy markets, as well as by market structures and subsidies (Choi et al., 2018). Despite varying regulatory frameworks and time horizons, persistent changes in international energy prices eventually impact consumers, albeit with varying degrees of pass-through. Therefore, the analysis presented here should be interpreted within the context of these diverse transmission mechanisms and the assumptions about complete pass-through and limited factor substitution.

2.4. Asymmetric relationship between fossil fuel prices and inflation

The concept of asymmetry in price transmission implies that rising oil prices tend to trigger a faster response in inflation rates than when prices decline. Choi et al. (2018) find evidence of an asymmetric impact of oil price shocks, with positive shocks having a greater effect than negative ones. Li and Guo (2022) identify a similar asymmetry in the short-run relationship between oil prices and inflation in China, although such asymmetry was either weak or nonexistent in other BRIC countries. Lacheheb and Sirag (2019) study the Algerian case using a nonlinear approach and confirmed the existence of asymmetric behavior in the relationship between oil shocks and CPI variations.

Husaini and Lean (2021) analyze the pass-through of oil prices to inflation in a group of Southeast Asian emerging economies. Their findings indicate that increases in oil prices have a more pronounced impact on the Consumer Price Index (CPI) in all countries. However, a decrease in oil prices was only found to be significant in one country. López-Villavicencio and Pourroy (2019) compared the pass-through of oil prices to consumer prices in inflation-targeting and non-inflation-targeting countries. While there were minimal differences in how oil price increases affected consumer prices, the study revealed that inflation-targeting countries experienced a higher pass-through when oil prices declined.

2.5. The literature gap and contribution

This research contributes to the existing literature in at least four ways by examining how oil and natural gas price changes influence inflation and its energy component. First, it presents a novel approach to analyzing the impact of oil and natural gas price shocks on inflation in the Latin America and Caribbean region by leveraging the heterogeneity of electricity matrices. Second, by distinguishing between positive and negative shocks, the study examines potential asymmetries in the inflation response conditioned by the electricity matrix. Third, it expands our understanding of the diverse energy variables that can influence the pass-through of international fossil fuel prices to inflation, building upon the work of Ganapati et al. (2020), Choi et al. (2018), Gelos and Ustyugova (2017), and Peersman and Van Robays (2012). Fourth, this study complements existing research on the broader implications of energy resource diversification, which has primarily focused on economic activity and development. Our analysis contributes to a growing body of literature exploring the multifaceted impacts of energy diversification, as exemplified by the work of Balza et al. (2024b), Burke (2013), Chen et al. (2024), Juhro et al. (2024), and Gozgor and Paramati (2022).

3. Data and methodology

Our identification strategy consists of a two-stage approach. In the first stage, we identify global fuel price shocks through a structural model of the global oil and natural gas markets following the methodology in Kilian (2009a). In the second stage, we estimate the transmission of those shocks to local inflation conditioned by an electricity matrix with low or high penetration of renewable electricity using local projection methods for a panel data (Jordà, 2005).

3.1. Global fuel price shocks identification

To identify global fossil fuel price shocks, we estimate a Structural Vector Autoregressive (SVAR) model as developed by Kilian (2009a) based on monthly data for $Y_t = (\Delta prod_t, \Delta rea_t, \Delta price_t)'$, where $\Delta prod_t$ is the monthly log-difference in global fossil-fuel production, Δrea_t denotes the monthly log-difference index of real economic activity as proposed in Kilian (2009a) with the correction discussed in Kilian (2019a), and $\Delta price_t$ is the monthly log-difference of real price of fossil fuels.[1] The sample period is 2004:1-2021:12 for both fossil fuels.[2] For each fossil fuel price (i.e. oil and natural gas), we identify three types of shocks: fossil fuel supply, fossil fuel-specific demand, and aggregate demand shocks by estimating the following SVAR model:

$$\mathbf{A_0 Y_t} = \alpha + \sum_{i=1}^{k} \mathbf{A_i Y_{t-i}} + \varepsilon_t \tag{1}$$

where $\boldsymbol{\varepsilon_t}$ denotes the vector of serially and mutually uncorrelated structural innovations and k is the lag length that minimizes AIC. We assume that $\mathbf{A_0^{-1}}$ has a recursive structure such that the reduced-form errors e_t can be decomposed according to $\mathbf{e_t} \equiv \mathbf{A_0^{-1}} \boldsymbol{\varepsilon_t}$:

$$\mathbf{e_t} \equiv \begin{pmatrix} e_t^{\Delta prod} \\ e_t^{\Delta rea} \\ e_t^{\Delta price} \end{pmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{21} & a_{22} & 0 \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{pmatrix} \varepsilon_t^{fuel\ supply\ shock} \\ \varepsilon_t^{aggregate\ demand\ shock} \\ \varepsilon_t^{fossil\ fuel\ specific-demand\ shock} \end{pmatrix} \tag{2}$$

The structural shocks are estimated via parametric non-Gaussian maximum likelihood[3] as described by Lanne et al. (2017) using the restriction matrix proposed in equation (2). This model allows us to identify the three structural shocks for each fossil fuel based on the following assumptions:

- Fossil fuel supply shocks are defined as unpredictable innovations to global fossil fuel production. Fossil fuel supply is assumed not to respond to innovations to the demand for fossil fuel within the same month. Fossil fuel-producing countries are assumed to be slow to respond to demand shocks, given the costs of adjusting

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[1] Nominal prices are deflated by the U.S. consumer price index.

[2] The sample period starts in 2004:1 to estimate structural shocks from 2005:1 to 2021:12 after evaluating up to 12 lags.

[3] The independent structural innovations are assumed to exhibit a Student t-distribution.

production and the uncertainty about the state of the global fossil fuel market. This vertical short-run supply curve assumption seems reasonable on a monthly basis.

- Aggregate demand shocks are innovations to global real economic activity (as a proxy of global demand for industrial commodities) that cannot be explained based on fossil fuel supply shocks. This exclusion restriction implies that increases in the real price of fossil fuels driven by shocks that are specific to the fossil fuel market will not lower global real economic activity immediately, but with a delay of at least one month.

- Fossil fuel-specific demand shocks are innovation to the real price of fossil fuels that cannot be explained based on supply shocks or aggregate demand shocks, reflecting changes in the demand for these fossil fuels as opposed to changes in the demand for all industrial commodities. This latter structural shock will reflect fluctuations in precautionary demand for fossil fuels driven by uncertainty about future fossil fuel supply shortfalls.

Figure 1 plots the time path of the structural oil and natural gas shocks implied by the model for the period 2005:1-2021:12. Figures A1 and A2 in the Appendix show the impulse-response analysis for crude oil and natural gas, respectively. After identifying these structural shocks $\boldsymbol{\varepsilon}_t$, we use them to study the pass-through of fossil fuel price shocks to inflation in LAC.

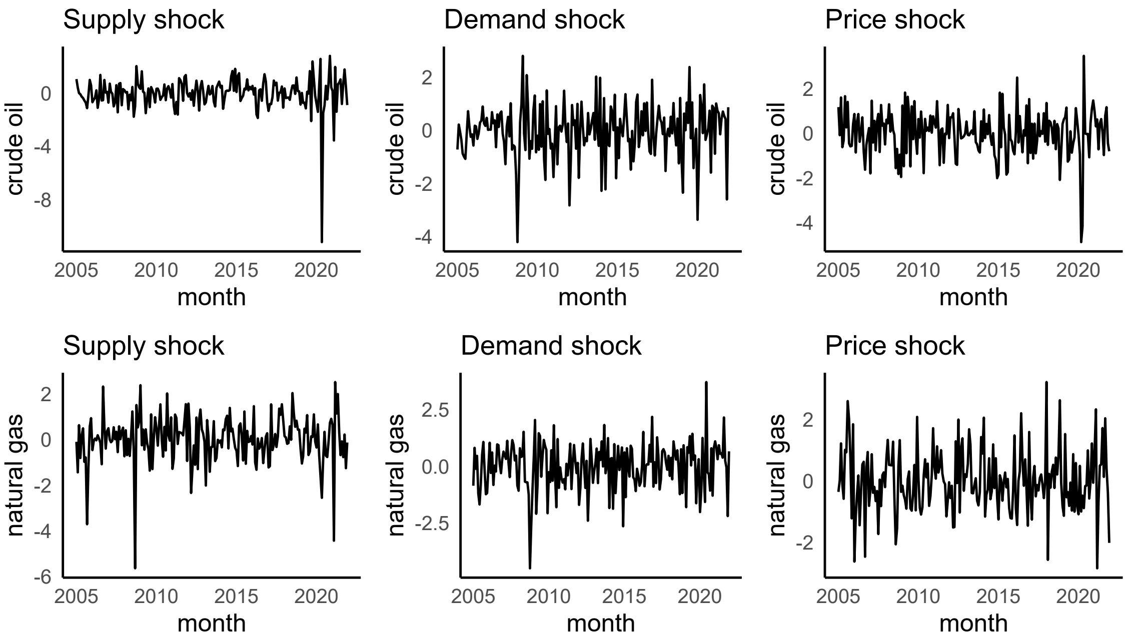

Figure 1: Historical evolution of the structural shocks, 2005:1-2021:12. *Note*: structural residuals implied by equation 1.

3.2. The pass-through estimation

To estimate the impact of the fossil fuel price shocks on domestic inflation, we follow the method proposed by Jordà (2005) which consists of estimating impulse response functions (IRFs) directly from local projections. Obtaining IRF using local projections has the advantage of estimating the parameters sequentially for each horizon of interest rather than extrapolating the parameters to increasingly distant horizons.

We consider a panel of 18 LAC countries spanning from 2005:1-2021:12 ($T = 204$).[4] The main advantage of working with a panel is that it allows capturing individual and temporal heterogeneities. The sample period starts in 2005 because prior to the 2000s there was no consolidated international market for natural gas and its price was largely correlated with oil. Although natural gas prices in HUBs are of considerable importance, many markets still remain segmented and do not reach the level of integration observed in crude oil markets. In this context, in many instances, gas prices are still indexed to various pricing formulas, which can incorporate both international

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[4] Due to data availability, the sample comprises the following 18 countries: Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, and Uruguay. Argentina was excluded from the analysis as it showed a persistent inflation during the period of study.

oil prices and local natural gas prices. Over the last decade, the dependence of natural gas prices on oil prices has decreased significantly, a phenomenon largely attributable to the shale gas revolution (Albrizio et al., 2022). In this paper, the HUB Henry Hub natural gas price is adopted as a proxy measure, given its relevance for many countries in the region, including Mexico, reflecting its importance in the economic analysis of energy markets. Figure 2 shows the evolution of the real crude oil and natural gas prices over the sample period.

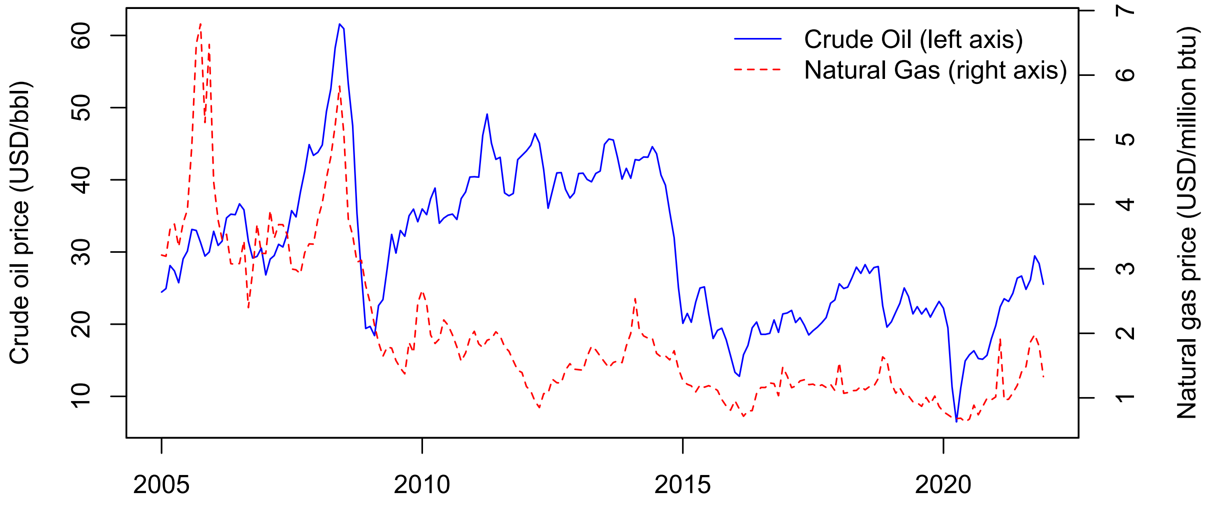

Figure 2: Real fossil fuel prices, 2005:1-2021:12.

This study aims to disentangle the effect of the two fossil fuel price shocks: oil and natural gas on local inflation rates. We follow Auerbach and Gorodnichenko (2012, 2013)'s nonlinear approach and use the local projection method to estimate the IRFs in a state-dependent model. Specifically, we estimate a smooth transition model using a logistic function as the transition between two different states: a low renewable electricity matrix (LR) and a high renewable electricity matrix (HR).[5]

Figure 3 shows the evolution of electricity generation by source to visualize the electricity transition in each LAC country over the 2005-2021 period.

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[5] Renewable electricity sources include hydropower, solar power, wind, geothermal, and biomass.

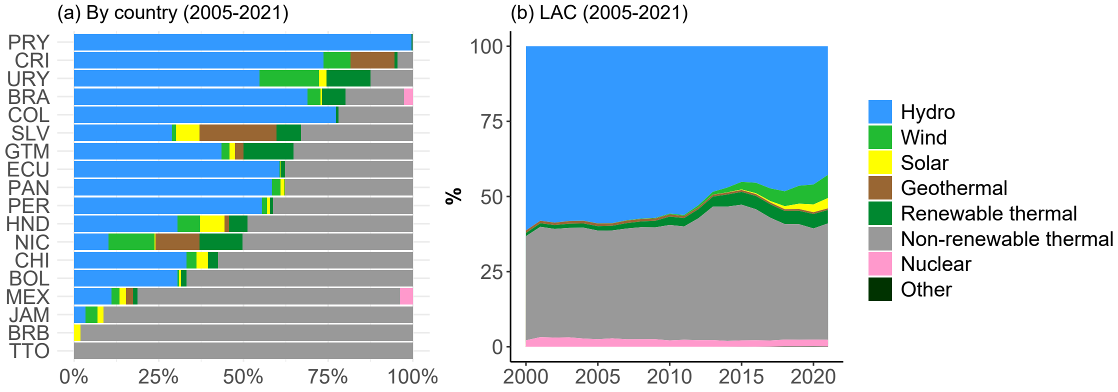

Figure 3: Electricity generation by source (%).

In the region we can observe a great heterogeneity in the production of renewable electricity between countries and over time. On the one hand, the region has some countries such as Paraguay, Brazil, Costa Rica and Uruguay that have generated most of their electricity from renewable sources throughout the period (mainly hydroelectric). On the other hand, countries such as Barbados, Jamaica, Trinidad and Tobago, and Mexico show a very low proportion of electricity generated from renewable sources during the entire period. Other countries, such as Ecuador, El Salvador, Honduras, Guatemala and Nicaragua show great heterogeneity in renewable electricity production over time. There are different explanations for the variability of renewable capacity in LAC, such as natural resources, strategic investment choices in the last decades and availability of hydrocarbons. Moreover, the generation is also impacted by the variability hydro regimes in the region which is often impacted by the El Niño phenomena. LAC power generation from hydroelectric plants are strongly impacted by weather conditions, in dry periods the demand for thermal power plants are higher.

Therefore, to estimate the pass-through of fossil fuel shocks on local inflation conditioned by the level of renewable electricity generation we estimate the following reduced-form equation on monthly data for each h period,

$$
\begin{aligned}
\pi_{i,t+h} = \alpha_{i,h} + F(z_{i,t}) \left[\sum_{l=1}^{12} \mu_{LR,l}^{h} \pi_{i,t-l} + \beta_{LR}^{h} shock_t + \sum_{l=0}^{12} \theta_{LR,l}^{h} x_{i,t-l} \right] \\
+ (1 - F(z_{i,t})) \left[\sum_{l=1}^{12} \mu_{HR,l}^{h} \pi_{i,t-l} + \beta_{HR}^{h} shock_t + \sum_{l=0}^{12} \theta_{HR,l}^{h} x_{i,t-l} \right] + \varepsilon_{i,t+h}
\end{aligned} \tag{3}
$$

where π_{it} represents the inflation rate, as the monthly log difference of the consumer price index (i.e. all items or energy component), for country i on month t. α_i are the horizon-specific country fixed effects and $F(z_{i,t})$ can be interpreted as the probability of having a non-renewable electricity matrix in country i at time t based on a transition variable $z_{i,t}$. We construct $F(z_{i,t}) = \frac{exp(-\gamma z_{i,t})}{1 + exp(-\gamma z_{i,t})}$ with $\gamma > 0$, where $z_{i,t}$ is last year's share of renewable electricity generation which is normalized to have zero mean and unit variance. Therefore, $F(z_{i,t})$ denotes the probability of being in a low renewable state in country i. The smoothness parameter, γ, determines the speed of transition of the transition function towards the inner or outer regime as well as the degree of nonlinearity. In this case, we choose $\gamma = 3$ which allows a slightly slow speed for regime transitions. Alternative values of γ are evaluated in subsection *4.3.* The variable $shock_t$ refers to the structural fossil fuel shocks (i.e. oil or natural gas) identified previously. $x_{i,t-l}$ is a set of control variables that includes the percentage change in the exchange rate (national currency/dollar), a dummy variable that takes the value 1 if the country has an inflation targeting monetary policy, and the ratio of government expenditure to gross domestic product to proxy electricity subsidies.[6] Finally, $\varepsilon_{i,t}$ represents the error term.

To obtain the IRFs of the average effect of different global fossil fuel price shocks on local inflation, equation 3 is estimated for each horizon h (we choose $h = 12$) and the β^h coefficients show the response of the dependent variable (i.e. headline inflation or energy inflation) in h to an exogenous shock in t conditioned by the degree of renewable electricity generation.

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[6] The ratio of public spending to Gross Domestic Product (GDP) was considered as a proxy measure designed to capture subsidies of a fiscal nature implemented by governments in response to high international energy commodity prices. These fiscal subsidies tend to exhibit greater variability over time compared to other types of subsidies. Subsidies of a different nature, such as cross-subsidies and financial subsidies, are not included in this analysis as their impact varies significantly across different sectors of the economy (i.e. industrial or domestic, for different income levels or regions), and addressing this variation would require a more detailed country-level analysis.

4. Results

4.1. Baseline results

The reduced-form VAR model is consistently estimated by the least-squares method. The resulting estimates are used to construct the structural VAR representation of the model. The last rows in Figures A1 and A2 show the responses of real oil and natural gas prices to the three types of shocks identified through the SVAR model defined in equation (1).

Prices respond differently depending on the source of the shock. Unexpected and positive fossil fuel-specific demand shocks have an immediate and larger impact than other types of shocks. Nonetheless, supply shocks also trigger a partially significant decrease in the real prices. Aggregate demand shocks have the lowest impact. The different shocks tend to be transitionary.

Figure 4 and 5 shows the cumulative response of monthly local headline inflation and energy inflation to a one standard deviation fossil fuel shock as defined in equation (3).

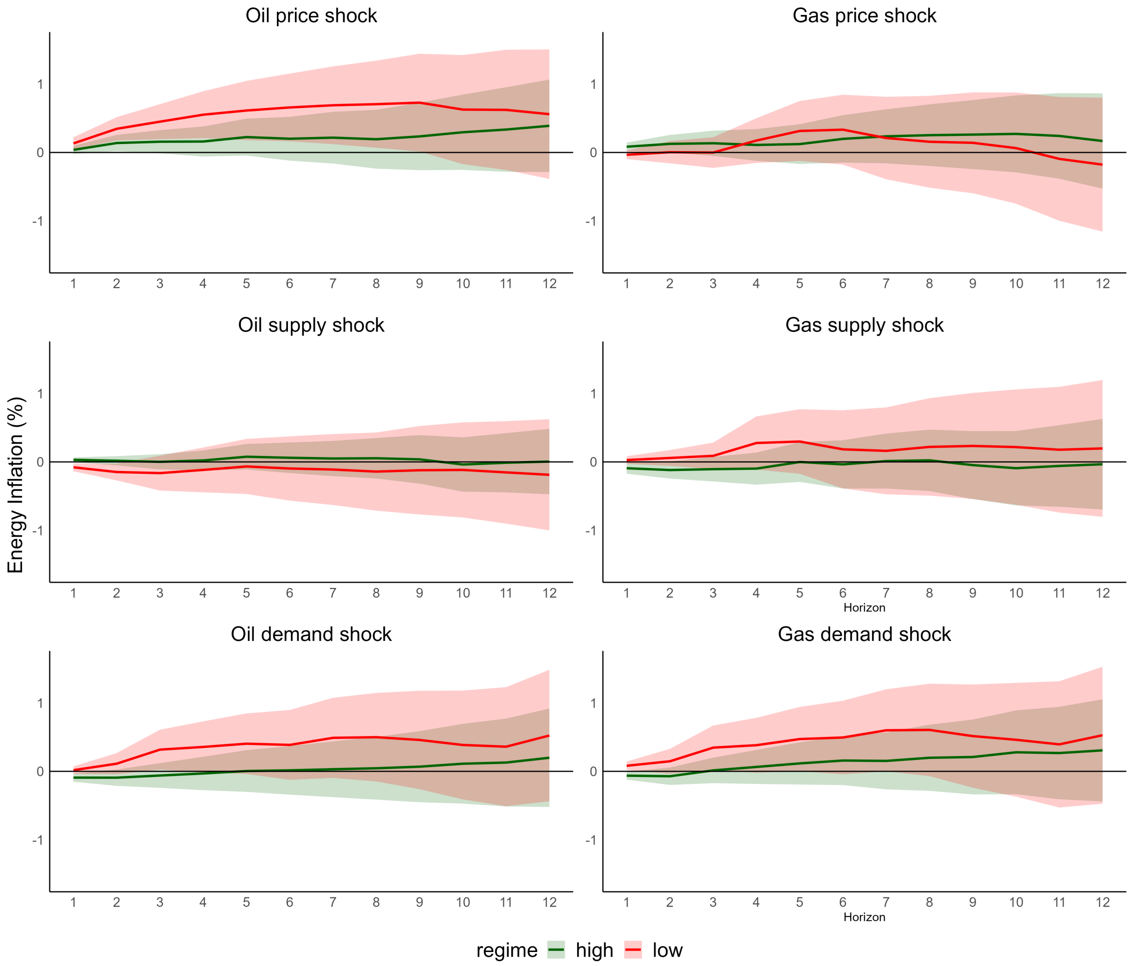

Figure 4: Cumulative response of energy inflation to structural crude oil and natural gas shocks conditional on the degree of renewable electricity generation.

Notes: The first and second columns show the cumulative response of energy inflation to crude oil and natural gas shocks, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.

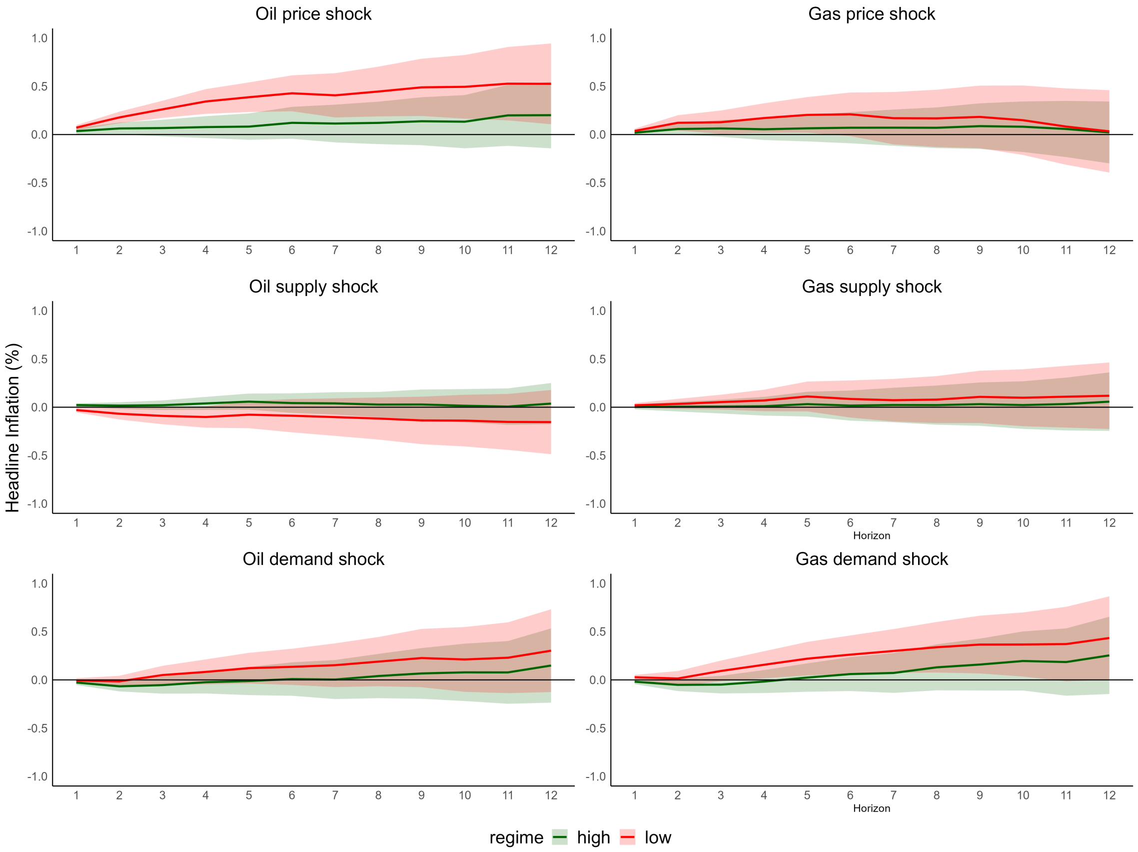

Figure 5: Cumulative response of headline inflation to structural crude oil and natural gas price shocks conditional on the degree of renewable electricity generation.
Notes: The first and second columns show the cumulative response of energy inflation to crude oil and natural gas shocks, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.

Both monthly inflation rates are sensible to crude oil price shocks, and in a lesser extent to natural gas shocks. Oil shocks are more persistent than natural gas shocks as there is still a high share of petroleum derivatives in the region's final energy consumption. Oil and natural gas shocks have a lower cumulative effect on headline inflation with respect to energy inflation.

There is a difference between countries with low or high levels of renewable electricity generation. Overall, results show that the electricity transition based on a higher share of renewable energies in each country's electricity generation had a dampening effect on international fossil fuel price shocks pass-through. The impact is statistically insignificant for countries with a high share of renewable electricity generation.

For energy inflation, the cumulative effect over nine months of a one standard deviation crude oil price shock - equivalent to a monthly increase of almost 11% over the sample period - is around 0.73 percentage points for countries that have not transitioned their electricity matrix. This impact, with a persistence of nine months, is seven times higher than in countries with a high-renewable electricity matrix.

For headline inflation, a one standard deviation crude oil price shock has a lower impact - a cumulative effect over nine months of 0.49 percentage points for low-renewable countries, but it is more persistent. It has a significant cumulative effect over sixteen months for low-renewable countries.

4.2. Asymmetry in the transmission of fossil fuel price shocks

This paper also studies the possible asymmetric responses of local inflation rates to positive or negative shocks of equal magnitude in international fossil fuel prices. Recent evidence suggest that positive shocks have a greater impact on local inflation rates than negative shocks of equal magnitude (Abbas and Lan, 2020; Bala and Chin, 2018; Choi et al., 2018).

To assess this asymmetrical effect we extend the model represented in 3 by replacing the shocks as follows:

$$shock_t^{pos} = shock_t \quad \text{if } shock_t > 0, \ = 0 \text{ otherwise} \tag{4}$$

$$shock_t^{neg} = |shock_t| \quad \text{if } shock_t < 0, \ = 0 \text{ otherwise} \tag{5}$$

Figures 6 and 7 show the cumulative response of local energy inflation rates to oil and natural gas shocks of different sign, while Figures 8 and 9 show the cumulative response of local headline inflation rates to oil and natural gas shocks of different sign. There is a clear asymmetry in the transmission of oil price shocks, but inflation rates are still not responsive to positive or negative natural gas shocks. These results show the importance of distinguishing between positive and negative oil shocks. In a low-renewable electricity generation regime, a positive shock has a cumulative effect on energy inflation that doubles the effect of an equivalent negative shock.

Results also show that inflation is more responsive to positive or negative oil shocks than headline inflation.

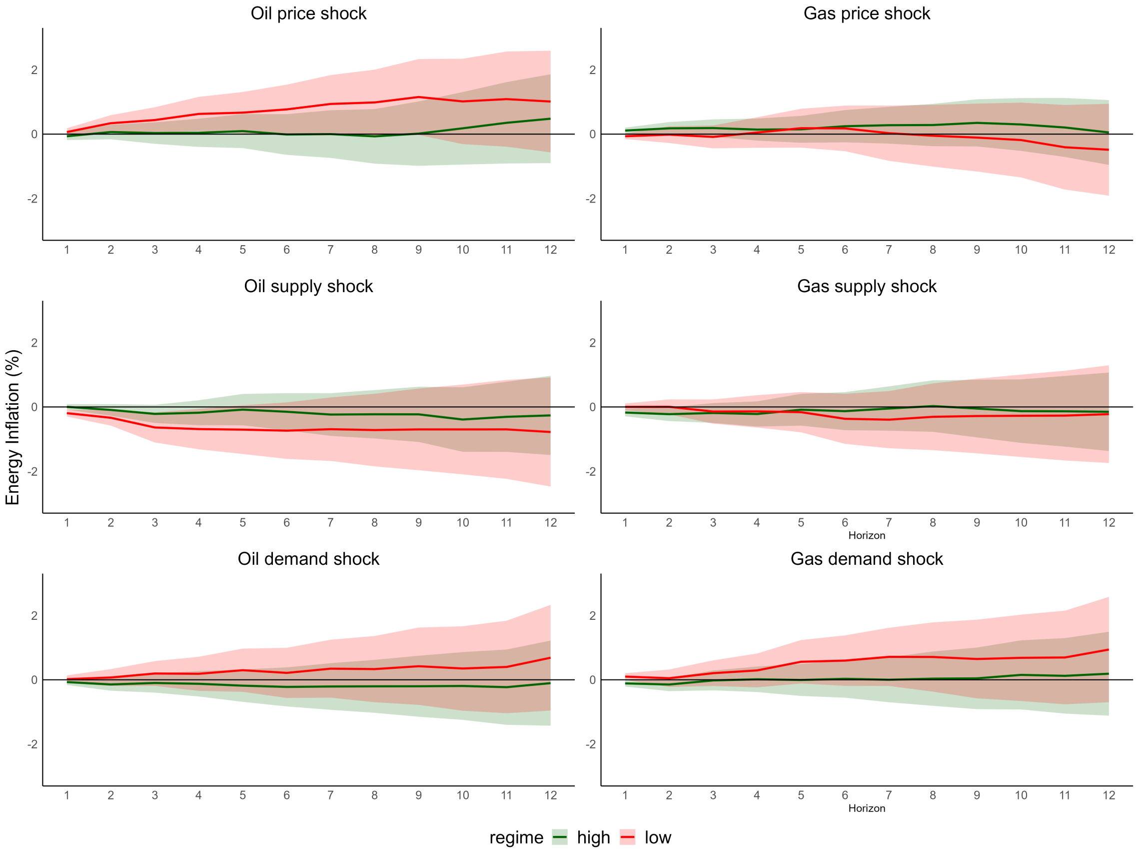

Figure 6: Cumulative response of energy inflation to positive structural crude oil shocks conditional on the degree of renewable electricity generation.

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation positive shock. Shaded areas denote 90% confidence intervals.

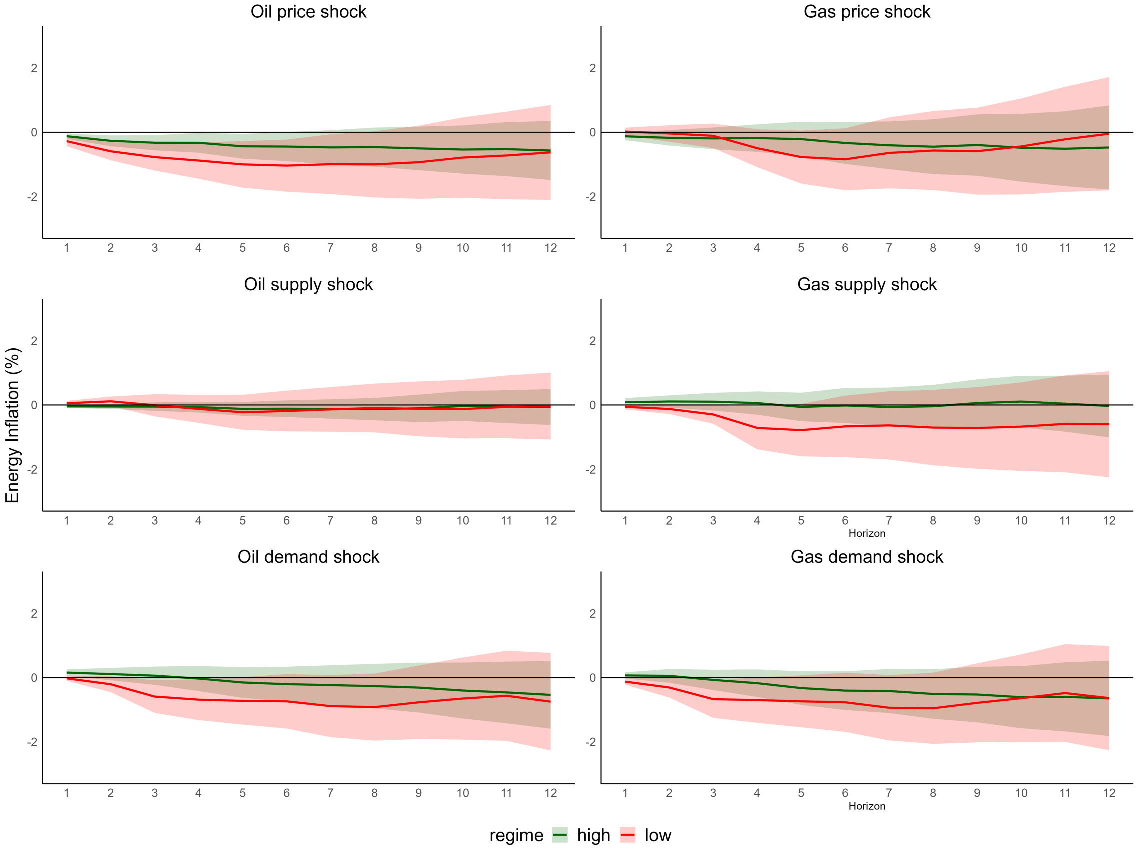

Figure 7: Cumulative response of energy inflation to negative structural crude oil shocks conditional on the degree of renewable electricity generation.

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation negative shock. Shaded areas denote 90% confidence intervals.

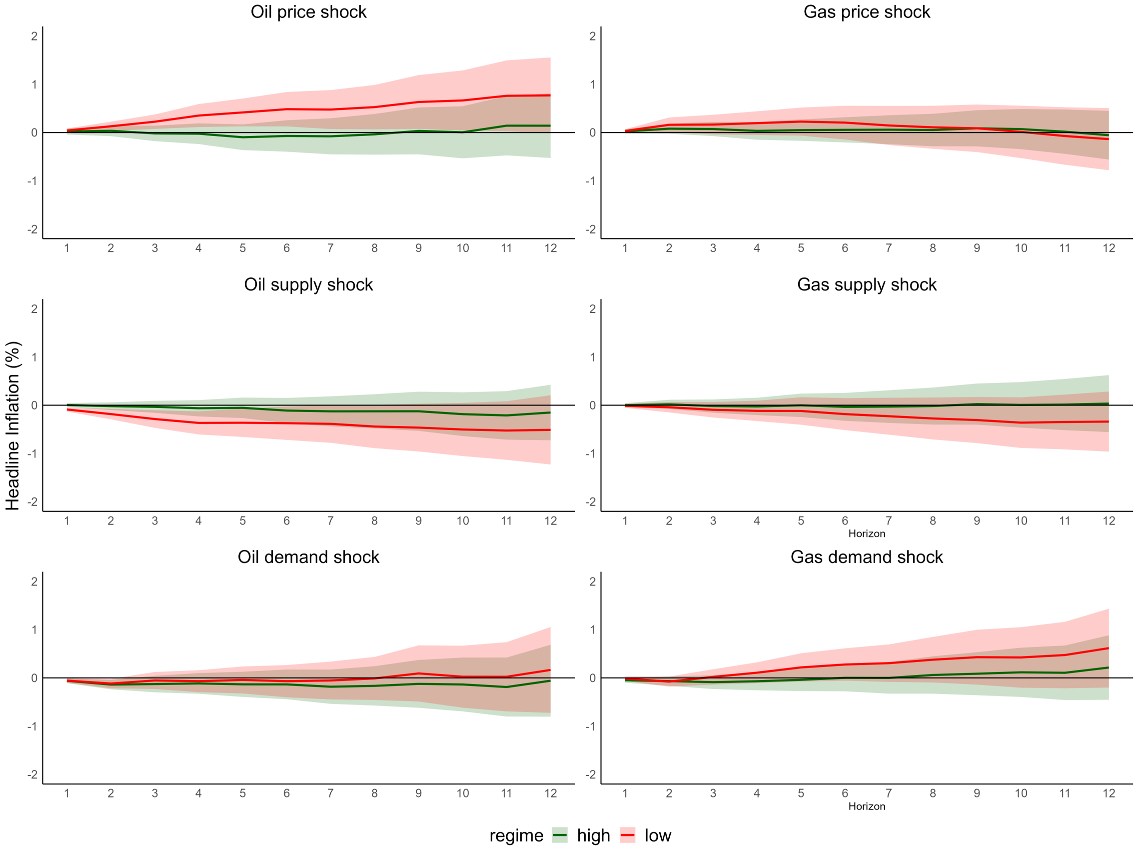

Figure 8: Cumulative response of energy inflation to positive structural crude oil shocks conditional on the degree of renewable electricity generation.

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation positive shock. Shaded areas denote 90% confidence intervals.

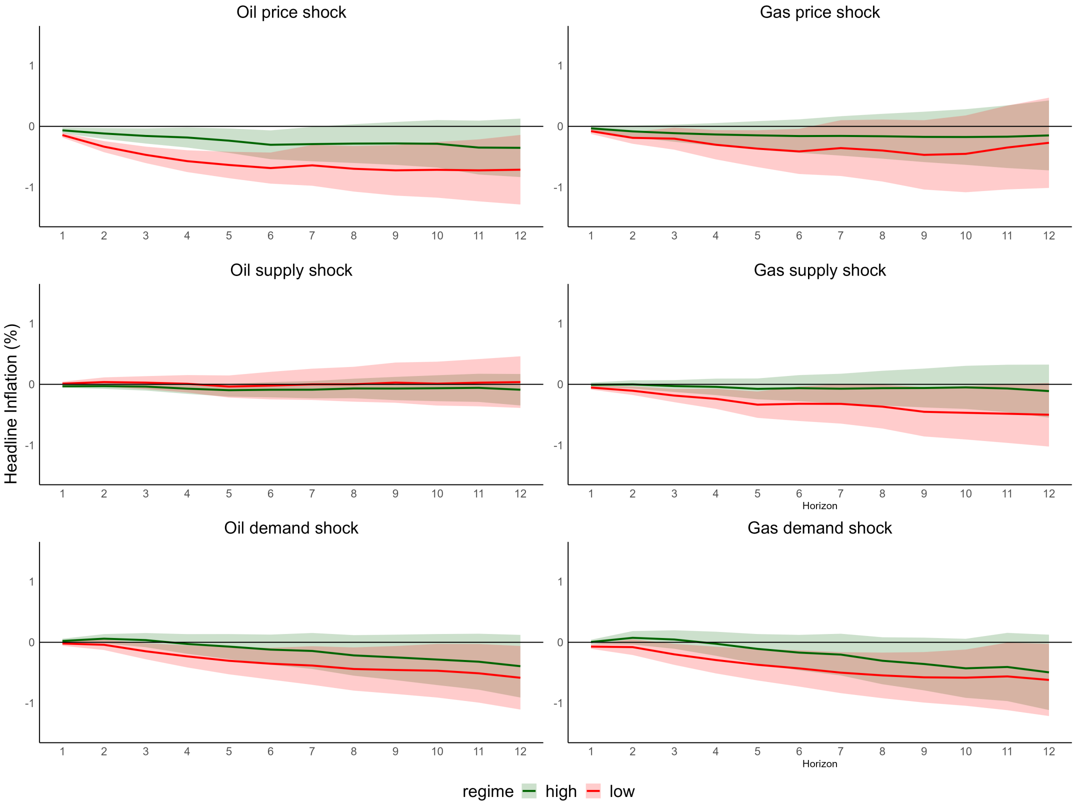

Figure 9: Cumulative response of headline inflation to negative structural crude oil shocks conditional on the degree of renewable electricity generation.
Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation negative shock. Shaded areas denote 90% confidence intervals.

4.3. Robustness checks

In this section, we test the robustness of the results obtained to: (i) the choice of the speed of transition between regimes (γ), and (ii) the method used to define the transition between states.

4.3..1 Sensitivity to γ

Our nonlinear framework proposed in 3 to obtain IRF through local projections separates the data into two regimes by computing state probabilities with the logistic function. The logistic function depends on the smoothness parameter γ, which defines how sharply the two regimes are separated. To investigate how different choices of γ might affect the results, we compare the nonlinear impulse responses for a shock on oil or natural gas prices on local inflation rates using $\gamma = 1$, and $\gamma = 10$. Choosing a low value of γ makes the regime-switching smooth, whereas higher values of γ case the switching to be quick.

Figures A3 and A4 in the Appendix show the cumulative impulse responses for an oil or natural gas price shock on local inflation rates using $\gamma = 1$ (a slow electricity transition), while Figures A5 and A6 show the respective cumulative impulse responses using $\gamma = 10$ (a fast electricity transition).

Although the choice of γ affects the results, it does not change the overall conclusion, namely that a higher share of renewable electricity generation significantly mitigates the impact of global fossil fuel price shocks on local inflation rates.

4.3..2 An alternative definition of the transition

A simplest approach to separate data into two regimes is using a binary (dummy) variable. We estimate a threshold state-dependent model represented in the following equation:

$$\begin{aligned}\pi_{i,t+h} = \alpha_{i,h} + D_{i,t}\left[\sum_{l=1}^{12}\mu^h_{LR,l}\pi_{i,t+h-l} + \beta^h_{LR}\delta_{i,t}shock_t + \sum_{l=0}^{12}\theta^h_{LR,l}x_{i,t+h-l}\right] \\ + (1 - D_{i,t})\left[\sum_{l=1}^{12}\mu^h_{HR,l}\pi_{i,t+h-l} + \beta^h_{HR}\delta_{i,t}shock_t + \sum_{l=0}^{12}\theta^h_{HR,l}x_{i,t+h-l}\right] + \varepsilon_{i,t+h}\end{aligned} \tag{6}$$

where $D_{i,t}$ is a dummy variable that takes value 1 if last year's share of renewable electricity generation of country i is higher than 50% and takes value 0 otherwise. Therefore, the transition occurs when the state variable exceeds the threshold value. The drawback of this method relative to the approach used in 3 is that it lowers the degrees of freedom.

The estimated IRFs displayed in Figures A7 and A8 in the Appendix do not show significant differences with respect to the baseline model, confirming the robustness of our finding.

5. Discussion

Recent increases in international oil and gas prices have raised fears of persistently high domestic inflation, as well as concerns about a possible spiral in energy prices. This study shows that the electricity transition towards a greater share of renewable sources has mitigated the impacts of international fossil fuel price shocks, particularly oil prices. Consistent with previous research using energy variables to explain the pass-through of oil prices to inflation, our renewable electricity matrix share measure highlights the significance of energy factors in accounting for cross-country heterogeneities in pass-through rates. The estimates presented are based on monthly data from Latin America and the Caribbean, a region that has the highest share of renewables in its electricity matrix, although with significant heterogeneities across countries and over time. This empirical approach can also be applied in other regions and periods in the future.

Beyond mitigating climate change through CO_2 reduction, transitioning to renewable energy offers a range of potential benefits, including increased employment opportunities in these sectors and enhanced resilience to external shocks caused by energy disruptions. Expanding renewable energy capacity and generation can strengthen regional economies by mitigating the risks associated with volatile international hydrocarbon prices and other disruptions.

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A Appendix

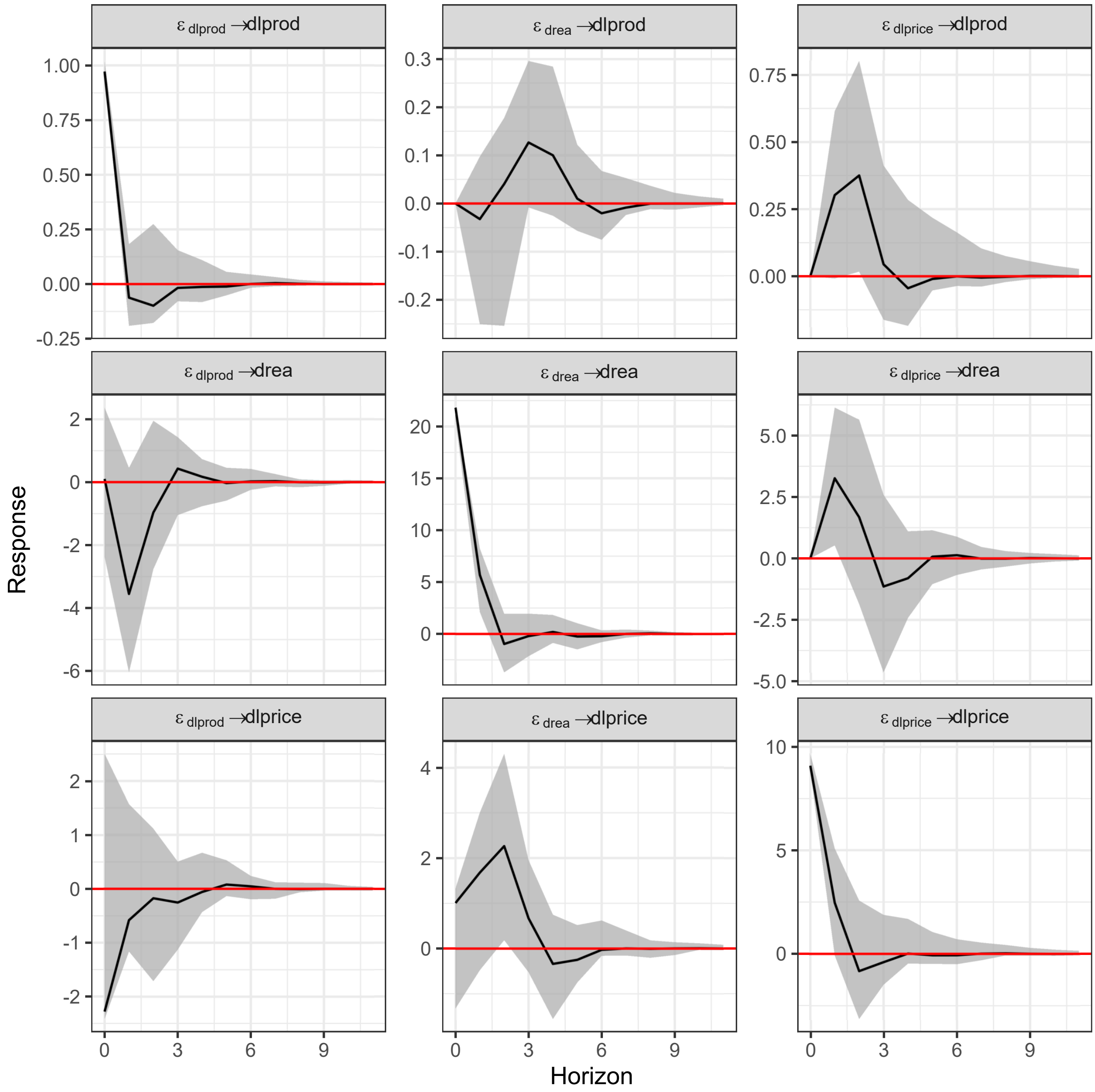

Figure A1: Crude oil impulse-response functions with 95% bootstrap confidence bands.

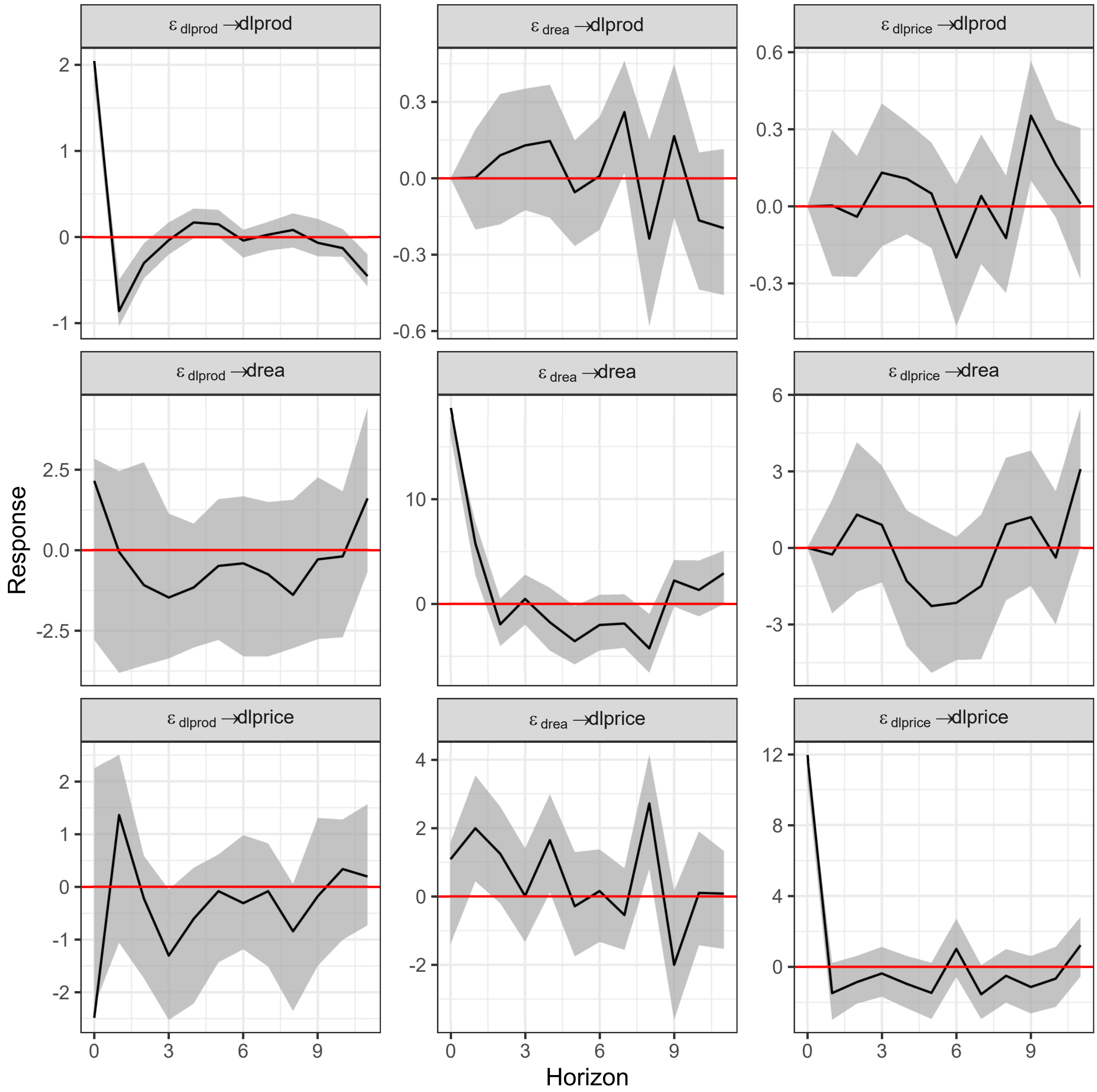

Figure A2: Natural gas impulse-response functions with 95% bootstrap confidence bands.

Variable	Definition	Source
Oil price	Refiner acquisition cost of imported crude oil	EIA
Gas price	Natural gas spot price at Henry Hub, Louisiana	Thomson Reuters
US CPI	U.S. consumer price index for all urban consumers, s.a.	Federal Reserve Economic Data
Oil production	World crude oil production in Mb/d	EIA
Gas production	U.S. natural gas gross withdrawals in MMcf	EIA
Economic activity	Index of real economic activity	Kilian (2009b, 2019b)
CPI	Consumer price index: All items	IMF-IFS and National Institutes of Statistics
Energy CPI	CPI: Housing, water, electricity, gas and other fuels	IMF-IFS and National Institutes of Statistics
Renewables	Share of renewable electricity generation	sieLAC-OLADE
Exchange rate	Exchange rate, national currency per U.S. dollar	IMF-IFS
Govt. Expenditure	Ratio of government expenditure to GDP (in %)	World Economic Outlook - IMF

Table A1: Sources and definitions of variables

Variable	ADF	PP
Δ real oil price$_t$	-10.317***	-11.082***
Δ oil production$_t$	-11.792***	-14.517***
Δ real natural gas price$_t$	-11.805***	-16.802***
Δ natural gas production$_t$	-19.568***	-44.504***
Δ real economic activity index$_t$	-10.355***	-11.621***
Oil supply shock$_t$	-4.387***	-14.056***
Oil aggregate demand shock$_t$	-2.8140***	-3.182**
Oil-specific demand shock$_t$	-2.970***	-2.873**
Natural gas supply shock$_t$	-3.737***	-16.901***
Natural gas aggregate demand shock$_t$	-2.372***	-2.945**
Natural gas-specific demand shock$_t$	-3.300***	-3.076**
Variable	IPS	MW
Energy inflation$_{it}$	-43.511***	1671***
Headline inflation$_{it}$	-38.9***	-1415.1***
Δ exchange rate$_{it}$	-28.688***	935.99***
Government expenditure$_{it}$	-0.251	40.787
z_{it}	0.903	31.196

Notes: tests include a drift term and the selected number of lags is based on BIC. ADF = Augmented Dickey-Fuller test, PP = Phillips-Perron test, IPS = Im-Pesaran-Shin test, MW = Maddala-Wu test. *p<0.1; **p<0.05; ***p<0.01

Table A2: Unit root tests

Country	Energy inflation (%)			Headline inflation (%)			Renewables generation (%)		
	Mean	S.D.	Obs.	Mean	S.D.	Obs.	Mean	S.D.	Obs.
Barbados	0.35	3.32	199	0.37	0.74	199	1.47	2.06	204
Bolivia	0.27	0.26	203	0.37	0.52	203	34.75	7.15	204
Brazil	0.46	0.62	203	0.43	0.29	203	82.88	4.61	204
Chile	0.29	2.35	203	0.29	0.40	203	42.47	5.65	204
Colombia	0.43	2.28	203	0.33	0.33	203	78.10	5.87	204
Costa Rica	0.48	1.27	203	0.40	0.50	203	95.18	3.76	204
Ecuador	0.21	0.26	203	0.23	0.35	203	58.65	10.61	204
El Salvador	0.33	1.91	203	0.17	0.50	203	62.02	8.67	204
Guatemala	0.26	0.65	203	0.38	0.44	203	59.33	8.31	204
Honduras	0.43	0.46	203	0.44	0.36	203	45.15	8.22	204
Jamaica	0.63	0.72	203	0.64	0.72	203	6.74	2.27	204
Mexico	0.25	1.16	203	0.34	0.37	203	17.19	2.54	204
Nicaragua	0.54	0.85	203	0.56	0.63	203	44.22	12.47	204
Panama	0.08	1.33	203	0.21	0.39	203	62.40	7.25	204
Paraguay	0.35	0.50	203	0.42	0.75	203	100.00	0.00	204
Peru	0.37	2.66	203	0.43	2.58	203	59.86	6.97	204
Trinidad and Tobago	0.11	0.43	203	0.43	0.79	203	0.14	0.14	204
Uruguay	0.67	2.32	203	0.63	0.57	203	84.45	12.49	204

Table A3: Summary statistics on selected variables by country, 2005:1-2021:12

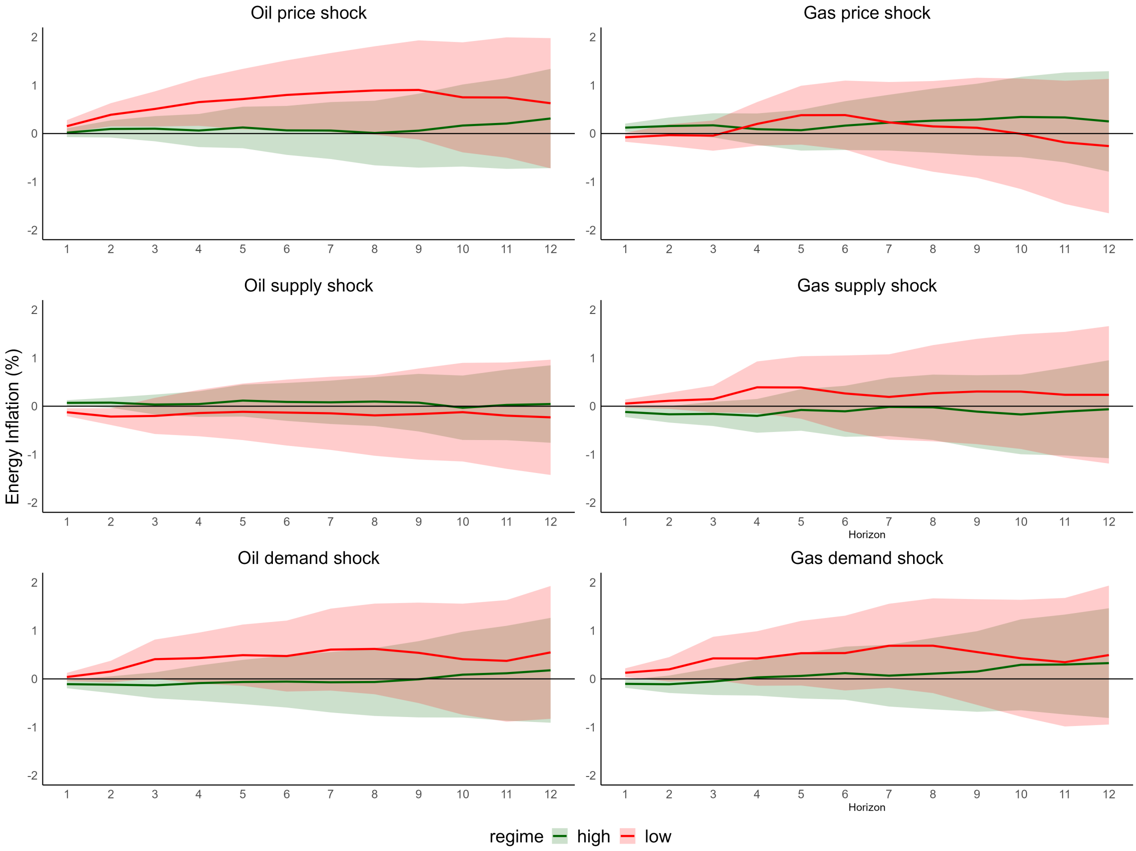

Figure A3: Cumulative response of energy inflation to structural crude oil and natural gas price shocks conditional on the degree of renewable electricity generation considering a very slow transition ($\gamma = 1$).

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.

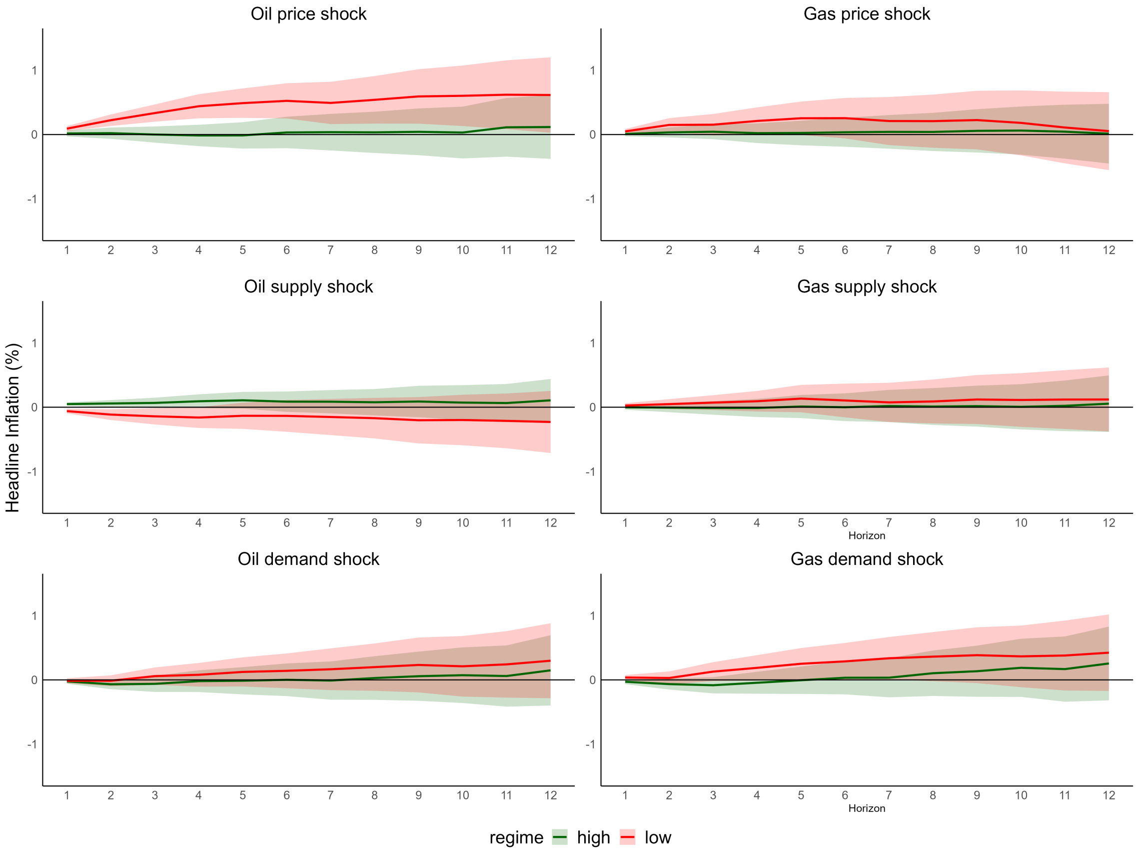

Figure A4: Cumulative response of headline inflation to structural crude oil and natural gas price shocks conditional on the degree of renewable electricity generation considering a very slow transition ($\gamma = 1$).

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.

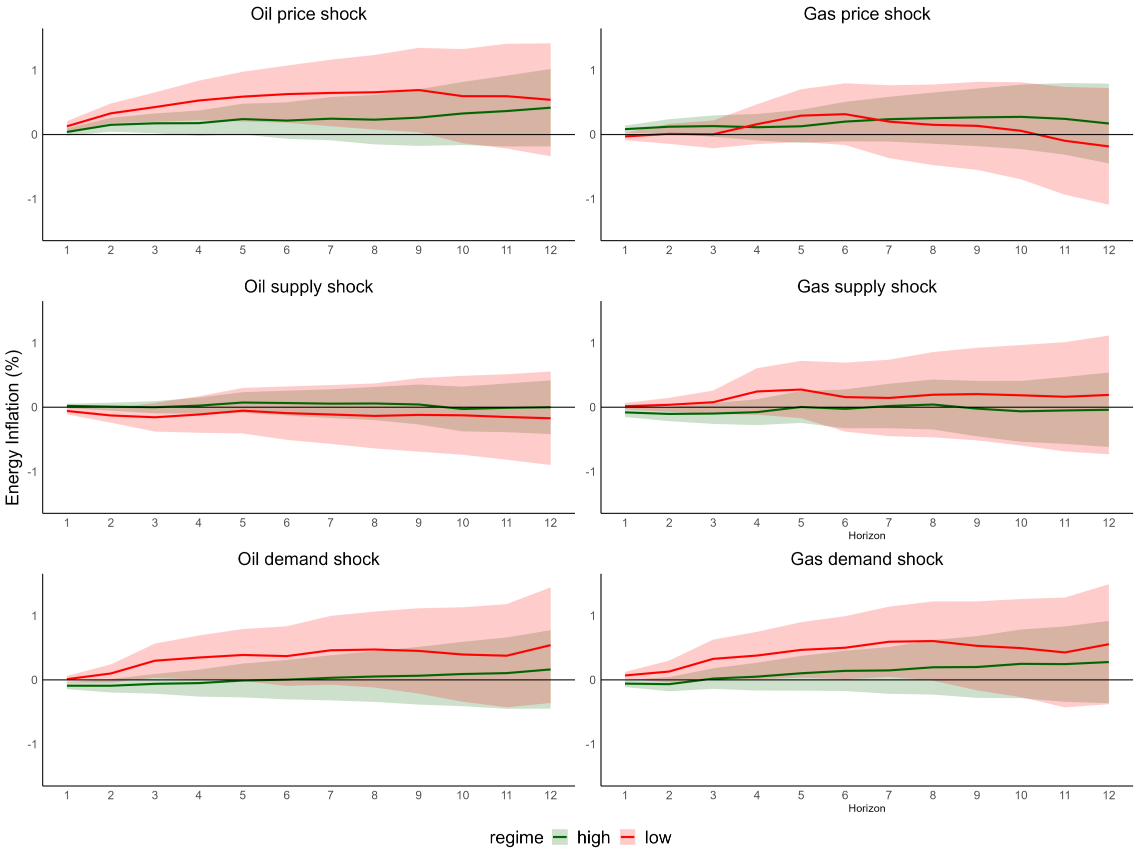

Figure A5: Cumulative response of energy inflation to structural crude oil and natural gas price shocks conditional on the degree of renewable electricity generation considering a fast transition ($\gamma = 10$).

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.

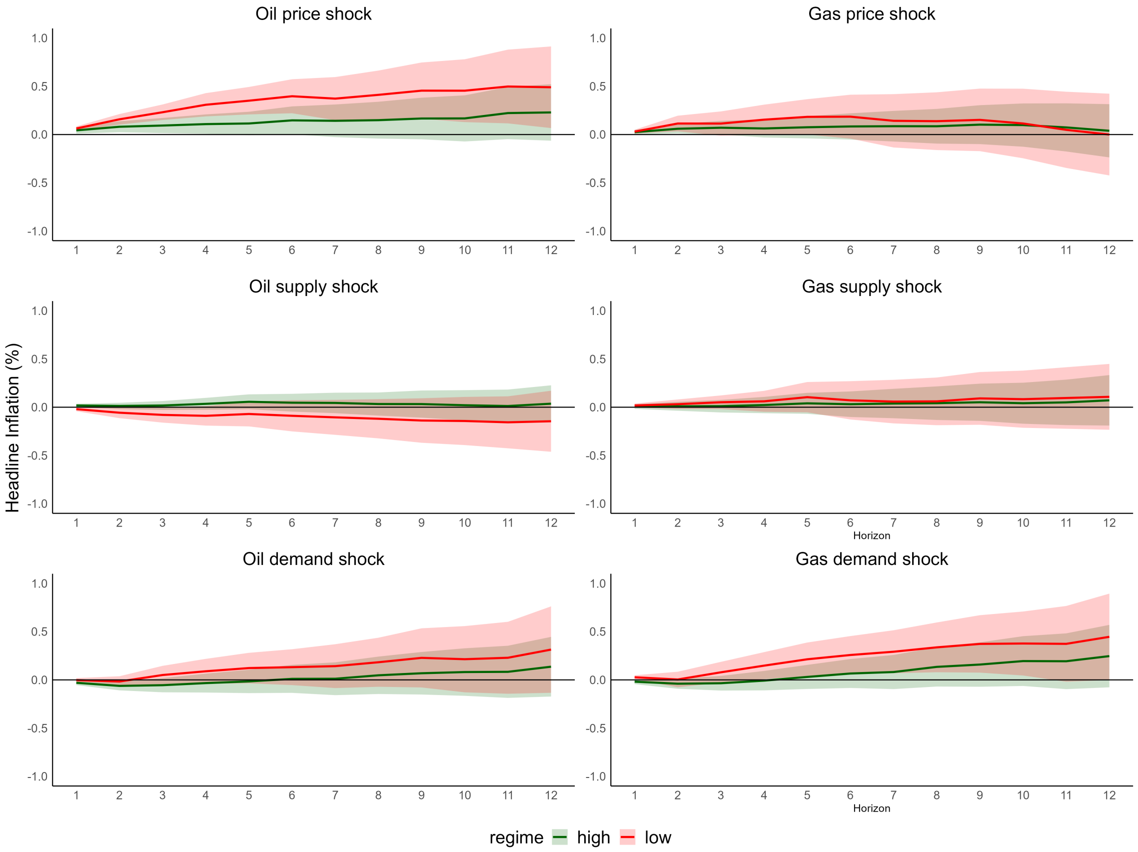

Figure A6: Cumulative response of headline inflation to structural crude oil and natural gas price shocks conditional on the degree of renewable electricity generation considering a fast transition ($\gamma = 10$).

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.

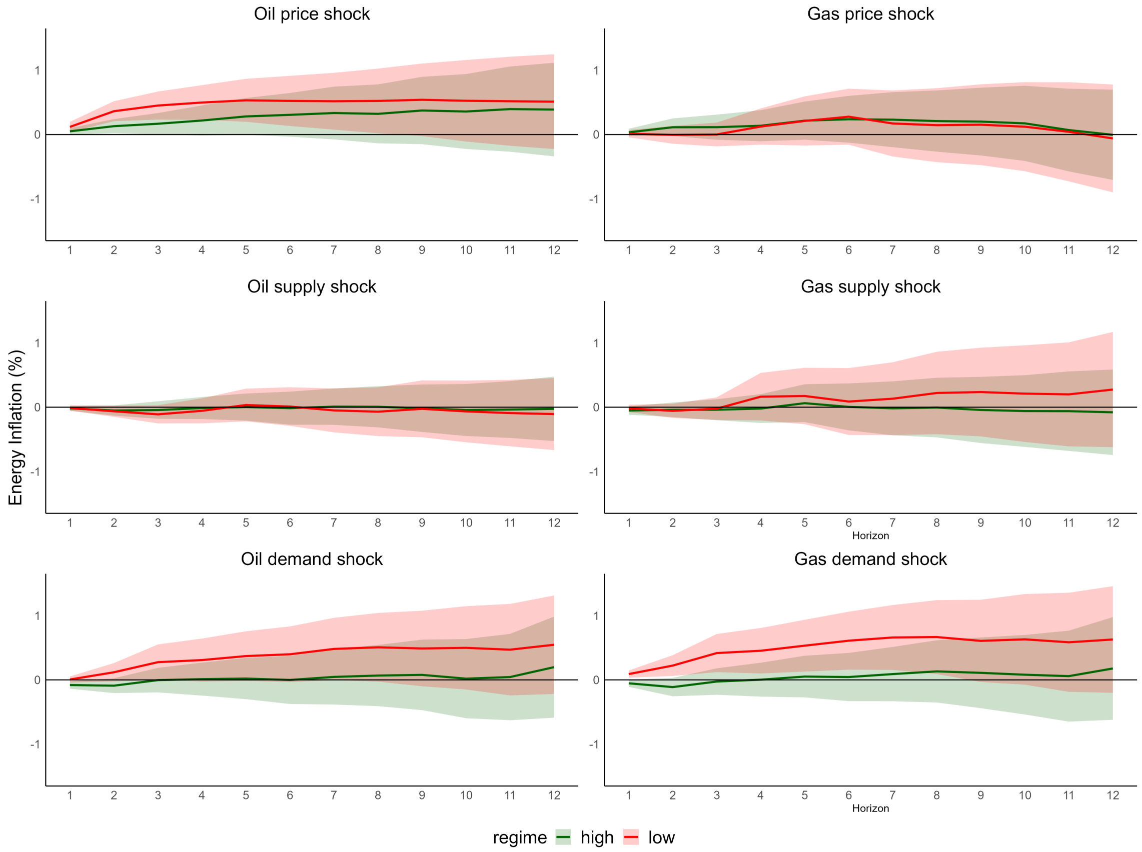

Figure A7: Cumulative response of energy inflation to structural crude oil and natural gas price shocks, conditional on an alternative definition of renewable electricity transition.

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.

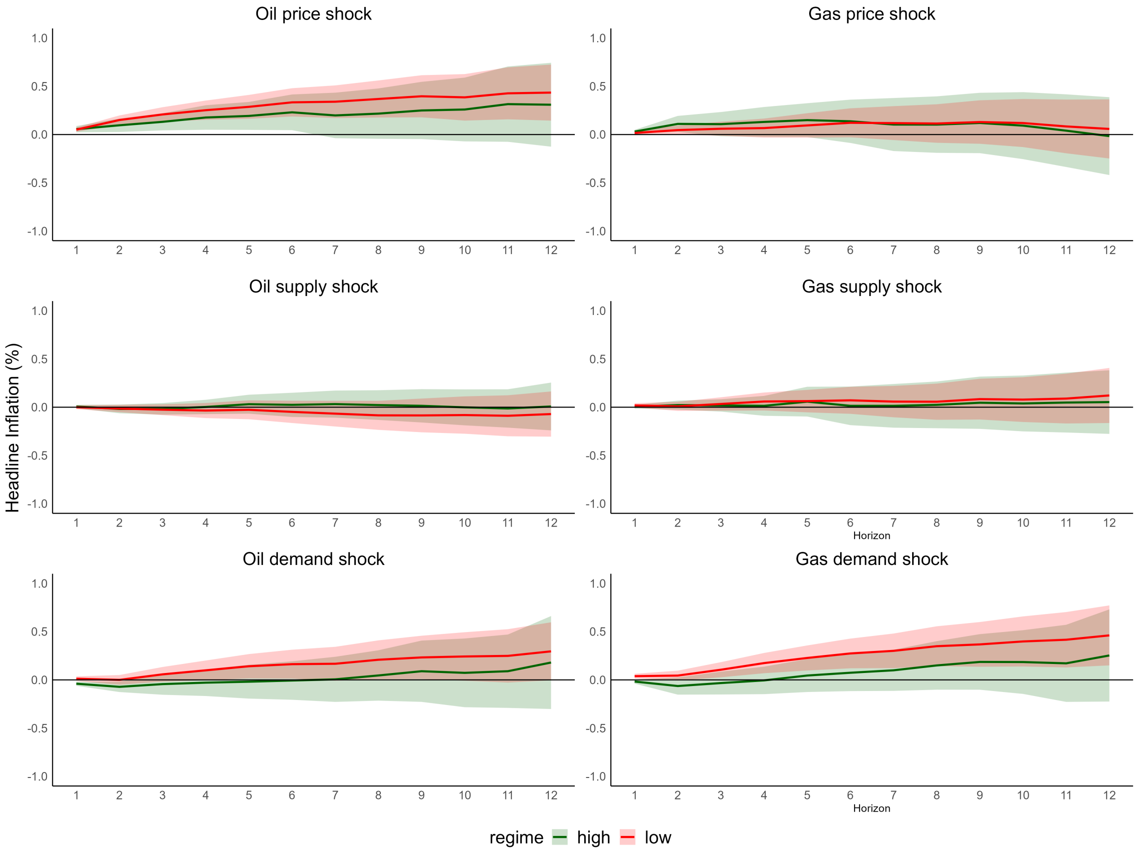

Figure A8: Cumulative response of headline inflation to structural crude oil and natural gas price shocks, conditional on an alternative definition of renewable electricity transition.

Notes: The first and second columns show the cumulative response of energy inflation and headline inflation, respectively. The colors distinguish the periods of renewable electricity generation: red for low and green for high generation. The figures show the cumulative effect on inflation of a one standard deviation shock. Shaded areas denote 90% confidence intervals.