# The macroeconomic effects of carbon pricing at a subnational level: evidence from California's cap and trade

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**Abstract**

This paper addresses the macroeconomic effects of subnational carbon pricing initiatives, focusing on California's cap and trade. Using high-frequency data and regulatory news, I construct a carbon policy surprise series to understand the aggregate effects of a carbon policy shock using impulse response functions from a SVAR model. Results suggest that a shock tightening the carbon pricing regime leads to an immediate significant reduction in carbon emissions by 0.05%, albeit this reduction in emissions comes at the expense of an immediate temporary fall in economic activity by 0.01%. On the other hand, results suggest that increasing carbon prices do not transmit to either household energy prices or consumer prices. Likewise, estimations suggest that a positive shock to carbon prices decreases the monetary policy rate and increases unemployment, albeit not statistically significant at the 10%. I resort to local projections as robustness checks and find that the prior conclusions hold, i.e., that the California's cap and trade initiative has significant macroeconomic effects.

***Keywords***— Carbon pricing, macroeconomy, impulse response functions, SVAR, carbon policy surprises.

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# 1 Introduction

Carbon pricing has become one of the most common and useful environmental tools across the world. From the first emissions trading system established in 2004 in the EU, commonly referred to as EU-ETS, there currently exists 39 carbon pricing initiatives across countries and 33 carbon pricing programs across subnational jurisdictions, which in total would cover around 23% of global greenhouse gases (GHG) emissions. Carbon pricing is generally represented by either a carbon tax, an emissions trading system such as a cap and trade initiative, or a combination of the two.

In the United States, only subnational cabon pricing initiatives have been in place: the so-called Regional Greenhouse Gas Initiative (RGGI from now on), a cap and trade system established in 2009 encompassing eleven Northeast states including Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont, and Virginia; Washington's Climate Commitment Act (CCA), an economy-wide emissions trading system implemented in 2023; and California's Cap and Trade (CCAP from now on) program, initiated in 2012.

This paper addresses the macroeconomic effects of subnational carbon pricing initiatives, focusing on California's cap and trade. Using high-frequency data and regulatory news, I construct a carbon policy surprise series to understand the aggregate effects of a carbon policy shock using impulse response functions from a SVAR model. Results suggest that a shock tightening the carbon pricing regime leads to an immediate significant reduction in carbon emissions by 0.05%, albeit this reduction in emissions comes at the expense of an immediate temporary fall in economic activity by 0.01%. On the other hand, results suggest that increasing carbon prices do not transmit to either household energy prices or consumer prices. Likewise, estimations suggest that a positive shock to carbon prices decreases the monetary policy rate and increases unemployment, albeit not statistically significant at the 10%. I resort to local projections as robustness checks and find that the prior conclusions hold, i.e., that the California's cap and trade initiative has significant macroeconomic effects.

The contributions of this paper are simple but straightforward. To the best of my knowledge, this is the first work to analyze the macroeconomic effect of California's cap and trade program using high frequency identification strategies. Moreover, this paper contributes to the literature of carbon pricing focusing on subnational instead of national macroeconomic variables, which tend to remain oversighted.

This paper is structured as follows. In section II, I develop the literature related to carbon pricing. In section III, I explain the high frequency approach, in section IV, I develop the empirical methodology

and in section IV, I present the data used in this paper. In section V, I present my main findings and in section VI, I present some robustness checks. Finally in section VII, I present my conclusions and show some limitations and future projects related to this work.

## 2 Related Literature

The vast majority of the carbon pricing has mostly focused on their environmental impact (Lin and Li, 2011; Pretis, 2020; Baioni, 2021; Yan, 2021). However, some papers have highlighted as well their economic impact. Focusing on European carbon taxes, Metcalf and Stock (2020) estimate the macroeconomic impacts of these taxes on GDP and employment, resorting to local projections, and find no robust evidence of a negative effect of the tax on employment or GDP growth. In contrast, theoretical studies based on computable general equilibrium models tend to find contractionary output effects (see McKibbin et al., 2017; Woollacott, 2018; Goulder and Hafstead, 2018).

Focusing on the US, most studies investigate the effect of the RGGI program. Moffa (2021) analyzes its impact on annual employment growth using a difference-in-difference framework and finds that, although there was no significant impact on overall annual employment growth rate, when broken down into industry-specific effects, the mining industry is perceived to have had a significant 0.09 percentage point decrease in its annual employment growth rate. Similarly, Roach and Gittings (2023) find that implementation of the RGGI has had no effect on employment or earnings in the utilities sector but increased the rate at which workers flow in and out of jobs. In particular, within the utilities sector, they observe some job destruction and worker separation combined with increased labor reallocation across establishments.

On California's cap and trade initiative, Baioni (2023) uses an interrupted time series analysis approach (ITSA) to estimate the economic impact of the mentioned program for the period 1990–2019, and observes that California's per capita personal income significantly increased after the implementation of the cap and trade in $741.504, significantly higher than with respect to control states. Likewise, the author finds that the Californian real GDP as well as its renewable electric generation increased significantly, outperforming the control states. Analogously, Bravo Roger (2023) uses industry-coverage data for California from the CARB Mandatory GHG Reporting to compute triple-difference models and observes an average 3.1% increase in employment for Californian county-industries after the introduction of the policy holding, all else equal.

As already mentioned, this paper uses a high frequency identification strategy to analyze the macroeco-

nomic impact of carbon pricing programs. Although this approach is relatively new in the environmental literature, it encompasses some years in the macroeconomic literature, especially when analizing monetary policy surprises to focus on the FED and the ECB hiking cycle (Gertler and Karadi, 2015; Nakamura and Steinsson, 2018); and more recently when focusing on the shock to global oil prices (Känzig, 2021; Gazzani et al. 2024). The idea behind this approach is fairly simple but important: to isolate the impact of policy news (e.g. a hike/cut in the monetary policy rate, an oil production cut by the OPEC, etc.), this is, to avoid endogeneity issues arising from macroeconomic variables, policy surprises are identified using high-frequency asset price movements around these events, such as the FOMC or OPEC announcements, in a tight window around the decisions.

This paper, however, follows closely on the strategy proposed in Känzig (2023), who uses a novel carbon policy surprise framework to estimate the macroeconomic impact of the EU-ETS program. Simply put, the author collects a comprehensive list of regulatory events affecting the supply of carbon allowances in the EU ETS, including decisions of the European Commission, a vote of the European Parliament or a judgement of an European court (see Känzig, 2023, for further information).

## 3 High frequency approach: carbon policy surprises

As already stated, the idea of this paper is to exploit high frequency data to analyze the impact of carbon pricing programs on macroeconomic variables, as discussed in Känzig (2023). To do so, I resort to a daily regulatory news approach over the period 2013-2023.

For the carbon price time series, I utilize carbon futures known as the California vintage $CO_2$ allowance from ICE, which is found to dominate the carbon market (Stefan and Wellenreuther, 2020). These carbon allowances futures are physically delivered GHG allowances issued by the California Air Resources Board or a linked program ("California Carbon Allowance") representing one metric ton of $CO_2$ equivalent under California Assembly Bill 32 "California Global Warming Solutions Act of 2006" and its associated regulations, rules and amendments, all together known as the "California Cap and Trade Program" (ICE, 2024).

California Carbon Allowances acceptable for delivery are those issued as a limited authorization to emit up to one metric ton of $CO_2$ or $CO_2$ equivalent in the California Cap and Trade Program, having a vintage corresponding to the calendar year of the expiring contract, and allowances having a vintage of any year prior to the calendar year of the expiring contract. However, I use December vintage for each year of interest to construct the carbon price futures, since they tend to be more liquid.

Then, I look for daily news that relate to California's cap and trade, directly or indirectly. The literature on event studies in high-frequency identification highlights the importance of choosing the size of the event window. There is a trade-off between capturing the entire response to the announcement and background noise generate by other news confounding the response (Nakamura and Steinsson, 2018). Even though I sometimes have the exact times of the regulatory news (see Table 3 in the Appendix), it is not feasible to use an intraday window since the carbon futures prices are established on a daily basis. Hence, I resort to a daily window.

Thus, the carbon policy surprise series (CPS from now on) is computed by measuring the percentage change in the California futures price on the day of the regulatory event to the last trading day before the event as:

$$CPS_{t,d} = F_{t,d} - F_{t,d-1} \tag{1}$$

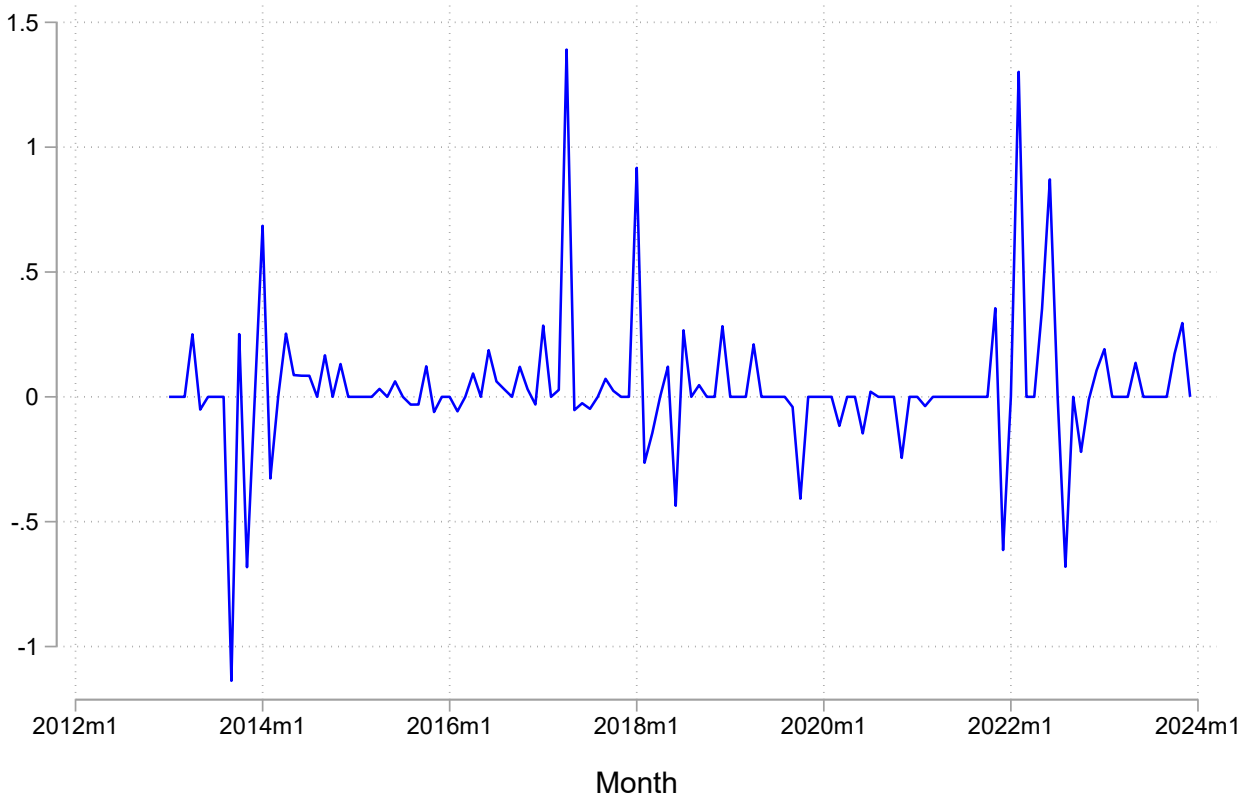
where d and t indicate the day and the month of the event, respectively, and $F_{t,d}$ is the logarithm settlement price of the California futures contract in month t on day d. Then, the daily surprises $CPS_{t,d}$ are aggregated to a monthly series, by summing over the daily surprises in a given month. In months without any regulatory events, the series takes zero value.

Another important aspect in the narrative approach is the selection of news pertaining to said policy. As already stated, the idea is to have news that impact (directly or indirectly) the supply of carbon allowances, which affects the carbon futures prices, without incorporating news that affect the economy in a more general manner, which then affects carbon futures prices (e.g. COVID 19 news, quarantine policies, etc.). However, this entails a broad definition as to what include in these news. Hence, I limit the amount of news chosen to minimize inclusion errors, including changes and ammendments to California's cap and trade, Supreme court decisions and the application of environmental policies both in California and in the US (see the Appendix for the detailed list of regulatory news).

The carbon policy surprise series is shown in Fig. 1. As can be observed, regulatory news can have important effects. In September 17, 2013, California's Air Resources Board announced the issuance of compliance offset credits eligible for use in California's cap-and-trade greenhouse gas emissions reduction program, this is, carbon offset credits for greenhouse gas emission reductions that take place in sectors not covered under the cap-and-trade program. On that day, carbon futures prices fell by 1.14%. Analagously, in August 22, 2022, the US Congress passed the IRA into law. On that day, carbon prices drop 0.68%. On the other hand, in April 6, 2017, the state's Third District Court of Appeal rejected a challenge to the carbon auctions in California's cap-and-trade program, which

increased carbon prices by 1.63%. Likewise, in June 30, 2022, the U.S. Supreme Court imposed limits on the federal government's authority to issue regulations to reduce carbon emissions from power plants, increasing the carbon futures prices by 0.87%.

**Figure 1:** Carbon policy surprise series (in %)




Note: figure showcases daily carbon surprises which were aggregated to a monthly basis.

## 4 Data and methodology

As already mentioned, I investigate on the macroeconomic impact of the California cap and trade program. Consider the reduced-form VAR model expressed as:

$$y_t = \sum_{i=1}^{K} B_i y_{t-i} + u_t \tag{2}$$

where $y_t$ is vector of endogenous variables, $B_i$ a the coefficient matrix, and $u_t$ corresponds to the regression residuals with the variance-covariance matrix $Var(u_t) = \sum$.

The identification of the structural shocks relates to searching for a matrix S between the regression

residuals $u_t$ and the structural shocks $\epsilon_t$. This is, under the assumption that the VAR is invertible, one can write the innovations $u_t$ as combinations of the structural shocks $\epsilon_t$ as:

$$u_t = S\epsilon_t \tag{3}$$

As opposed to Känzig (2023), who resorts to an instrumental variable SVAR (IV-SVAR from now on) approach, I utilize my carbon pricing surprise as a normal variable shock (despite being measured with error and representing only a partial measure of the shock of interest as it may not capture all relevant instances of regulatory news in the carbon market, as highlighted in Stock and Watson, 2012, 2018), since the IV-SVAR approach takes a significant amount of time to compute.

The baseline specification consists of a total of 6 variables: household energy prices ($\pi_t^E$), headline consumer prices ($\pi_t$), monetary policy rate ($i_t$), unemployment rate ($u_t$), economic activity ($x_t$) and energy emissions ($\epsilon_t$) (see the Appendix for data sources). The sample spans from January 2013-December 2023, since this is the first month where I find data for the carbon policy surprise series. However, I test as well extending the database for the period January 2000-December 2013 to increase the precision of the estimates, by imputing all missing values in the surprise series as zero following Känzig (2023), and find similar results. All variables are log-transformed into their first differences to circumvent non-stationary issues and 4 lags are included as suggested by the usual tests (see Table 3 in the Appendix for further information).

Blanchard and Quah (1993) showed that the advantage of the SVAR over the standard VAR model is that one can used economic theory to impose restrictions on the values of estimated residuals and recover the underlying structural disturbances. It is well-known in the literature that auxiliary restrictions ought to be imposed on matrix S, in order to identify the structural shocks. Following Sims (1980), I follow a Cholesky decomposition of the variance-covariance matrix, which implies imposing a "recursive causal order" where variables that appear later in the ordering are assumed to have no contemporaneous effect on the variables before them.

Following the common literature (Blanchard and Gali, 2007; Anzuini et al., 2010; Ugarte Ruiz, 2023), my baseline order of the variables is defined as follows:

$$y_t = (x_t, u_t, \pi_t^E, \pi_t, \epsilon_t, i_t \tag{4}$$

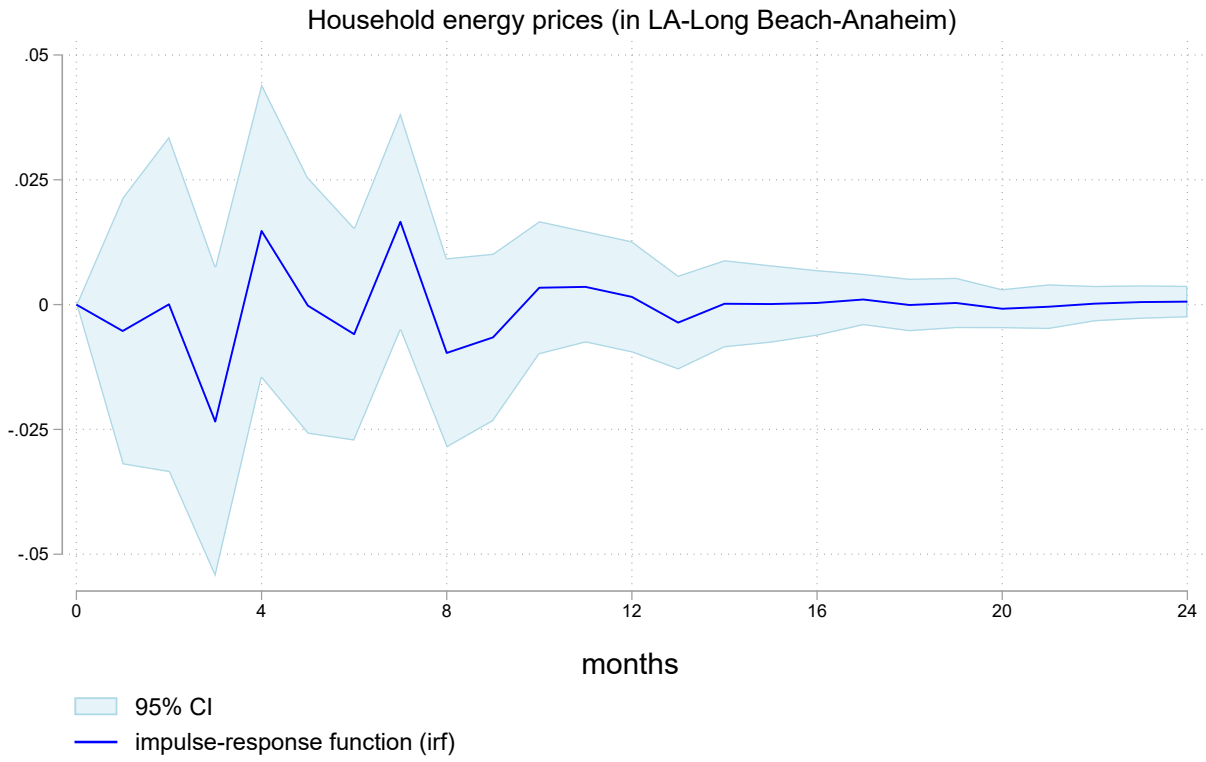
The rationale behind this order is straightforward and follows other works in the literature. The monetary policy rate is assumed to affect all the variables in the model after a lag, therefore is placed

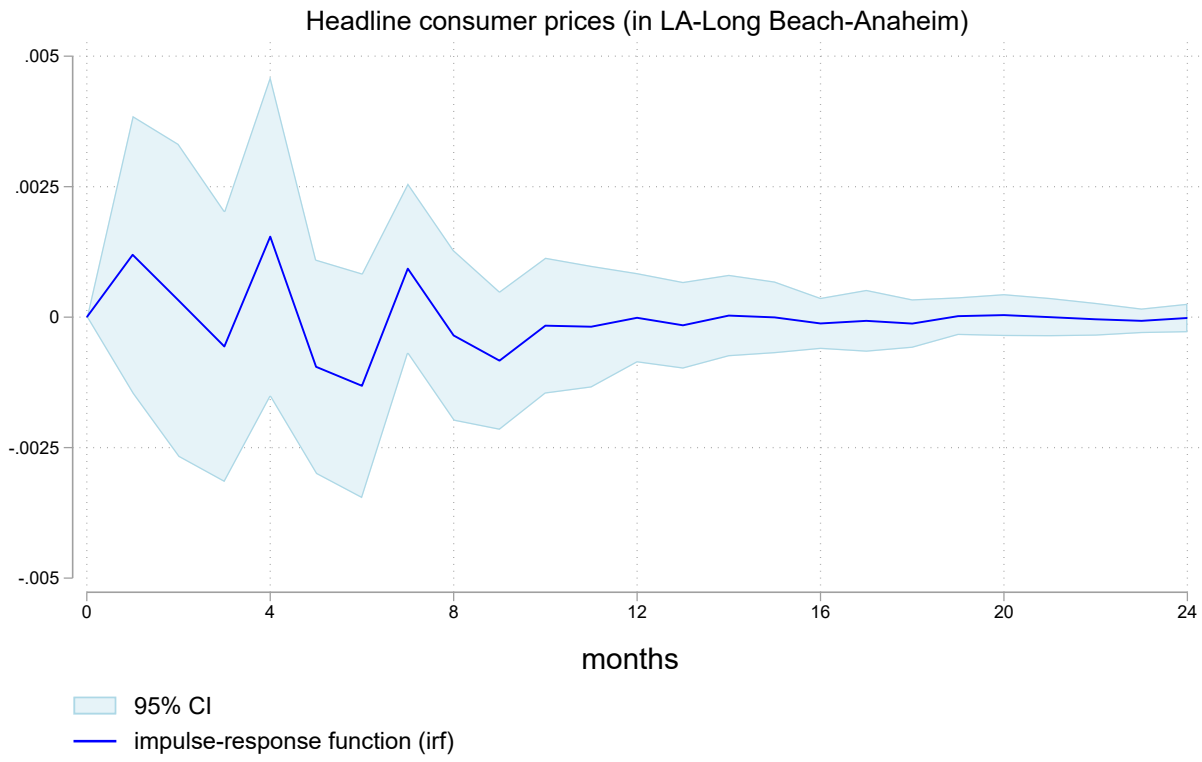
last. Energy emissions are assumed to have only a contemporaneous effect on the interest rate and not on the other variables in the model, as I assume increasing emissions positively affect the cost of credit and capital from a environmental perspective (green investing). On the other hand, I assume the unemployment rate affects contemporaneously consumer prices from a fall in consumer confidence. Finally, economic activity is assumed to affect all variables contemporaneously.

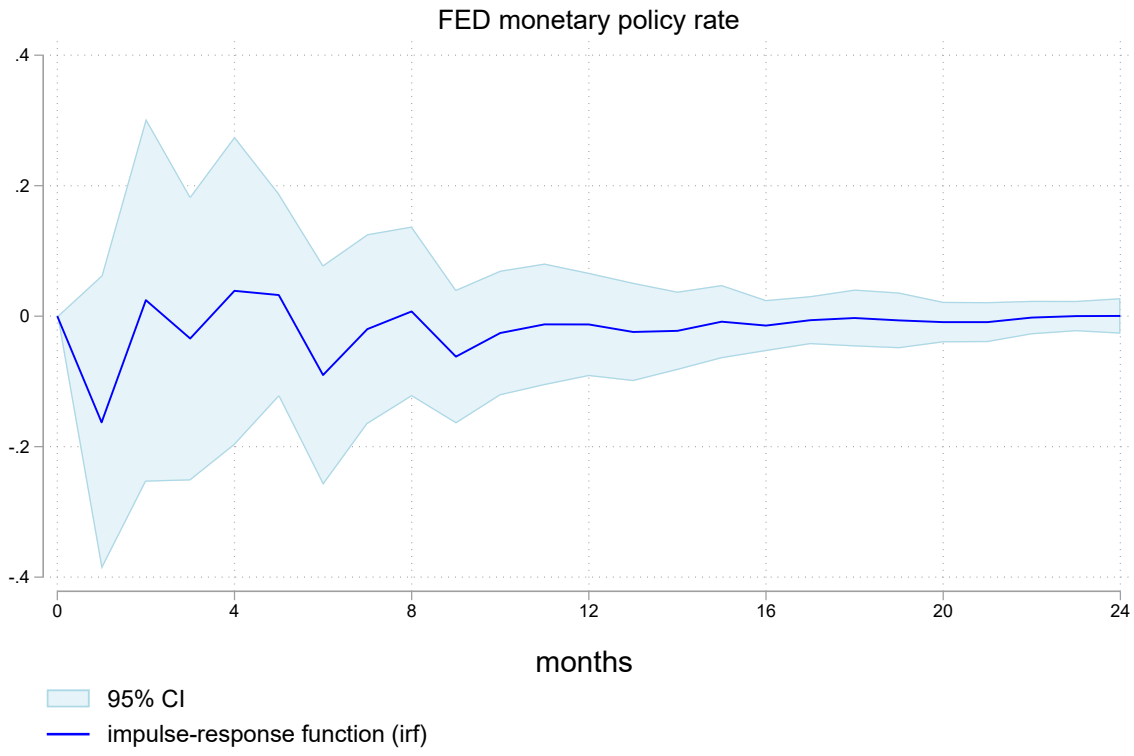
# 5 Results

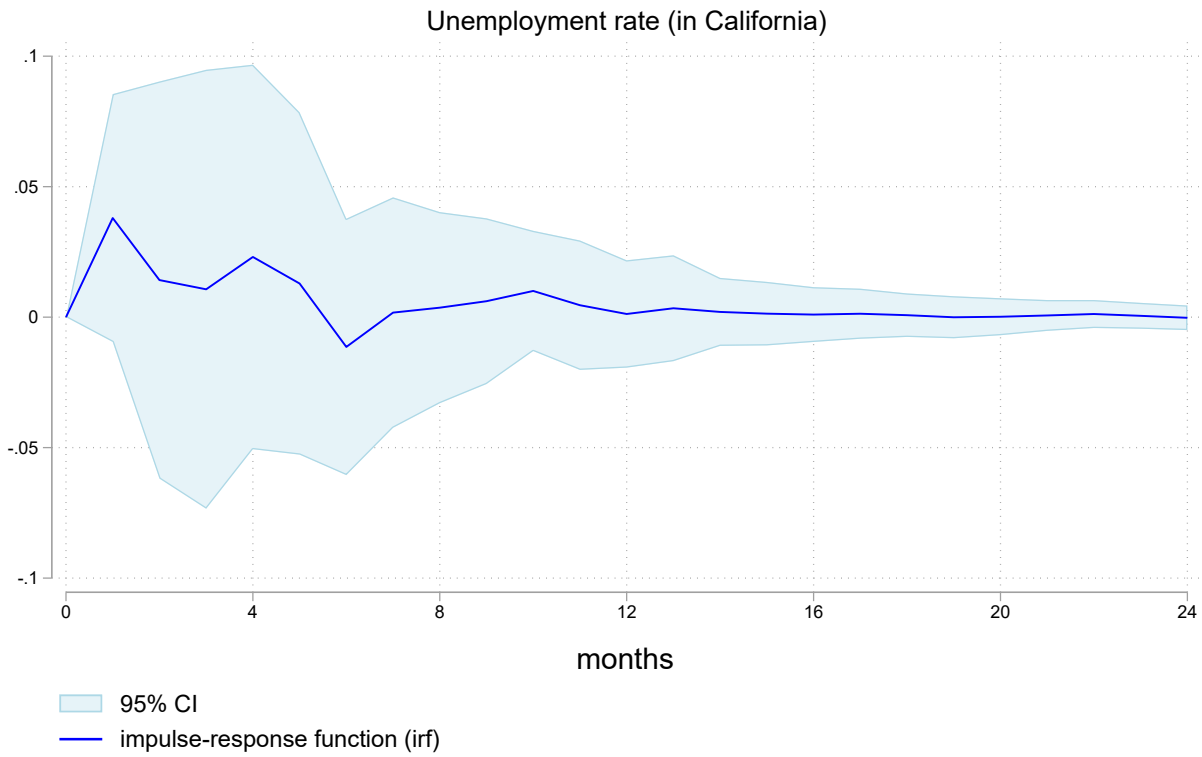
Figure 2 represent the main results of this paper. My estimations suggest that, as documented in Känzig (2023), a shock tightening the carbon pricing regime leads to an immediate significant reduction in carbon emissions by 0.05%. However, this reduction in emissions comes at the expense of a significant temporary fall in economic activity by 0.01% after one period, and remains negative until after half of a year, although not statistically significant. On the other hand, results suggest that increasing carbon prices do not transmit to either household energy prices or consumer prices on a statistically significant manner. Likewise, estimations suggest that a positive shock to carbon prices decreases the monetary policy rate and increases unemployment, albeit not statistically significant at the 10% level. For every variable included in the model, results suggest that the carbon policy shock dissipates after one year.

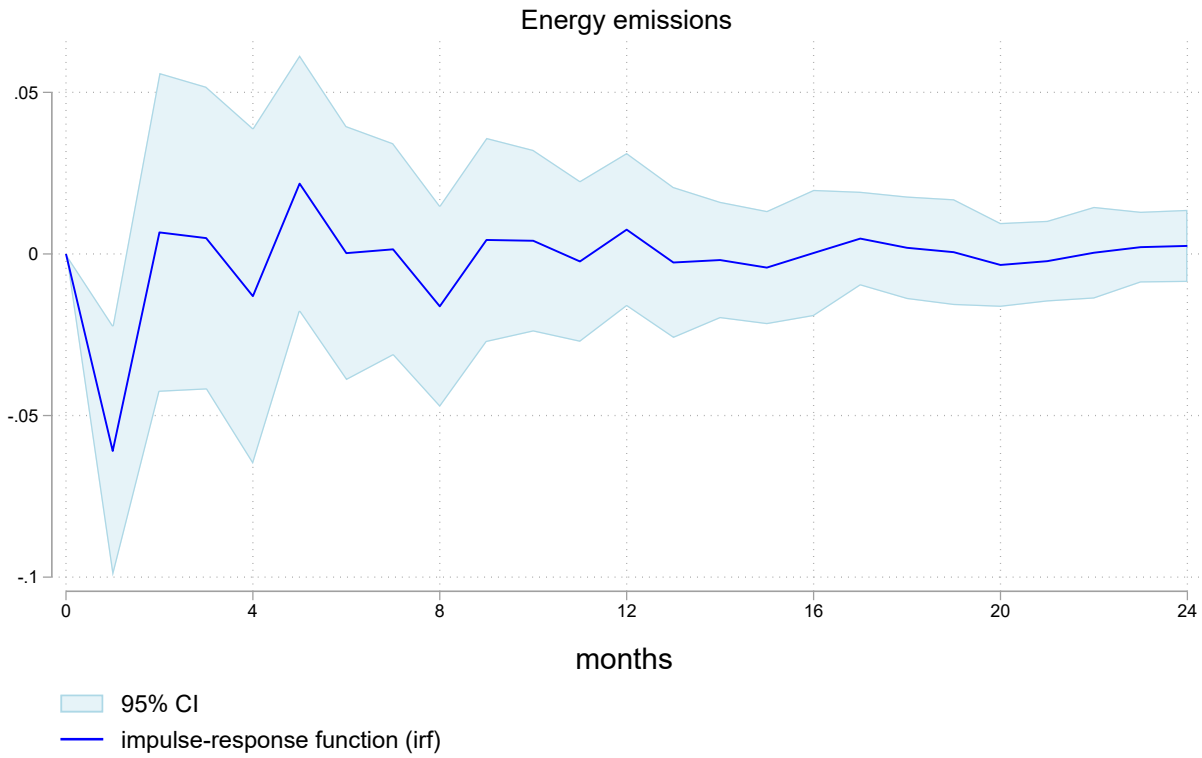
**Figure 2:** Response functions from a 1% carbon policy shock

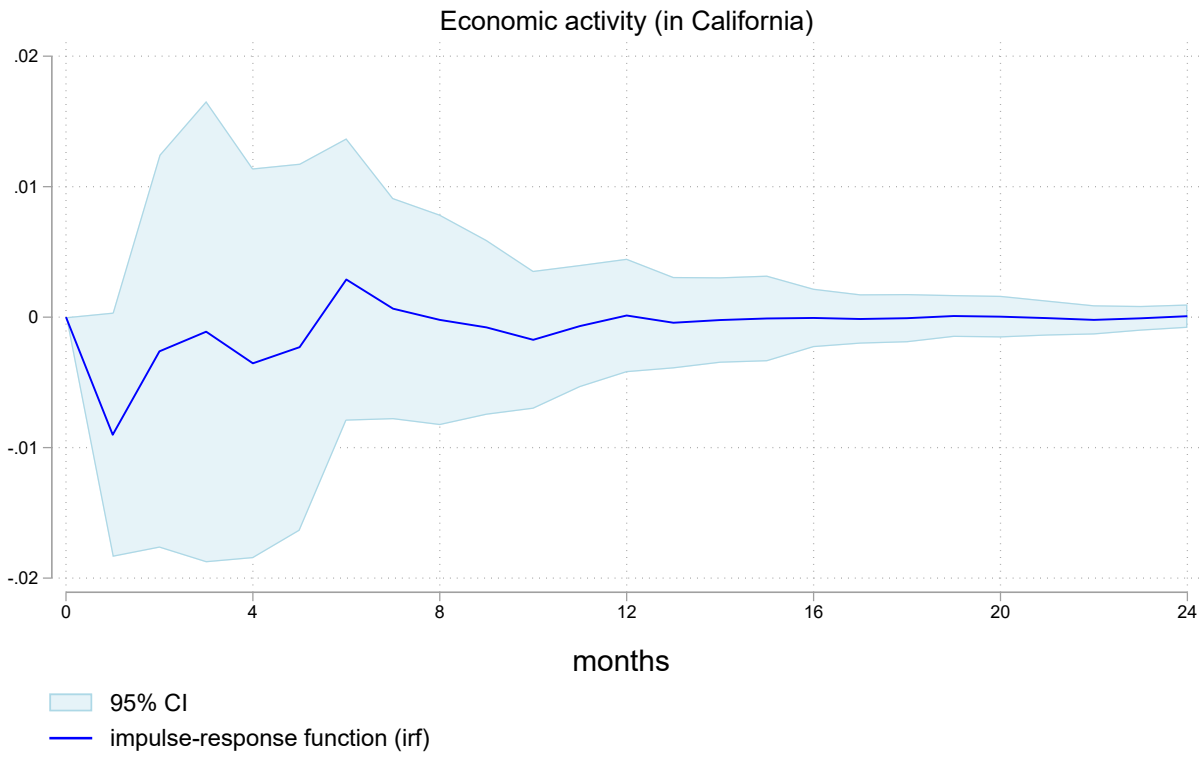



Headline consumer prices (in LA-Long Beach-Anaheim)
.005
.0025
0
-.0025
-.005
0
4
8
12
16
20
24
months
95% CI
impulse-response function (irf)


FED monetary policy rate
.4
.2
0
-.2
-.4
0
4
8
12
16
20
24
months
95% CI
impulse-response function (irf)


Unemployment rate (in California)
.1
.05
0
-.05
-.1
0
4
8
12
16
20
24
months
95% CI
impulse-response function (irf)

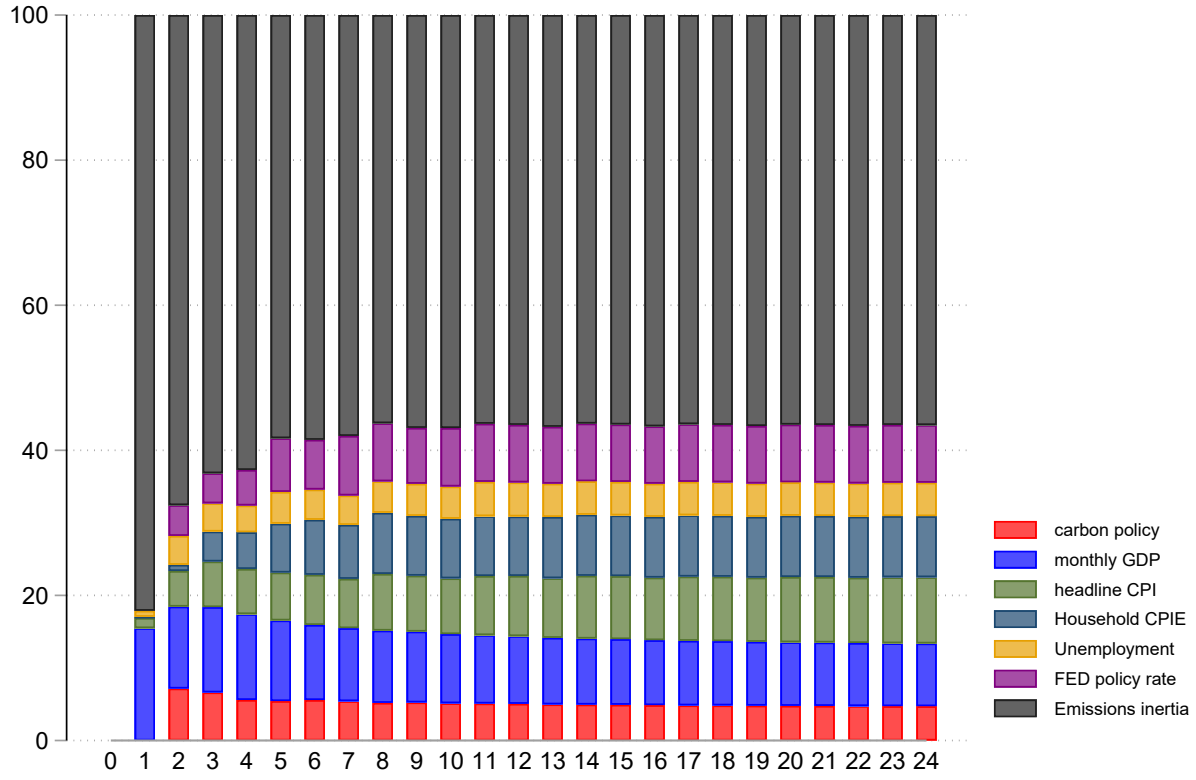

Energy emissions
.05
0
-.05
-.1
0
4
8
12
16
20
24
months
95% CI
impulse-response function (irf)




Note: own calculations with 95% boostrapped CI (100 reps).

Looking at the variance decomposition graph for energy emissions in Figure 3, it is suggested that the carbon policy surprise series explains around 7.2% of energy emissions after 2 months, and represents on average 5.1% of energy emissions thereafter. All the variables included in the model account for only 17.9% of energy emissions in the first month, and represent on average 42.2% of energy emissions thereafter.

**Figure 3:** Energy emissions variance decomposition share (in %)




Note: own calculations after SVAR model. CI have not been included for sake of space.

## 6 Robustness checks

I resort to the local projection (LP from now on) approach developed by Jordà (2005) as robustness checks to estimate the dynamic responses from a shock in the carbon policy series, since it is found to estimate the same impulse response functions as shown in Plagborg-Møller and Wolf (2019), it provides a flexible framework without any explicit long-run restrictions on the variables of interest, it is robust to nonlinear specifications and state dependency, and does not constrain the shape of the impulse response functions, thus making it less sensitive to misspecification (Ramey and Zubairy, 2018; David et al., 2019; Colavecchio and Rubene, 2019; Lusompa, 2020).

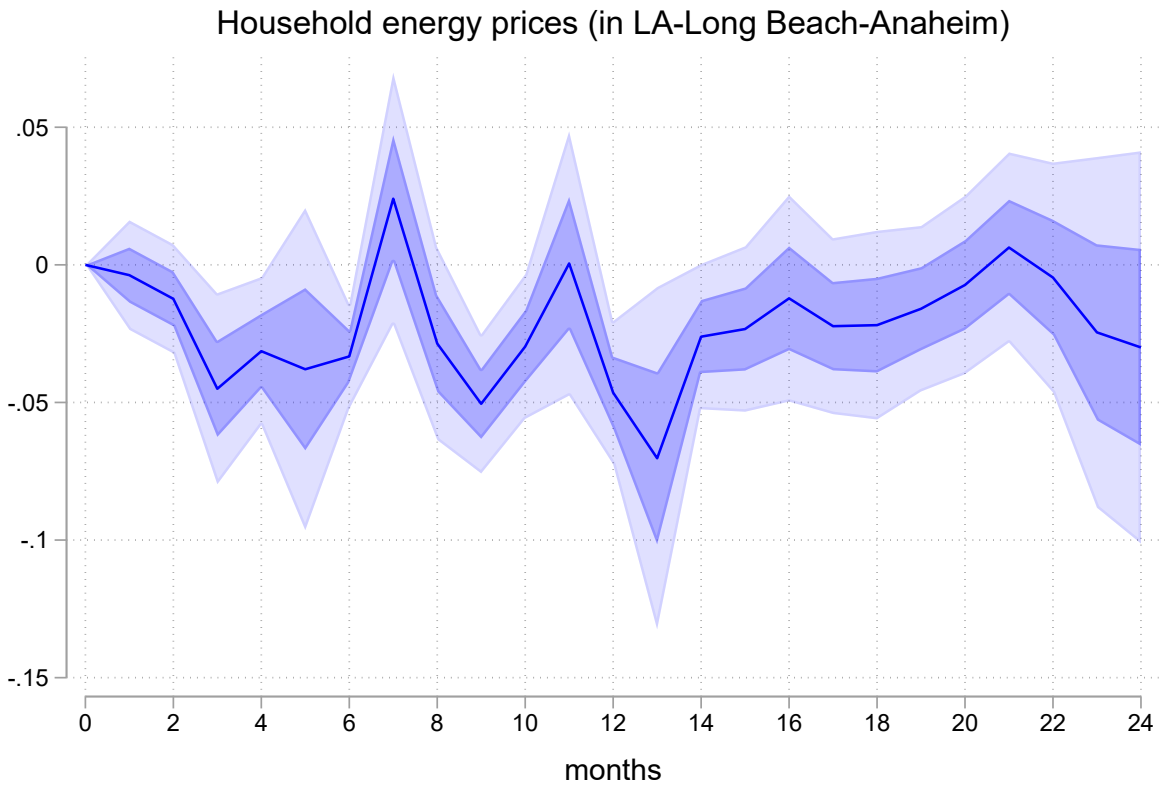
In simple words, the LP method generates impulse responses estimates for each forecast horizon $h$ by regressing the dependent variable at $t+h$ on the available information set at time $t$. The benchmark specification for different horizons (h=0,..., h=24) is defined as follows:

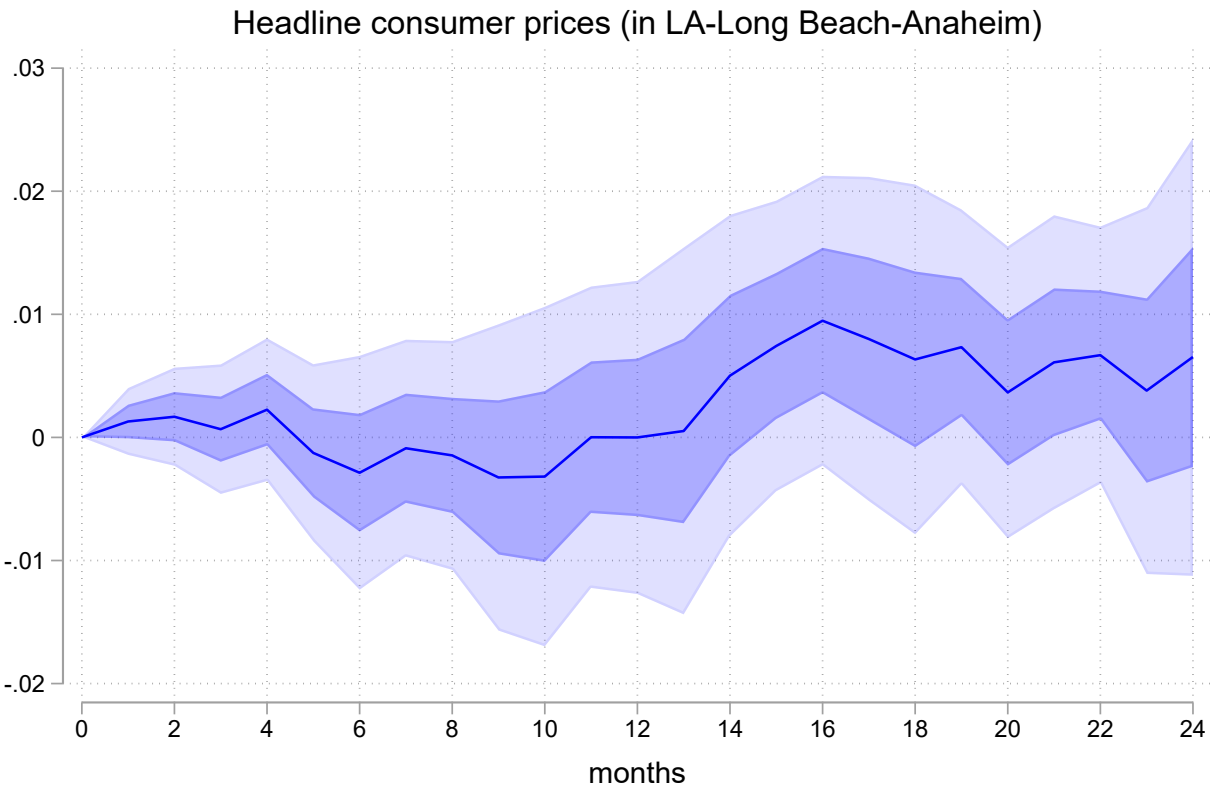
$\epsilon_{t+h}$ - $\epsilon_{t-1} = \alpha(h) + \phi(h)\ \Delta\ CPS_t + \sum_{i=0}^{k} x'_{t-i}(h)\ \omega_i(h) + \sigma(h)u_{t+h}(h)$

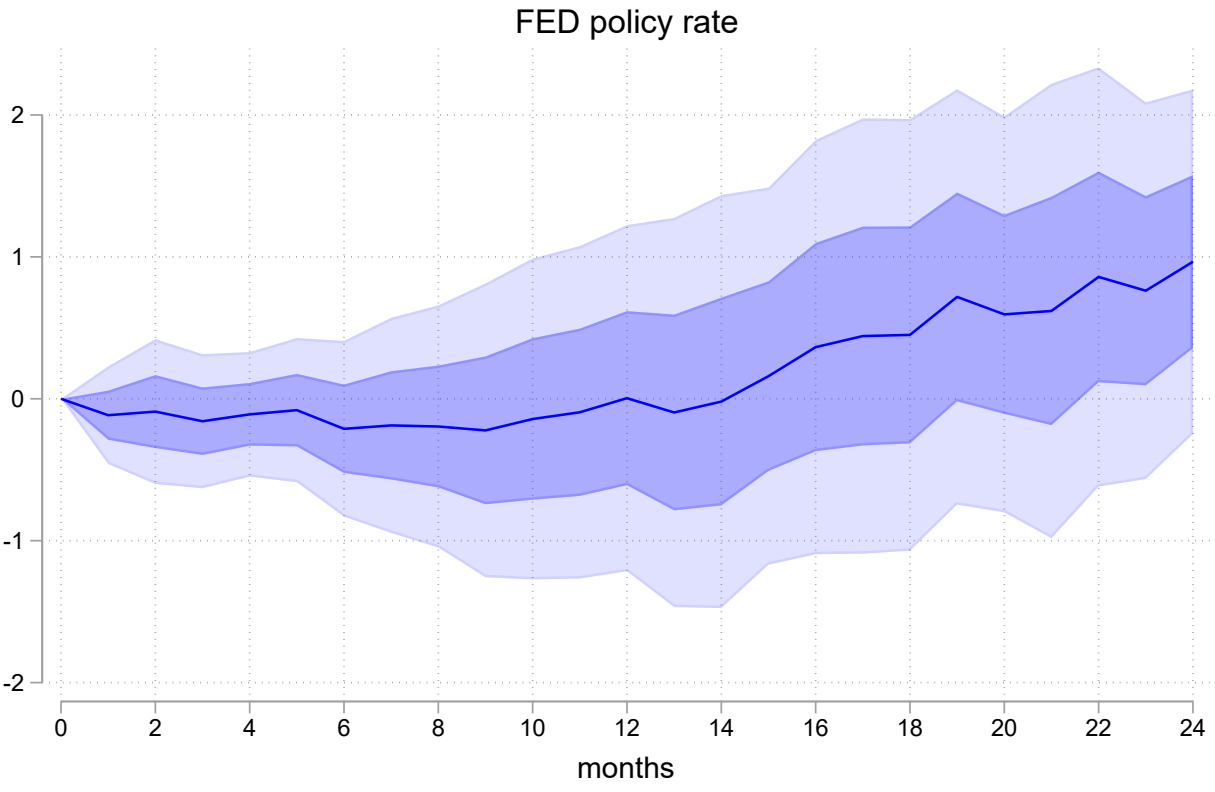
where $u_{t+h}(h) \sim \mathcal{N}(0,1)$, $\sigma(h) > 0$ for all h and $x_t(h)$ a nx1 vector of control variables up to 4 lags, as already modelled in the VAR specification. The cumulative impulse responses are then constructed based on the estimated $\phi(h)$ coefficients at each horizon.

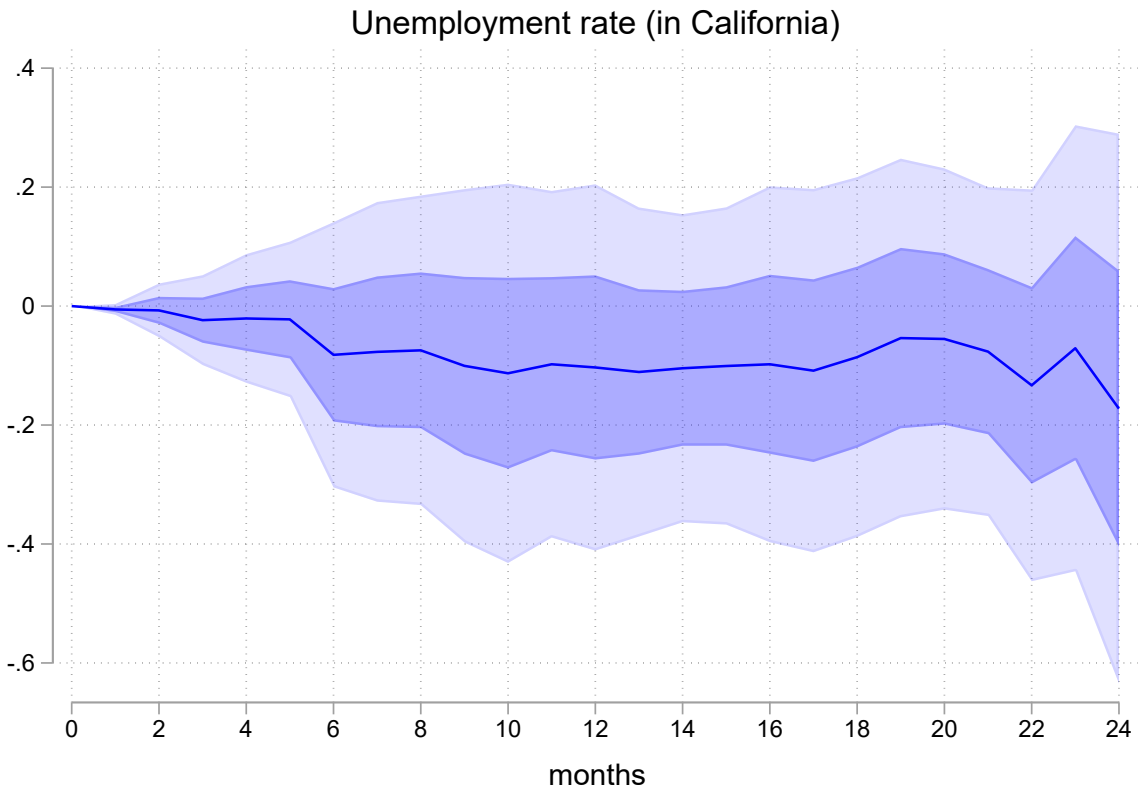
From the results, it is suggested that a shock increasing carbon prices leads to a significant reduction in carbon emissions by 0.045% after one month, consistent to my previous estimates under the SVAR model, albeit it remains not statistically significant at the 5% for the rest of the periods. Although economic activity falls immediately after a shock to carbon prices, consistent with my former estimates, results are not statistically significant at the 5%. Likewise, my other results are consistent with the estimates under the SVAR model: the FED policy rate decreases immediately, headline consumer prices increase after one month and the unemployment rate decreases with some lag, although results are not statistically significant. One interesting result is that household energy prices decrease with a shock to carbon prices, suggesting a positive economic result. Nonetheless, results are too volatile, which could mean a regional result, since this series corresponds to prices in Los Angeles, Long Beach and Anaheim, so one should take this result locally.

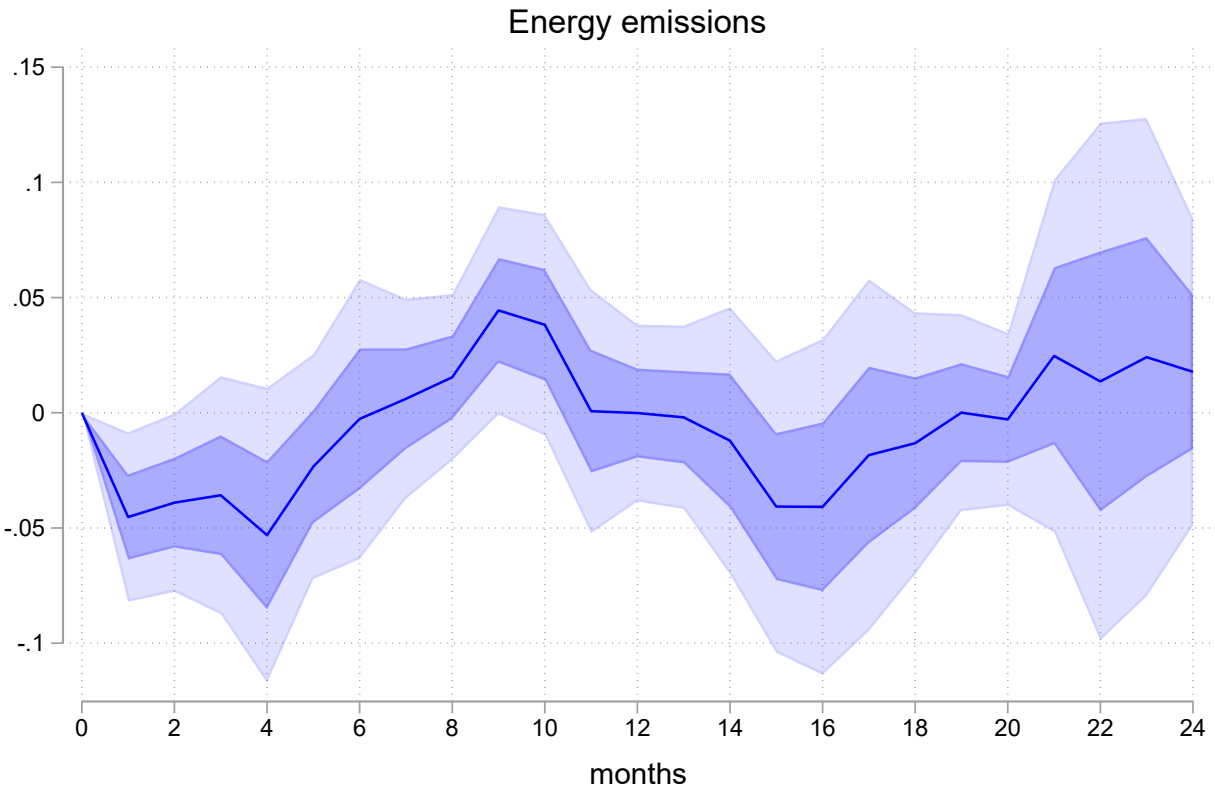
**Figure 4:** Cumulative response functions from a 1% carbon policy shock

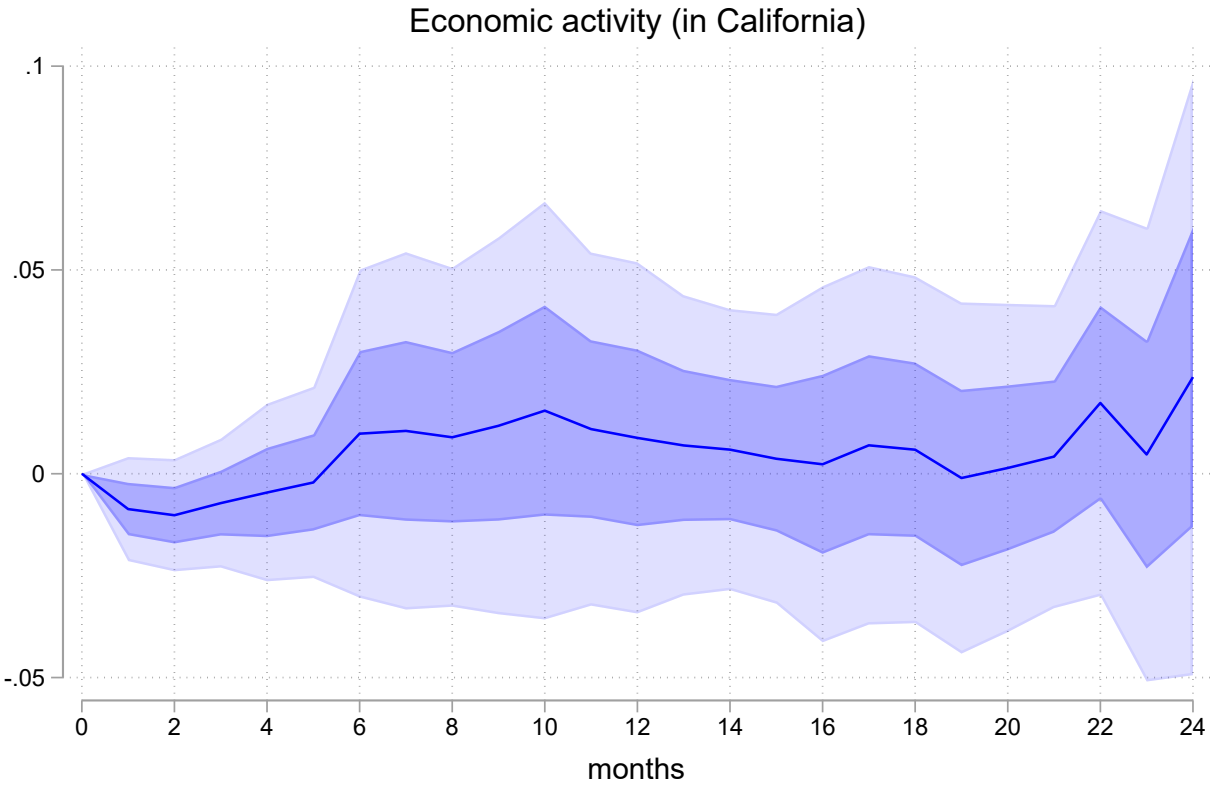



Headline consumer prices (in LA-Long Beach-Anaheim)
.03
.02
.01
0
-.01
-.02
0
2
4
6
8
10
12
14
16
18
20
22
24
months


FED policy rate
2
1
0
-1
-2
0
2
4
6
8
10
12
14
16
18
20
22
24
months


Unemployment rate (in California)
.4
.2
0
-.2
-.4
-.6
0
2
4
6
8
10
12
14
16
18
20
22
24
months


Energy emissions
.15
.1
.05
0
-.05
-.1
0
2
4
6
8
10
12
14
16
18
20
22
24
months




Note: own calculations with Newey-West standard errors to correct for heteroscedasticity and serial correlation.

## 7 Conclusion and Policy Implications

This paper addresses the macroeconomic effects of subnational carbon pricing initiatives, focusing on California's cap and trade. Using high-frequency data and regulatory news, I construct a carbon policy surprise series to understand the aggregate effects of a carbon policy shock using impulse response functions from a SVAR model. Results suggest that a shock tightening the carbon pricing regime leads to an immediate significant reduction in carbon emissions by 0.05%, albeit this reduction in emissions comes at the expense of an immediate temporary fall in economic activity by 0.01%. On the other hand, results suggest that increasing carbon prices do not transmit to either household energy prices or consumer prices. Likewise, estimations suggest that a positive shock to carbon prices decreases the monetary policy rate and increases unemployment, albeit not statistically significant at the 10%. I resort to local projections as robustness checks and find that the prior conclusions hold, i.e., that the California's cap and trade initiative has significant macroeconomic effects.

Despite some interesting findings, this work has several limitations that I would like to highlight.

Firstly, it is focused on California's cap and trade initiative with several local/regional findings, which limits the external validity of this work. And secondly and as already highlighted, this paper relies on the carbon policy surprise series as a direct measure of the shock instead of the instrumental variable approach, which could be measured with error and represent only a partial measure of the shock of interest, as it may not capture all relevant instances of regulatory news in the carbon market. Nevertheless, I am confident this paper will contribute to the literature of carbon pricing programs and their impact on macroeconomic variables and to the literature of high frequency identification approaches based on regulatory news. Furthermore, I am confident this paper will contribute to the implementation of carbon pricing policies at subnational levels, which have become more extended over the last decade.

## 8 Statements and Declarations: competing interests

I disclose there exists no conflict of interest.

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# 9 Appendix

## 9.1 Constructing the carbon policy surprise series: regulatory news

Most of the news are taken from the ARB official news page: https://ww2.arb.ca.gov/news and from the International Carbon Action Partnership website as well: https://icapcarbonaction.com/en/news

**Table 1:** Regulatory news included

| | Date | Rationale |
|---|---|---|
| 1 | April 19, 2013 | ARB sets date for linking cap-and-trade program with Québec |
| 2 | May 14, 2013 | California to borrow $500MM from CaT fund in Brown Plan |
| 3 | September 17, 2013 | ARB prepares to issue first carbon offset credits |
| 4 | October 1, 2013 | California and Quebec sign agreement to integrate their CaT |
| 5 | October 10, 2013 | Ammendments to cap and trade |
| 6 | November 13, 2013 | First California carbon offsets approved under Forestry Protocol |
| 7 | January 1, 2014 | California and Quebec CaT linkage effective |
| 8 | February 10, 2014 | Updated AB 32 Scoping Plan builds on California's framework |
| 9 | February 14, 2014 | ARB takes action against CaT program bidding violations |
| 10 | April 25, 2014 | ARB approves amendments to California's CaT regulation, new offset protocol |
| 11 | May 22, 2014 | California ARB approves first AB 32 Scoping Plan Update |
| 12 | June 3, 2014 | Québec and California announce plans for joint auction of GHG emission allowances |
| 13 | July 1, 2014 | 2013 CaT regulation effective |
| 14 | September 18, 2014 | California and Quebec announce first joint CaT auction |
| 15 | November 25, 2014 | California – Québec first joint auction |
| 16 | April 14, 2015 | Ontario to adopt a linked CaT system with California and Quebec |
| 17 | June 25, 2015 | California allows rice farming offsets, amends forestry offset protocols |
| 18 | August 3, 2015 | President Obama and EPA announced the Clean Power Plan |

| | Date | Rationale |
|---|---|---|
| 19 | September 12, 2015 | California Legislature Passes Bill Setting Target of 50 Percent Renewables by 2030 |
| 20 | September 18, 2015 | EPA issued a Notice of Violation of the Clean Air Act to Volkswagen Group |
| 21 | October 8, 2015 | California's 50% renewable energy target signed into law |
| 22 | November 1, 2015 | 2014 rice and forestry protocols regulation effective |
| 23 | February 9, 2016 | U.S. Supreme Court issued a stay against the Clean Power Plan |
| 24 | June 10, 2016 | CARB releases proposed strategy to reduce climate pollutants |
| 25 | July 18, 2016 | 2016 Amendments to the Californian Cap-and-Trade Program |
| 26 | August 3, 2016 | California suggests CaT to comply with Clean Power Plan |
| 27 | October 25, 2016 | Federal court approves $14.7 billion settlement in VW violation case |
| 28 | November 28, 2016 | CARB posts revised draft of strategy to reduce "Super Pollutants" |
| 29 | December 20, 2016 | CARB announces partial Consent for Audi, Volkswagen and Porsche |
| 30 | January 20, 2017 | California issues proposed plan to achieve groundbreaking 2030 climate goals |
| 31 | March 23, 2017 | CARB approves broad plan for reducing climate "super pollutants" |
| 32 | April 6, 2017 | Court Upholds California's Cap-and-Trade Program |
| 33 | May 19, 2017 | CARB announces emissions modification for VW diesel vehicles |
| 34 | June 28, 2017 | California Supreme Court declined to review lower court decision upholding CaT |
| 35 | July 25, 2017 | Gov. Brown signed bill to extend the California CaT until 2030 |
| 36 | July 27, 2017 | CARB approves CaT improvements |
| 37 | September 22, 2017 | CaT linking agreement with Quebec and California |
| 38 | October 1, 2017 | 2016 CaT Regulation |
| 39 | January 1, 2018 | Ontario-Quebec-California joint CaT effective |
| 40 | February 28, 2018 | U.S. EPA's proposal to repeal the Clean Power Plan |
| 41 | March 22, 2018 | Ammendments to California's CaT |
| 42 | May 30, 2018 | 2018 Regulation (Narrow Scope) effective |

| | Date | Rationale |
|---|---|---|
| 43 | June 15, 2018 | Premier-Designate Doug Ford announces an end to Ontario's CaT |
| 44 | June 29, 2018 | Proposed amendments to the CaT Program |
| 45 | July 3, 2018 | Ontario revoked its CaT regulation |
| 46 | September 4, 2018 | California publishes draft amendments of CaT regulation |
| 47 | December 13, 2018 | CARB approves CaT amendments paving way until 2030 |
| 48 | April 1, 2019 | 2018 CaT Regulation effective |
| 49 | September 19, 2019 | California approves standard for assessing tropical deforestation credits |
| 50 | October 23, 2019 | Lawsuit challenges California's CaT program |
| 51 | March 31, 2020 | U.S. EPA releases new fuel efficiency standards for cars and trucks |
| 52 | June 24, 2020 | California proposes re-evaluating its landmark climate strategy |
| 53 | July 17, 2020 | U.S. District Court rendered its decision upholding California-Quebec CaT |
| 54 | November 24, 2020 | CARB approves changes to the requirements for reporting emissions |
| 55 | February 16, 2021 | California reviews carbon trading program as part of climate roadmap |
| 56 | November 9, 2021 | California joint declaration with New Zealand to cooperate against climate change |
| 57 | December 9, 2021 | CARB approves regulations requiring small off-road engines |
| 58 | February 23, 2022 | Legislators debated Newsom administration's LT strategy for cutting GHG |
| 59 | February 24, 2022 | CARB approves amendments to rule for Transport Refrigeration Units |
| 60 | May 10, 2022 | CARB releases draft climate action plan to reach carbon neutrality by 2045 |
| 61 | June 30, 2022 | Supreme Court limited the EPA's ability to regulate emissions from power plants |
| 62 | August 16, 2022 | IRA passes into law |
| 63 | October 14, 2022 | Community emissions reduction program for Arvin/Lamont approved |
| 64 | November 17, 2022 | CARB approves amendments to Off-Road Regulation |
| 65 | December 15, 2022 | California approves Final 2022 Scoping Plan |

| | Date | Rationale |
|---|---|---|
| 66 | January 6, 2023 | EPA Proposes to strengthen air quality standards |
| 67 | May 25, 2023 | CARB passes amendments to phase out toxic hexavalent chromium |
| 68 | October 26, 2023 | CARB approves 5-year strategy update for its Community Air Protection Program |
| 69 | November 16, 2023 | CARB approves funding plan to invest in transition to zero-emission |

### 9.2 Data sources and variables

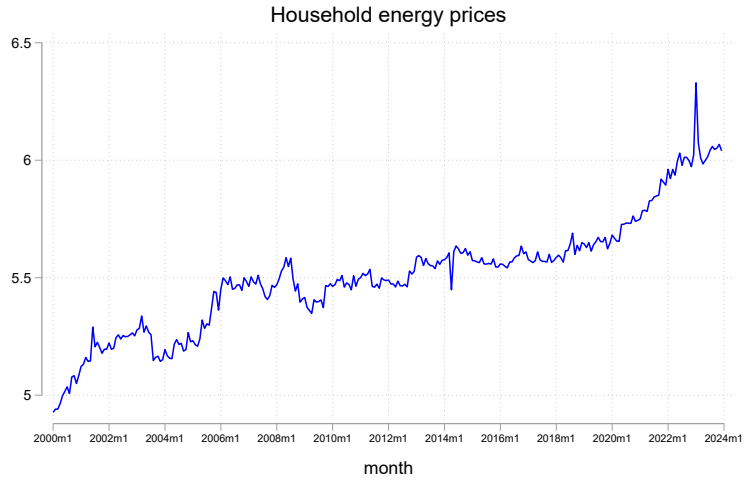
In this subsection, I provide details on the macroeconomic data used in the paper, including information on the data source and coverage.

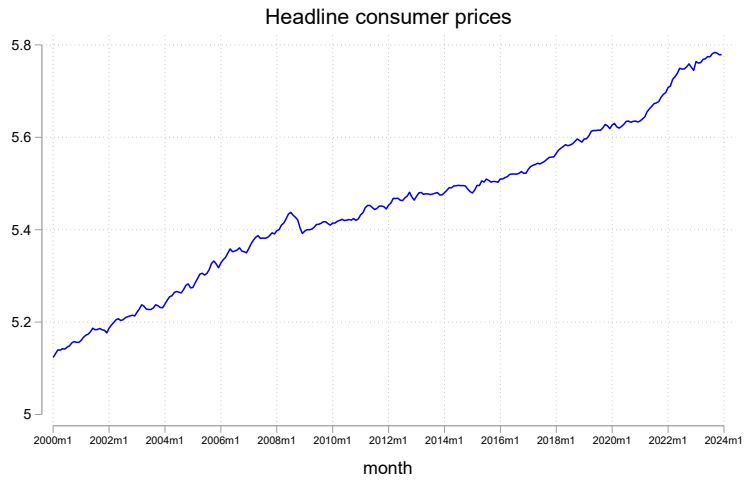
**Table 2:** Data coverage and sources of variables included in the model

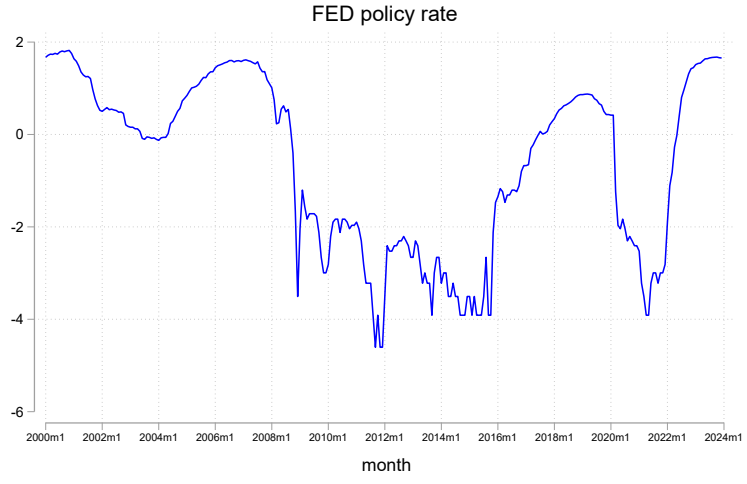
| Variable | Periodicity | Source |
|---|---|---|
| Monthly economic activity (in CA) | Jan 2000-Dec 2023 | Federal Reserve Bank of Boston |
| Headline consumer prices (in LA-Long Beach-Anaheim) | Jan 2000-Dec 2023 | US Bureau of Labour Statistics |
| Household energy prices (in LA-Long Beach-Anaheim) | Jan 2000-Dec 2023 | US Bureau of Labour Statistics |
| US energy emissions | Jan 2000-November 2023 | EIA database |
| Unemployment rate (in CA) | Jan 2000-Dec 2023 | Federal Reserve Bank of St. Louis |
| FED monetary policy rate | Jan 2000-Dec 2023 | Federal Reserve Bank of St. Louis |
| Electricity prices | Jan 2000-Dec 2023 | EIA database |

Figure 4 showcases all variables in log-levels.

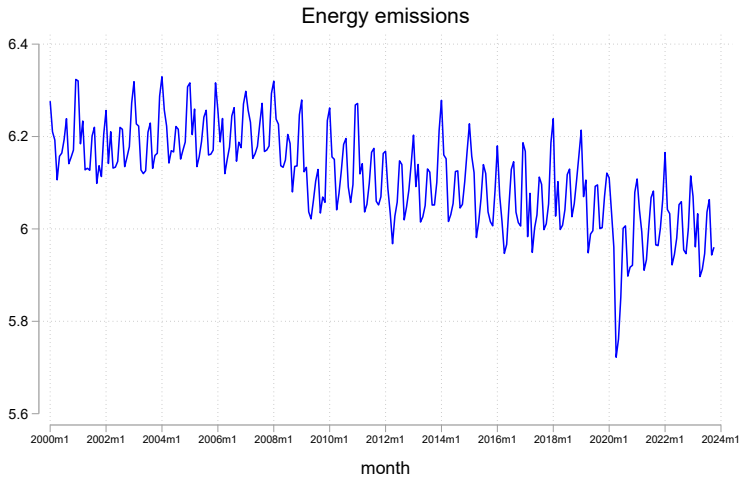
**Figure 5:** Variables included in the SVAR model (in logs)




Unemployment rate
3
2.5
2
1.5
1
2000m1
2002m1
2004m1
2006m1
2008m1
2010m1
2012m1
2014m1
2016m1
2018m1
2020m1
2022m1
2024m1
month


Energy emissions
6.4
6.2
6
5.8
5.6
2000m1
2002m1
2004m1
2006m1
2008m1
2010m1
2012m1
2014m1
2016m1
2018m1
2020m1
2022m1
2024m1
month

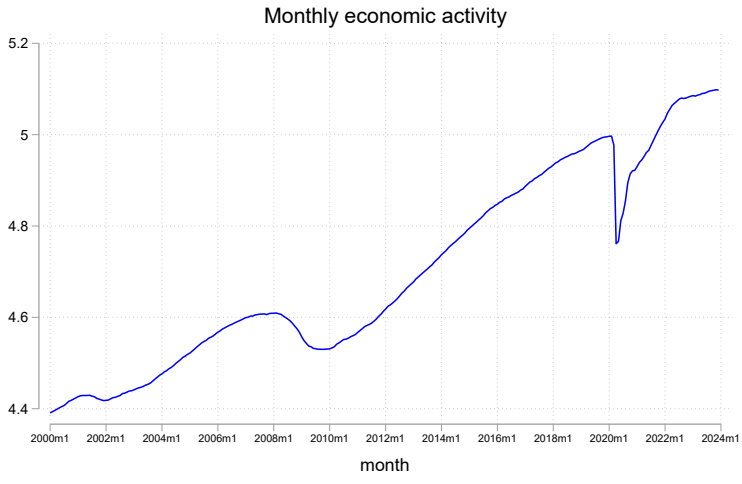

Monthly economic activity
5.2
5
4.8
4.6
4.4
2000m1
2002m1
2004m1
2006m1
2008m1
2010m1
2012m1
2014m1
2016m1
2018m1
2020m1
2022m1
2024m1
month

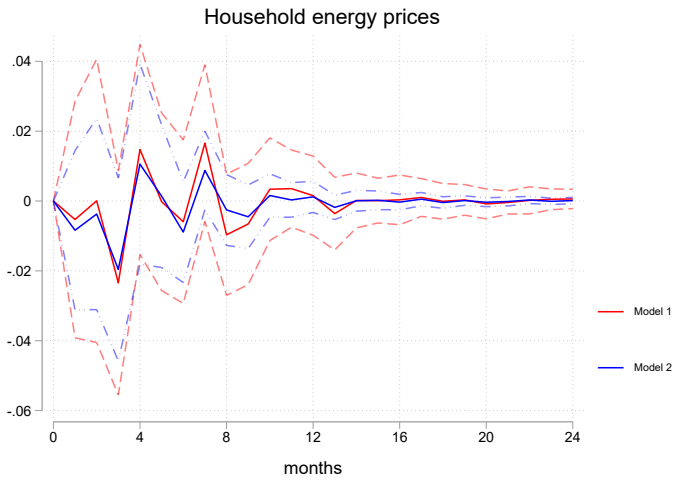
**Table 3:** Lag selection criterion

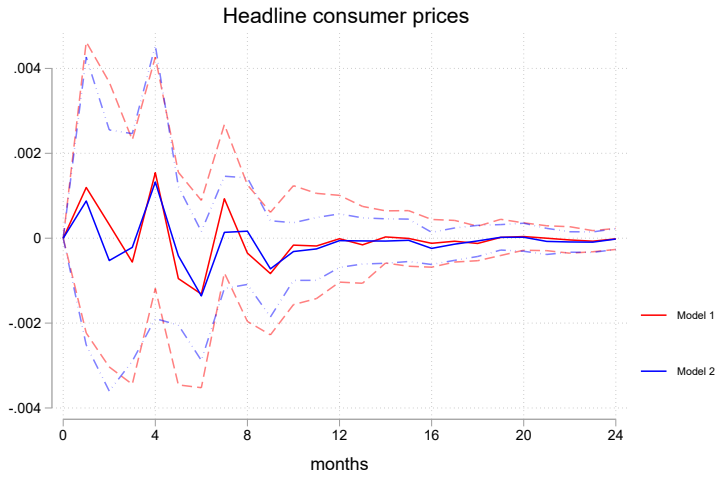
| Lag | Akaike Criterion |
|---|---|
| 0 | -23.054 |
| 1 | -23.626 |
| 2 | -24.054 |
| 3 | -24.405 |
| 4 | -24.491* |

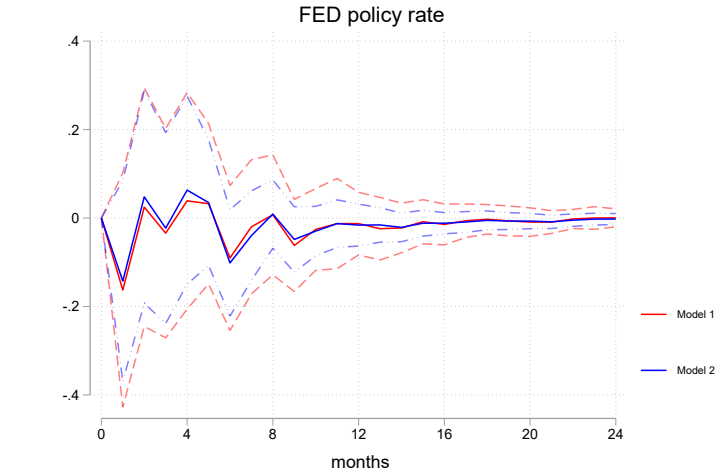
### 9.3 Sensitivity analysis

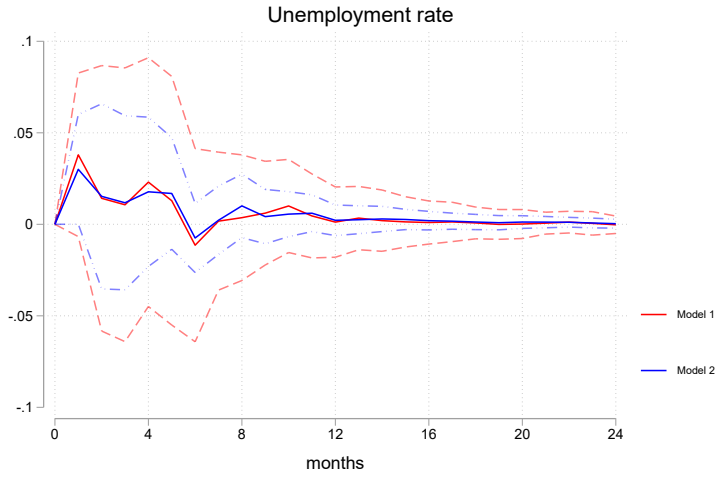
In this subsection, I provide several robustness checks. First, I extend the carbon policy surprise series up to January 2000 to increase the precision of the estimates, by imputing zeros for each missing value of the series (as justified theoretically in Noah, 2019). Figure 6 compares estimates from the former model (Model 1) with the model extended up to January 2000 (Model 2). As observed, results do not seem to vary significantly, although estimates become less volatile as expected. However, it is seen that the decline in the unemployment rate becomes significant at the 5% level, thus suggesting another possible impact from the cap and trade.

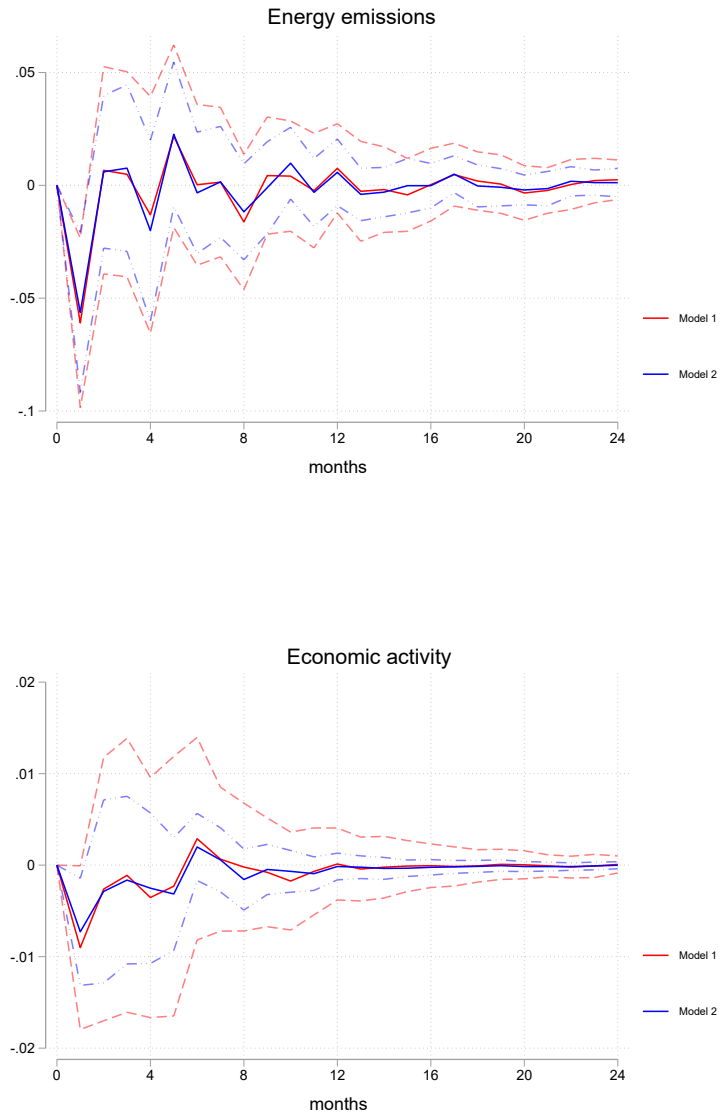
**Figure 6:** Comparison of estimates for each model




Headline consumer prices
.004
.002
0
-.002
-.004
0
4
8
12
16
20
24
months
Model 1
Model 2


FED policy rate
.4
.2
0
-.2
-.4
0
4
8
12
16
20
24
months
Model 1
Model 2


Unemployment rate
.1
.05
0
-.05
-.1
0
4
8
12
16
20
24
months
Model 1
Model 2




Note: own calculations with 95% boostrapped CI (100 reps).

Then, I test the strength of the former model (from January 2013-December 2023) by replacing the headline consumer prices variable by a core prices measure, since the latter explicitly excludes energy prices; and the household energy prices variable by an Energy CPI measure estimated by the U.S. Bureau of Labour Statistics, and by electricity prices (measured in cents per Kilowatthour) estimated by the EIA. Figure 7 compares estimates from each variable of interest and shows that conclusions do not vary significantly: although it is suggested that energy and electricity prices increase after a positive shock to carbon prices, whereas the immediate response on household energy prices is negative, it is not statistically significant.

**Figure 7:** Comparison of estimates in the former Model 1

