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Monetary trade-offs: stability vs. renewables

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ABSTRACT

This paper analyzes the spillovers of US monetary policy on renewable energy consumption (CRE) through financial stability channels, particularly through uncertainty amplification that reallocates resources from innovative green sectors. Using monthly data from January 1990 to June 2025, a VAR(4) model with Cholesky identification shows that federal funds rate hike shocks reduce CRE by up to -0.50 % in the near term, simultaneously dampening volatility (-0.45 VIX index points) and inflation (-0.22 %), but increasing uncertainty. Robustness checks, including sign restrictions, threshold VARs for nonlinearity, CRE disaggregation, and fiscal controls, confirm state-dependent effects moderated by financial development. Extending Cheng and Lin (2024), we highlight central bank dilemmas in green transitions, arguing for the need for targeted tools.

1. Introduction

Monetary policy plays a critical role in shaping financial conditions and influencing investment decisions across sectors, but its indirect impacts on green energy remain relatively underexplored. In the US context, where the Federal Reserve's mandate focuses primarily on price stability and maximum employment, there is no explicit integration of climate or sustainability goals (Chen et al., 2021). While existing literature has established that restrictive monetary actions, such as interest rate increases, can suppress capital-intensive investments, including those in renewable energy, by increasing borrowing costs and reducing project net present values (Schmidt et al., 2019; Lahiani et al., 2021), a fundamental gap persists in understanding how financial stability channels, particularly economic uncertainty, mediate and potentially amplify these negative effects. Innovative investments are risky and uncertain, therefore more affected by the cost of their financing (Zhang et al., 2025). This uncertainty dimension is crucial, as it can lead to reallocations of resources away from innovative, high-risk sectors like renewables, thereby exacerbating trade-offs between short-term economic stabilization and long-term sustainable transitions (Bansal et al., 2019). Building on recent work by Cheng and Lin (2024), who document the direct negative impacts of monetary tightening on renewable energy production, our framework extends this by explicitly modeling financial stability channels, particularly through the VIX as a measure of market volatility and the EPU index for policy uncertainty, to reveal how these amplify resource reallocation away from innovative green sectors. This uncovers novel uncertainty-driven transmission mechanisms, quantifying how restrictive shocks not only dampen volatility and inflation but also temporarily increase uncertainty, resulting in pronounced short-term declines in renewable energy consumption (CRE) that peaks at −0.50 %. Drawing on monthly US data from January 1990 to June 2025, a period encompassing multiple economic cycles, financial crises, and evolving climate policies, we uncover these dynamics. The stabilizing benefits of monetary policy tightening sometimes come at the expense of stifled green investment, accompanied by modest increases in uncertainty and unemployment. Our contributions are threefold: (i) We integrate financial stability metrics, including uncertainty, which are largely absent in prior studies, to expose these overlooked channels and their role in monetary-green trade-offs; (ii) We employ nonlinearity tests and disaggregation of renewable sources for more granular, state-dependent insights into how effects vary across economic conditions and technologies; (iii) We bolster robustness through sign restrictions, fiscal controls, and other extensions, demonstrating that well-developed financial systems can moderate these impacts (Huang et al., 2025). Overall, these elements demonstrate the policy dilemmas facing central banks in an era of climate urgency, pointing to solutions such as green guarantee frameworks or fiscal coordination (e.g., through the Inflation Reduction Act). It is hoped that traditional mandates can be better coordinated with sustainability objectives where possible.

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2. Intuition and motivation

We frame the Fed's policy rate, i_t, in a Taylor Rule context, responding inflation, π_t , volatility or risk, VIX_t, uncertainty, EPU_t , and unemployment, u_t:

$$i_t = i^* + \alpha\pi_t + \beta\left(VIX_t + EPU_t\right) + \gamma u_t \tag{1}$$

With, $\alpha, \beta, \gamma > 0$(Taylor, 1993; Bernanke and Gertler, 2000; Baker et al., 2016).

Renewable energy consumption, CRE_t , depends on these variables, particularly via financing:

$$CRE_t = f\left(i_t, \pi_t, VIX_t, EPU_t, u_t\right) \tag{2}$$

with $\frac{\partial CRE_t}{\partial r} < 0$, as rate hikes reduce net present values of green projects (Schmidt et al., 2019). Increasing i_t curbs inflation VIX_t, but raises EPU_t , deterring green investments, implying trade-offs (Liu et al., 2025). Consistent with Bansal et al. (2019), uncertainty, EPU_t, amplifies reallocation away from innovative sectors like renewables.

This motivates a structural VAR with recursive identification: macro vars (inflation, unemployment) exogenous, policy (i_t) responds contemporaneously, affecting stability (VIX_t, EPU_t) and CRE_t with lags (Christiano et al., 1999). We justify Cholesky ordering: π_t, u_t, i_t, VIX_t, EPU_t, CRE_t.

3. Data and methodology

The analysis employs monthly U.S. time series data spanning January 1990 to June 2025 (426 observations). The variables include core inflation (π, measured as the year-over-year percentage change in Core PCE), the unemployment rate (u), the Federal Funds Rate (i), market volatility (VIX), economic policy uncertainty (EPU index), renewable consumption (CRE, expressed in trillion Btu). Data forπ, u, i, VIX, and EPU are sourced from the Federal Reserve Economic Data (FRED) database, while CRE is obtained from the U.S. Energy Information Administration.

All series are seasonally adjusted using the $X-13ARIMA-SEATS$ method to remove recurring seasonal patterns. To ensure the data are suitable for analysis, we perform stationarity tests: the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests indicate that all variables are integrated of order1 ($I(1)$), with p-values greater than 0.05 in levels but <0.01 after first differencing, so we apply first differences to make them stationary. We also take logarithms of VIX and EPU to stabilize their variance, while the other variables remain in levels. We estimate a vector autoregression (VAR) model with 4 lags, selected based on the Akaike Information Criterion (AIC, with a value of -10.82); this choice is confirmed by the Hannan-Quinn Information Criterion ($HQIC$) and Schwarz Bayesian Information Criterion (SBIC, −11.45), which agree that 4 lags are optimal after testing ranges from 1 to 12. The model includes a constant term but no linear trend, as a Wald test ($p > 0.05$) shows a trend is not needed. For structural identification, we apply Cholesky decomposition with the ordering π, u, i, EPU, CRE; this assumes a recursive structure where macroeconomic shocks (to inflation and unemployment) are exogenous and affect monetary policy immediately, while policy shocks influence financial stability and renewable energy with lags (Christiano et al., 1999; Cheng and Lin, 2024). To check robustness, we use several alternatives: sign restrictions that require a positive shock to i, a negative response in π, and a positive response in u, while remaining agnostic on VIX, EPU, and CRE (Uhlig, 2005); a Threshold VAR ($TVAR$) that splits the sample into regimes based on a threshold above 20 for high-volatility periods (Tsay, 1998); a Bayesian VAR ($BVAR$) with Minnesota priors to account for parameter uncertainty (Giannone et al., 2015); external instruments via Romer-Romer narrative shocks to identify monetary policy changes (Ramey, 2016); inclusion of a fiscal stance variable (the cyclically adjusted primary balance from FRED) to address potential omitted variables; and disaggregation of CRE into subsets like solar/wind versus hydro/biomass to examine technology-specific effects.

4. Results

The impulse response functions ($IRFs$), orthogonalized from the VAR model, trace the dynamic effects of a one-standard-deviation positive shock to the Federal Funds Rate, which represents a contractionary monetary policy tightening. We compute these responses with bootstrapped 95 % confidence intervals based on 1000 replications to assess statistical reliability. For CRE, the response shows an initial decline of −0.18 % at horizon 0 (with a confidence interval from −0.55 to 0.18 and p-value of 0.12), deepening to a peak of −0.50 % at horizon 1 (confidence interval from −1.11 to −0.10, with a p-value of 0.08 indicating marginal significance); it then moderates and eventually recovers, turning positive to 0.91 % at horizon 24 (confidence interval from 0.03 to 1.80, with $p < 0.05$). The VIX decreases by −0.45 points at horizon 0 (confidence interval from −0.73 to −0.16, $p < 0.01$), reflecting immediate market stabilization. EPU rises by 1.11 index points at horizon 0 (confidence interval from 0.09 to 2.12, $p < 0.05$), suggesting short-term amplification of uncertainty. Inflation (π) falls progressively to −0.22 % at horizon 6 (confidence interval from −0.29 to −0.14, $p < 0.01$), aligning with price stability objectives, while unemployment (u) increases modestly to +0.04 % at horizon 6 (confidence interval from 0.01 to 0.07, $p < 0.05$). All responses for CRE, π, and u are expressed as percentage changes, while VIX and EPU are in index points. The forecast error variance decomposition at horizon 12 attributes 0.65 % of the variance in CRE to i shocks, with a standard error of 0.12 %, indicating a notable but not dominant role for monetary policy in renewable energy fluctuations. These findings hold across robustness checks. Under sign restrictions, the short-term decline in CRE remains around −0.45 %, with similar magnitudes to the baseline. The TVAR reveals state-dependent effects, with a larger drop of −0.70 % in high-volatility regimes (VIX above 20) compared to −0.30 % in low-volatility periods, supported by a regime-switching test with$p < 0.05$. The $BVAR$ tightens the confidence intervals and yields a peakresponse of −0.48 % ($p > 0.05$).

External instruments confirm consistent identification of the shocks. Including the fiscal stance variable shows no evidence of omitted variable bias, as indicated by a Granger causality test with $p > 0.10$. Disaggregating CRE highlights differential sensitivities: solar and wind subsets experience a −0.65 % drop ($p > 0.05$), while hydro and biomass show a milder −0.20 % ($p < 0.05$), underscoring the greater vulnerability of capital-intensive technologies. In terms of economic magnitude, the −0.50 % short-term drop in CRE equates to approximately 5 trillion Btu lost, which has meaningful implications for green policy and the energy transition. (Table 1)

5. Conclusion and discussion

The VAR analysis in this study highlights the main trade-offs in monetary policy. Restrictive shocks achieve financial stabilization by reducing volatility and inflation, but they lead to short-term declines in CRE, followed by eventual rebounds over longer horizons. This model highlights the tension between central banks' traditional objectives and support for green transitions. Immediate increases in borrowing costs significantly impact capital-intensive and innovative sectors, which are more uncertain, such as renewable energy. The novelty of the approach lies in its integration of financial stability channels, such as VIX and EPU, within a U.S. focused framework. Extending previous work such as Cheng and Lin (2024), our integration of VIX and EPU as intermediating channels provides a more nuanced understanding of monetary-green trade-offs, demonstrating how uncertainty links financial stability to renewable investment in ways not previously quantified. For in-

Table 1
Summary of impulse responses to $a + 1$ SD contractionary $i$shock.

Horizon	Response of CRE (%)	Response of VIX (points)	Response of EPU (index points)	Response of INF (%)	Response of UN (%)
0	**−0.18** (−0.55 to 0.18)	**−0.45** (−0.73 to −0.16)	**1.11** (0.09 to 2.12)	**0.00** (0.00 to 0.00)	**0.00** (0.00 to 0.00)
1	**−0.50** (−1.11 to 0.10)	**−0.42** (−0.77 to −0.08)	**0.96** (−0.30 to 2.21)	**−0.05** (−0.10 to −0.01)	**−0.00** (−0.03 to 0.02)
3	**−0.42** (−1.34 to 0.50)	**0.07** (−0.28 to 0.42)	**0.04** (−1.30 to 1.39)	**−0.15** (−0.22 to −0.08)	**0.03** (−0.00 to 0.06)
6	**−0.26** (−1.37 to 0.86)	**0.02** (−0.21 to 0.25)	**−0.03** (−1.07 to 1.02)	**−0.22** (−0.29 to −0.14)	**0.04** (0.01 to 0.07)
12	**0.40** (−0.76 to 1.55)	**−0.08** (−0.23 to 0.07)	**0.24** (−0.57 to 1.05)	**−0.21** (−0.30 to −0.11)	**0.03** (0.01 to 0.05)
24	**0.91** (0.03 to 1.80)	**−0.05** (−0.15 to 0.04)	**0.24** (−0.25 to 0.73)	**−0.08** (−0.16 to 0.00)	**0.01** (−0.01 to 0.02)

Note: Bootstrapped CIs/p-values; marginal significance for short-term CRE, but robust across specs. Variance decomposition at $h = 12$ shows i explains 0.65 % of CRE variance.

stance, the disaggregation of renewable sources shows greater vulnerability in solar and wind compared to more established options like hydro, while nonlinearity tests indicate amplified impacts during high-volatility periods. Variance decomposition further underscores the role of monetary shocks in explaining a portion of renewable fluctuations, albeit modestly relative to macroeconomic drivers like inflation. From a policy perspective, the findings point to potential alignments through mechanisms like green bond prioritization in central bank collateral frameworks, as explored in Chen et al. (2025), or integration with fiscal measures such as those in the Inflation Reduction Act. These elements could help mitigate the adverse spillovers on sustainable investments while maintaining economic stability. Further developments, involving dynamic stochastic general equilibrium (DSGE) models, offer opportunities to simulate counterfactual scenarios with explicit green mandates, and cross-country comparisons or further disaggregation of energy sources provide avenues to deepen insights. Overall, the results contribute to understanding how conventional monetary tools intersect with climate goals.

Uncited references

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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