The macroeconomic effects of green technology shocks

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3rd WS2 Workshop - Frankfurt am Main
24 April 2024

Introduction

- Climate change and **green transition** pivotal in general and policy debate
- Literature has mainly focused on the physical risk from climate change
- **Transition risk** = **economic consequences** of the **green transition**

- Studying transition risk is extremely **challenging**..
  1. **Transition** is **multifaceted** and related to a number of **heterogeneous** factors
  2. **Expected path** towards low emission economy is unobservable
  3. Empirical literature has typically focused on carbon policy shocks (Kanzig, 2023)

- ..but it has crucial policy implications for **monetary (and fiscal) policy**
  - **Demand** or **supply**?

This paper

Disclaimer: a (green) innovation has a positive effect on the economy, but here we are measuring something different...

- Measure **news on green transition** path by means of **patents**
- Exploit the **ratio of green to total patents** in a VAR model of the US economy
- An increase in the ratio (re-composition towards greener technologies) interpretable as a

  news on greener future technology mix

- In the US, carbon regulation is relatively weak and stable

Literature

1. **Economic (and emissions) effects of transition risks/carbon prices**
    - Theory: Nordhaus (2007); Golosov et al. (2014); Goulder et al. (2019); Rausch, Metcalf, and Reilly (2011), Ferrani and Nispi Landi (2023)
    - Empirics: Lin and Li (2011); Metcalf (2019); Bernard, Kichian, and Islam (2018); Metcalf and Stock (2020a,b), Ohlendorf et al. (2021); Kanzig (2023)
2. **Technological news & patents**
    - Griliches (1990), Lach (1995), Hall and Trajtenberg (2004), Kogan et al. (2017), Miranda-Agrippino et al. (2022), Popp et al. (2010), Popp (2019), Hege et al. (2023), Ciccarelli & Marotta (2023), Moench & Soofi-Siavashc (2023)
    - Green innovation necessarily driven by **climate policy:** Acemoglu et al. (2016), Ramadorai and Zeni (2023)
    - Consumer **preferences** and firms' competition linked to climate-change concerns as a driving force: Besley and Person (2022), Aghion et al (2023), Accetturo et al. (2023), Barnett (2023), Love and Phelan (2023), Hong et al. (2023)

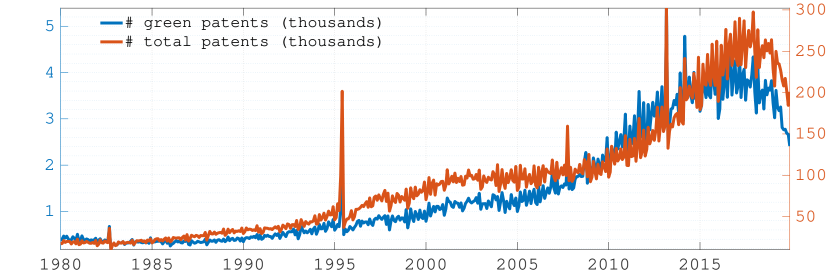
Data

- Combine two US patents dataset at the **monthly frequency 1980-today**
- USPTO **PatEx** ⇒ research patent database
- USPTO **PatViews** ⇒ information on CPC classication
- Only **granted patents** due to PatViews limitation (+ they provide stronger signal)
- **Green patents** = **climate change mitigation technologies** (Hege et al., 2023)
- Define measure of news on green tech transition as:

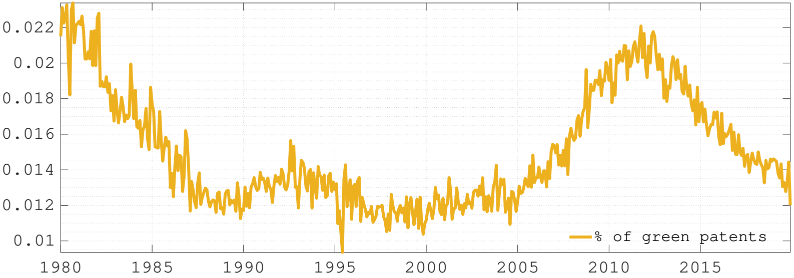
$$gp_t = \frac{\#\ \textbf{green patents} \text{ in month t}}{\#\ \textbf{patents} \text{ in month t}} \tag{1}$$

t = **month** in which the patent application was **filed** (not granted!)

Snapshot



green patents (thousands)
total patents (thousands)
5
4
3
2
1
300
250
200
150
100
50
1980
1985
1990
1995
2000
2005
2010
2015



0.022
0.02
0.018
0.016
0.014
0.012
0.01
% of green patents
1980
1985
1990
1995
2000
2005
2010
2015

Interpretation of gp_t

- Tech discovery may be partially **common** to **green** - **non-green**

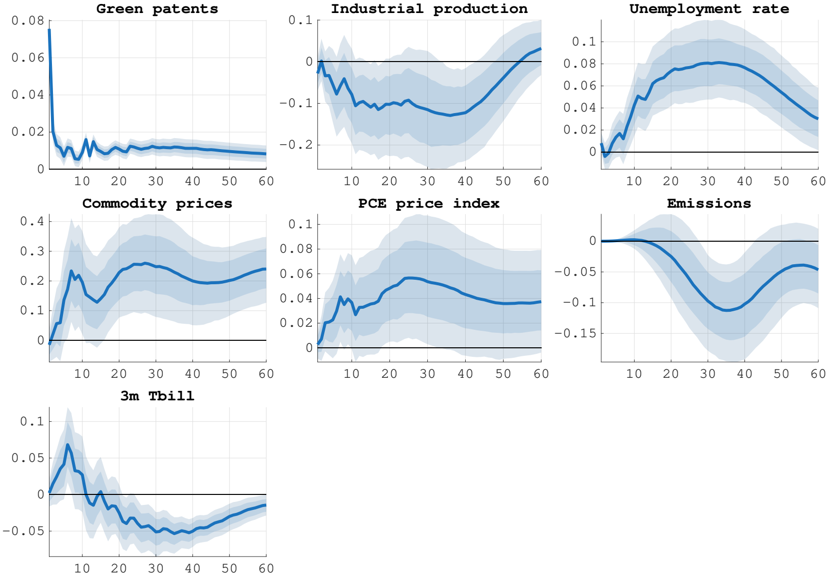
- Patenting **endogenous** to expected economic conditions (Miranda-Agrippino et al., 2022)
  - We test orthogonality of gp_t to several structural shocks and commodity prices
  - We only find explanatory power for transition metals

- gp_t
  - attenuates concerns
  - interpretable as **news** on the **expected path of the transition**
  - **economy** steering towards **green-based technology**

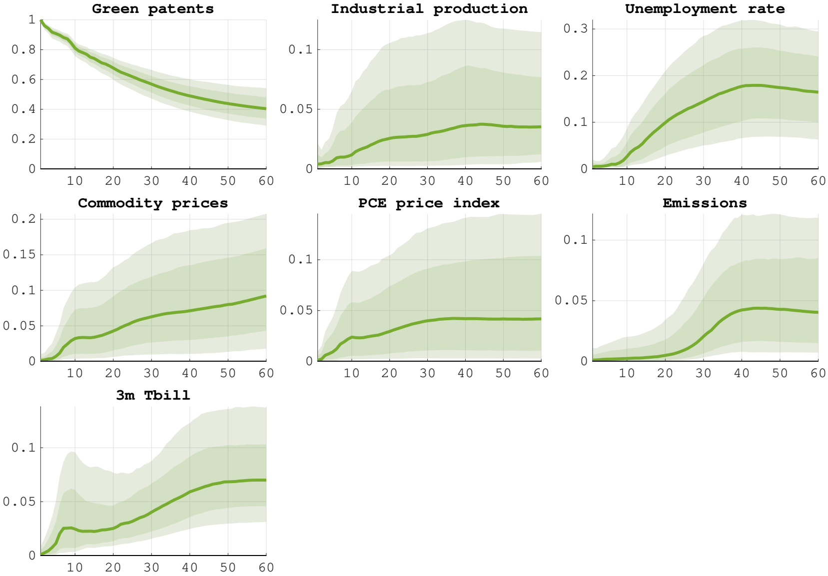
VAR analysis

- Monthly VAR
  - follow Gavriilidis, Kanzig, and Stock (2023)
  - larger info for estimation
- Quarterly VAR
  - can include **TFP**
  - talk to related literature
- **Identifying assumption**: gp_t contemporaneously exogenous wrt the other variables in the system
  - All variables respond with delay in line with a news shock interpretation

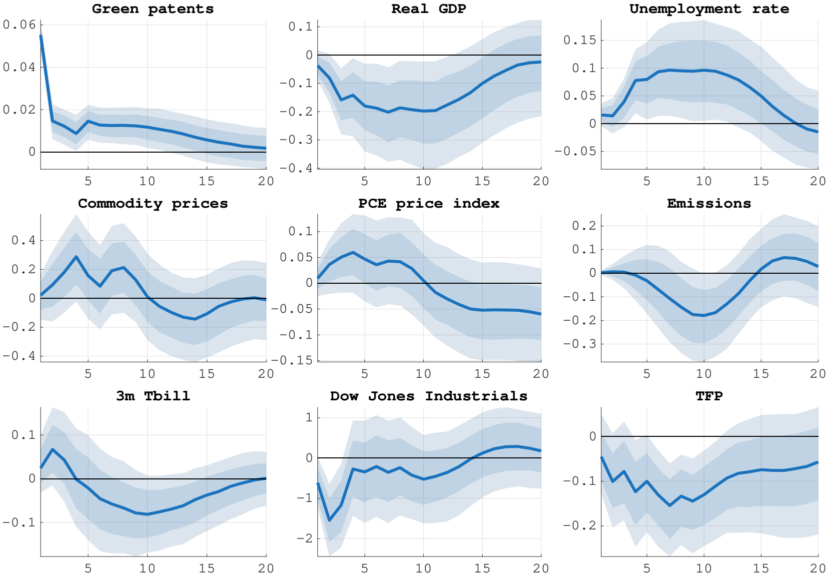
IRFs from MVAR



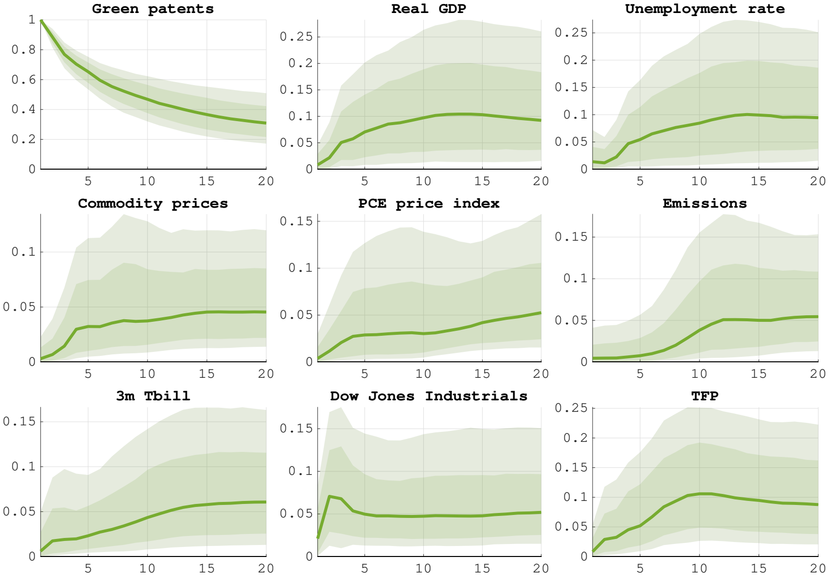
FEVD from MVAR



IRFs from QVAR



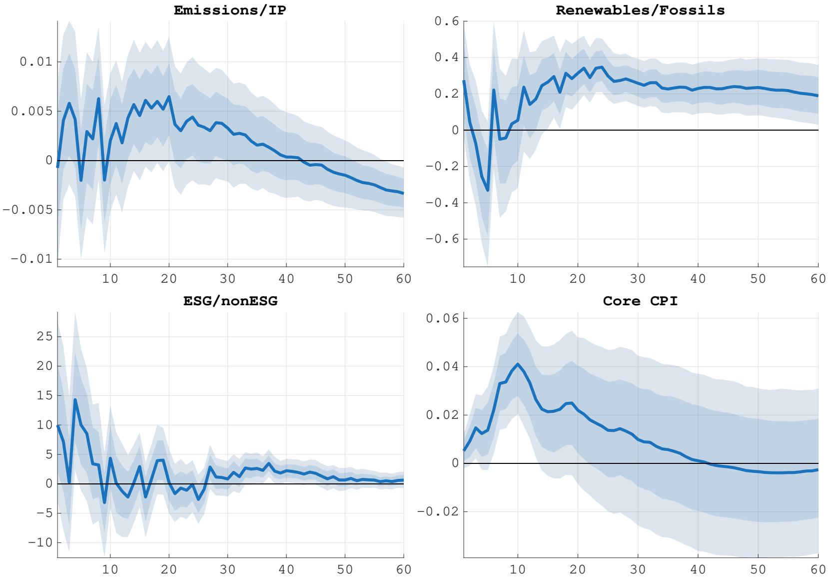
FEVD from QVAR



A negative supply shock

- News shock about **green transition** is
  - **negative supply shock** for the economy but..
  - ..the **persistent fall in emissions** makes it apart from general technology shocks Tech
  - FEVD estimates appear to provide a reasonable range
- US ideal setting: no Federal climate policy exists in the US
  ⇒ clean tech as a stand-alone driver of the transition
  ⇒ FEVD suggests that it is not enough for sustainability
- Results appear consistent with Ciccarelli & Marotta (2023) in a panel setting
  - They control for climate risk and environmental policies (annual)

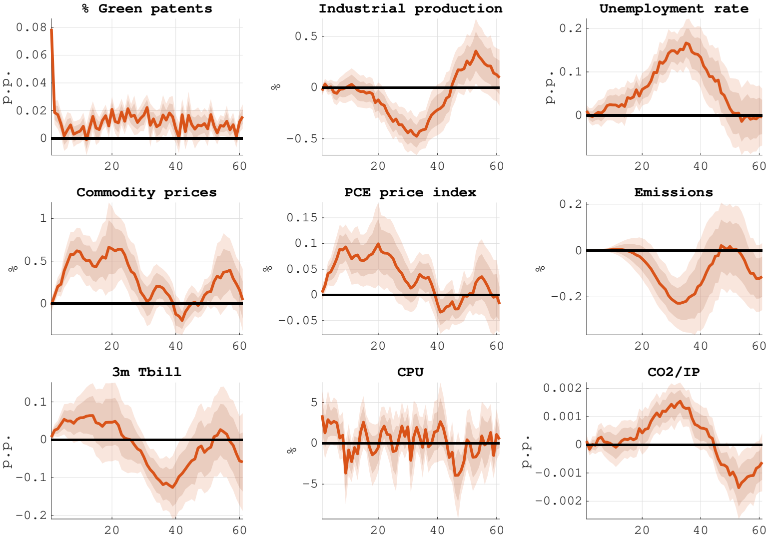
Interpretation (1): IRFs



Long-run effects (1)

- Study the long-term implications of shifts to green tech by means of LP (more precise than VAR)
- Negative implications of technological shock are temporary for the economy
- Emission reduction (via emission intensity) is more persistent
- Policy relevance: the green technology adoption can benefit both consumers and the environment in the long-run if agents can bear its economic costs

Long-run effects (2)



Robustness & extensions

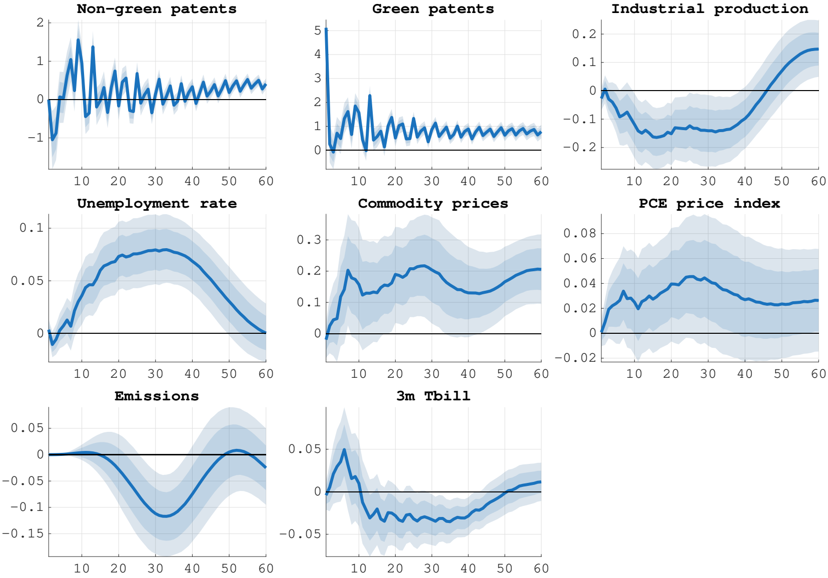
1. **Identification**
    a) shock to green patents after non-green patents in a Cholesky identification Levels
    b) use gp_t cleansed from expected economic conditions (CF) and wide range of commodity prices (WB)
    c) Control for climate-news indexes as CPU, EGKLS, MCCC Full IRFs
    d) Shock to green patents holding total patents constant Constant
2. Variable selection (stock prices, carbon emissions)
3. Estimation frequentist, bayesian, local projections
4. **Extensions**
    i) Use **citations**-based patents Citations
        - Larger explanatory power ⇒ exploits ex-post information
    ii) Exploit **type/sectoral patents** (goods, transport, energy, ...) Sectoral
        - Sharper and permanent effects for buildings and energy patents

Conclusions

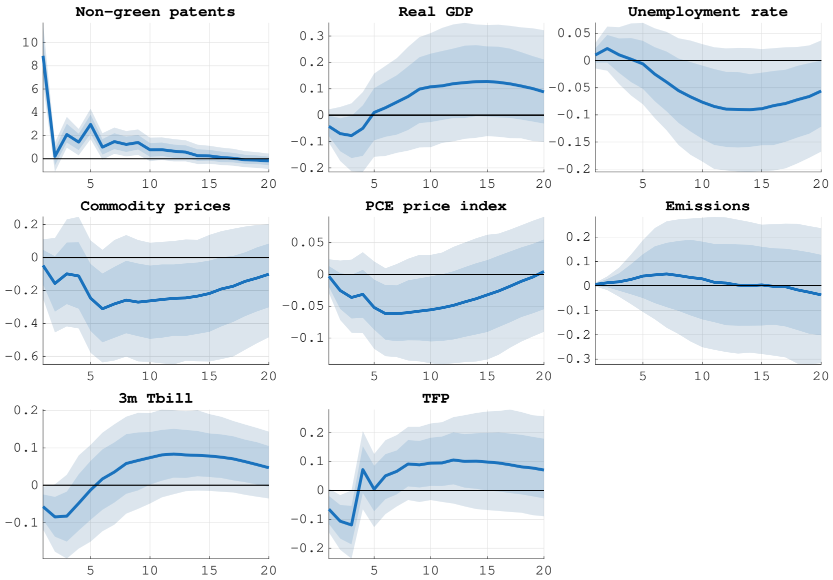
- Studying transition risk is extremely challenging
- This project focuses on relative **green patenting** as proxy for the future tech mix
- Tech transition shocks look like **supply shocks**
- **No transition free lunch**: bottom-up transition is costly (as climate policy transition) in the short run..
- ..but in the long-run the economy recovers and emissions fall, benefiting from a greener technological mix
- Central banks (and policymakers) face **starker trade-off** during the transition path towards a greener economy

Background

Specification in levels



A patent shock



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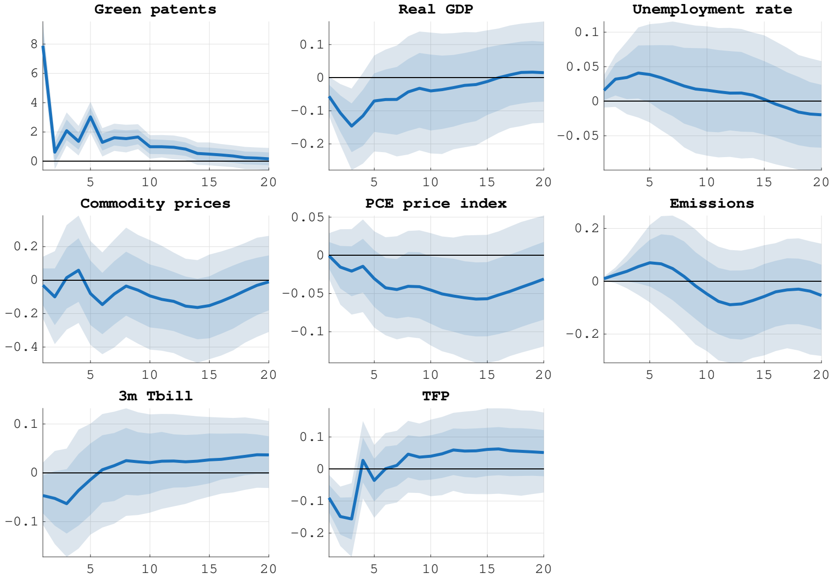
A green patent shock =! non-green



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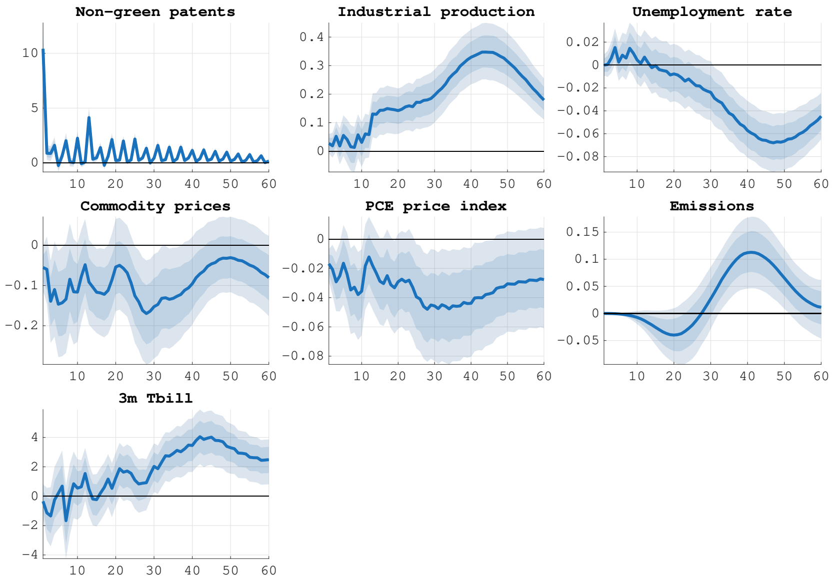
A patent shock MVAR



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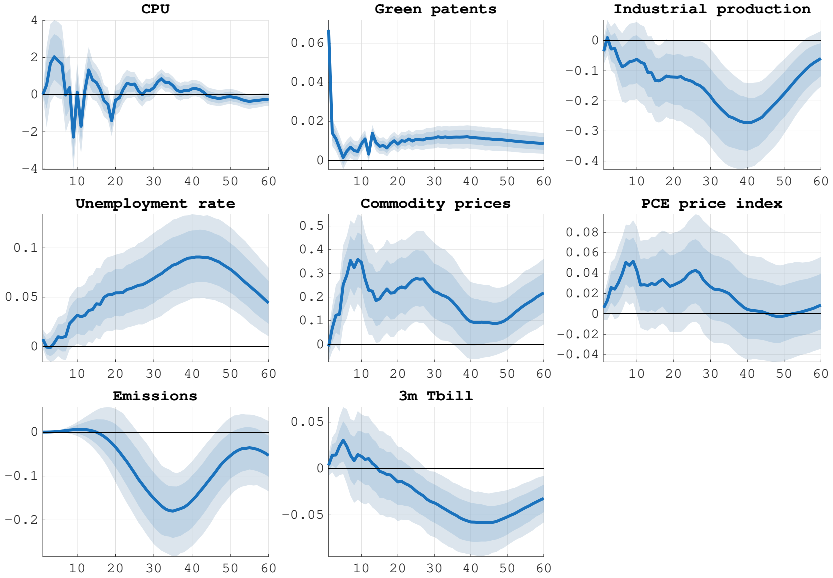
Controlling for CPU - Gavriilidis, Kanzig, and Stock



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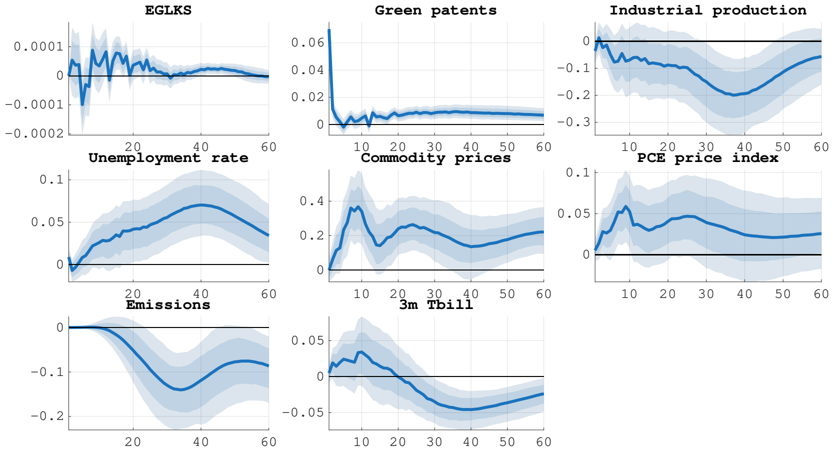
Controlling for WJS - EGLKS



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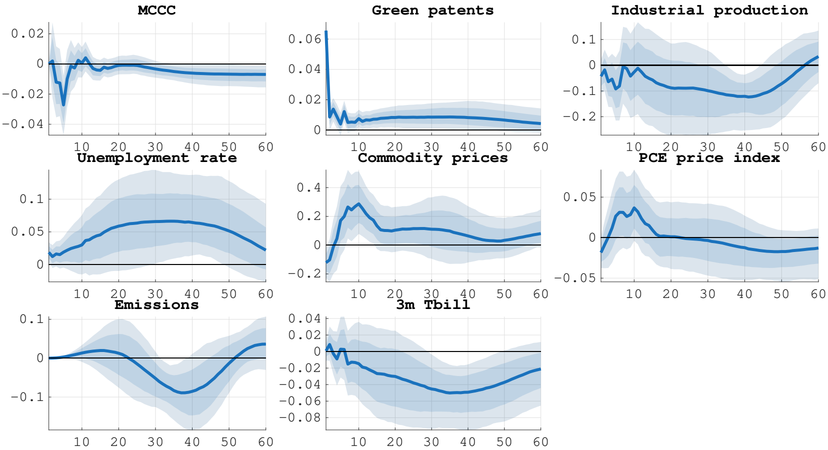
Controlling for MCCC - Ardia et al.



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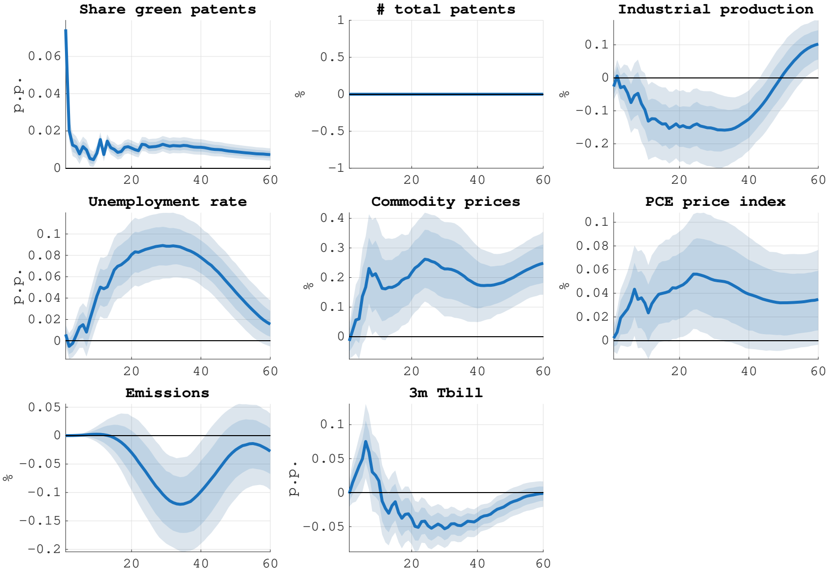
Controlling for endogeneity in innovation



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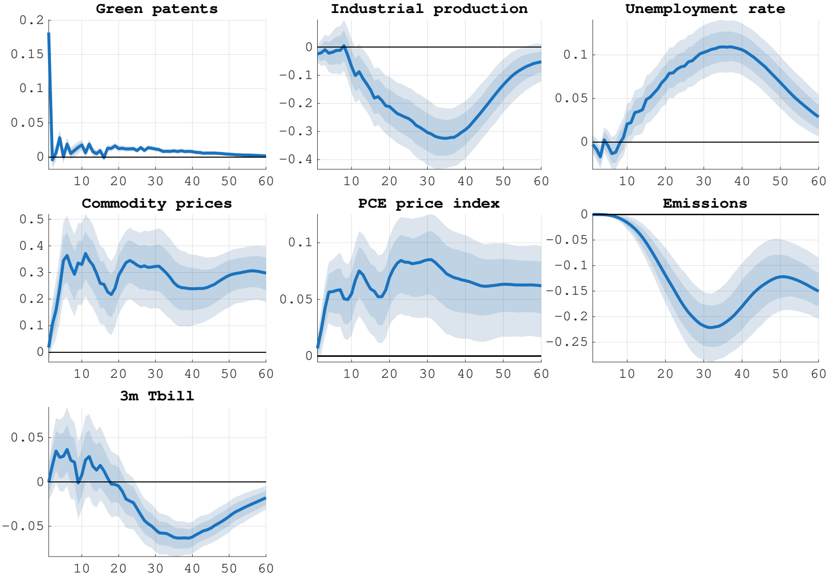
Citations-based gp_t



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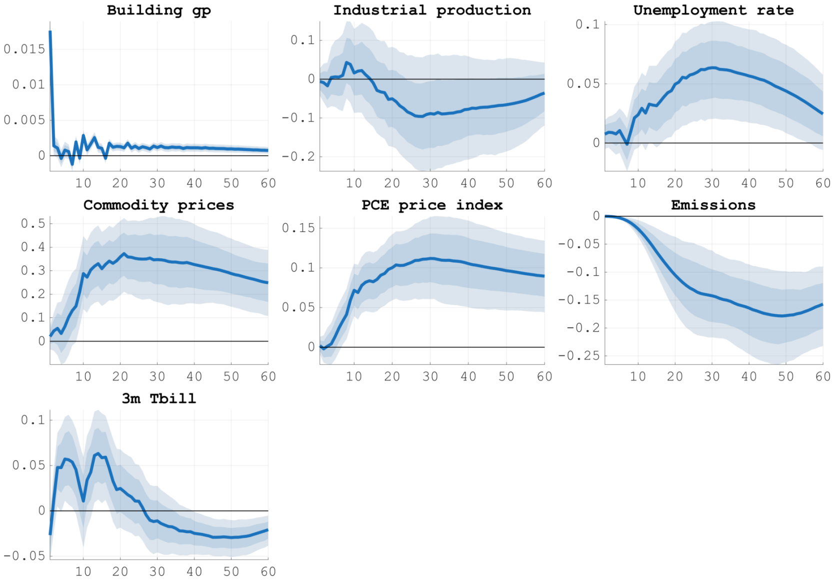
Buildings green patents



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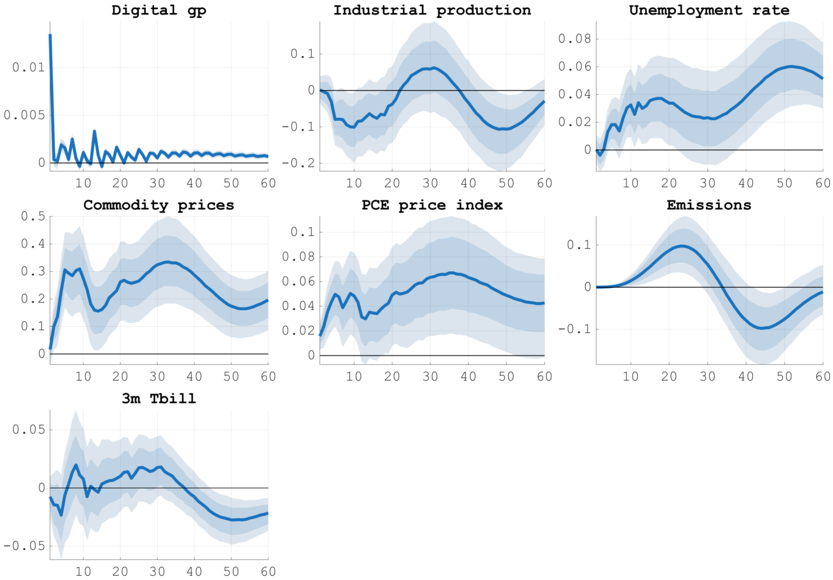
Digital green patents



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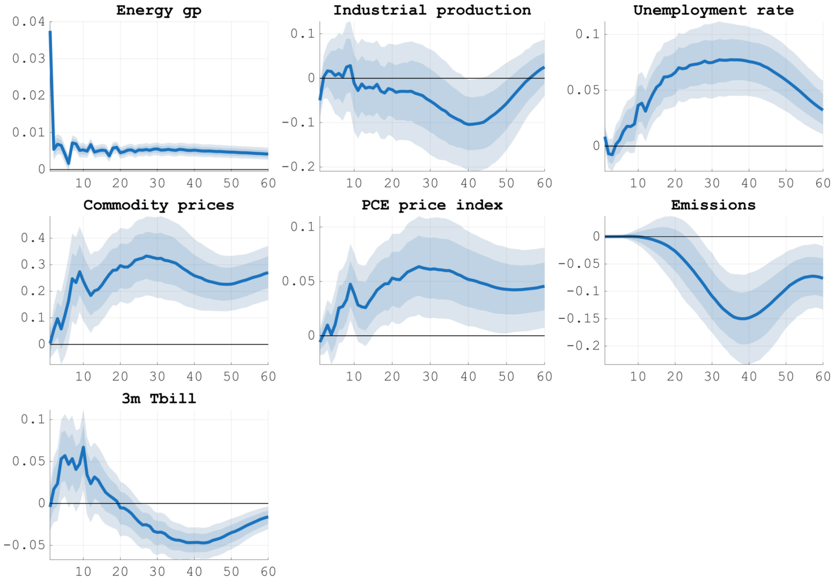
Energy green patents



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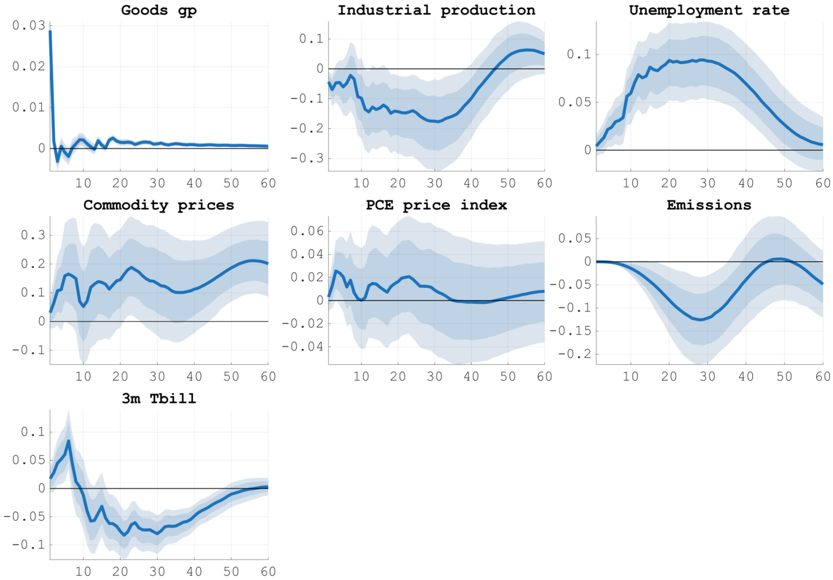
Goods green patents



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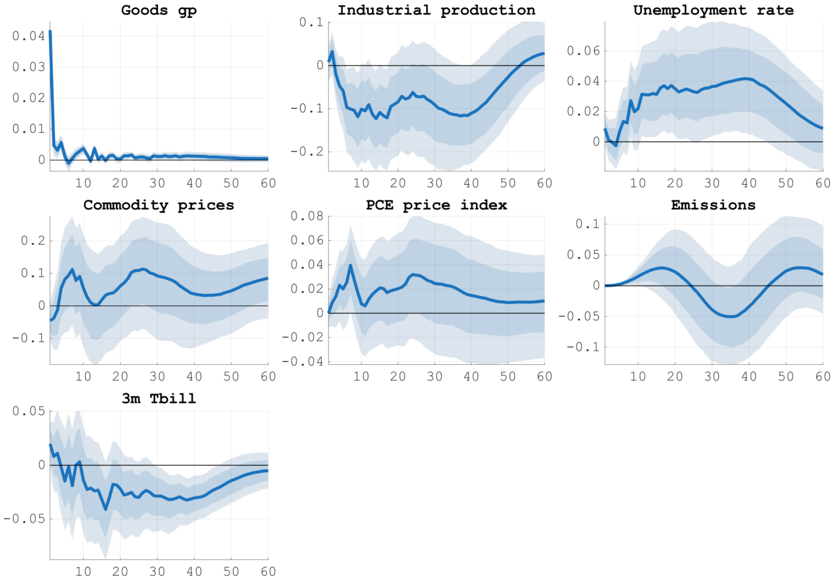
Transport green patents



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