GDP-at-Risk:
The state of play and future priorities

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13 June 2024

First Annual Czech National Bank Workshop

Introduction

- Macropru as a policy framework is severely hampered by the lack of a quantitative objective
- This was not a problem in the immediate aftermath of the Global Financial Crisis as the direction of policy was clearly to build resilience (Barwell, 2021)
- But a decade plus on from that episode, the countercyclical component of the macroprudential framework is rudderless

Introduction

Problems created by the lack of a quantifiable objective

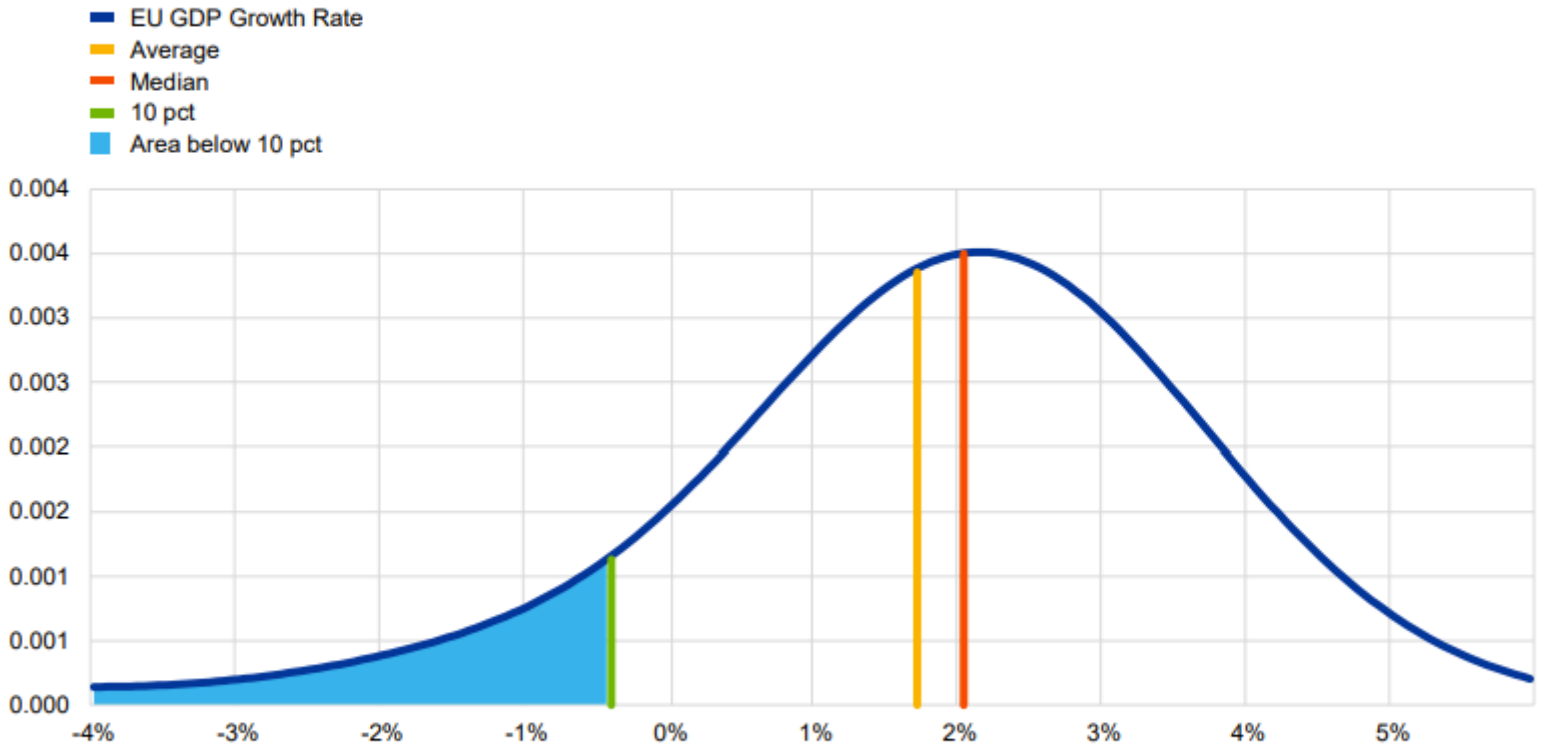
- Accountability is impeded
- Ambiguity fosters a status quo bias
- The attention of policymakers may gravitate to more measurable goals like supporting competition and growth
- Imagine the task of Monetary Policy Committees in recent years if we didn’t have inflation targets in place!

Introduction

GDP-at-Risk as a potential quantifiable objective

Moments of real GDP growth distribution in the EU

(kernel density distribution of EU annual growth)



Sources: Eurostat and ESRB Expert Group calculations.

Notes: The moments of the distribution are computed on annual real GDP growth based on the available data since 1995. The heterogenous availability across countries also underpins the available data structure in the estimation.

Outline

- How is GDP-at-risk being used by policy institutions?
- What advancements have been made in modelling GDP-at-risk?
- Some new empirical results (work in progress!)
- Some thoughts for researchers and policy advisors

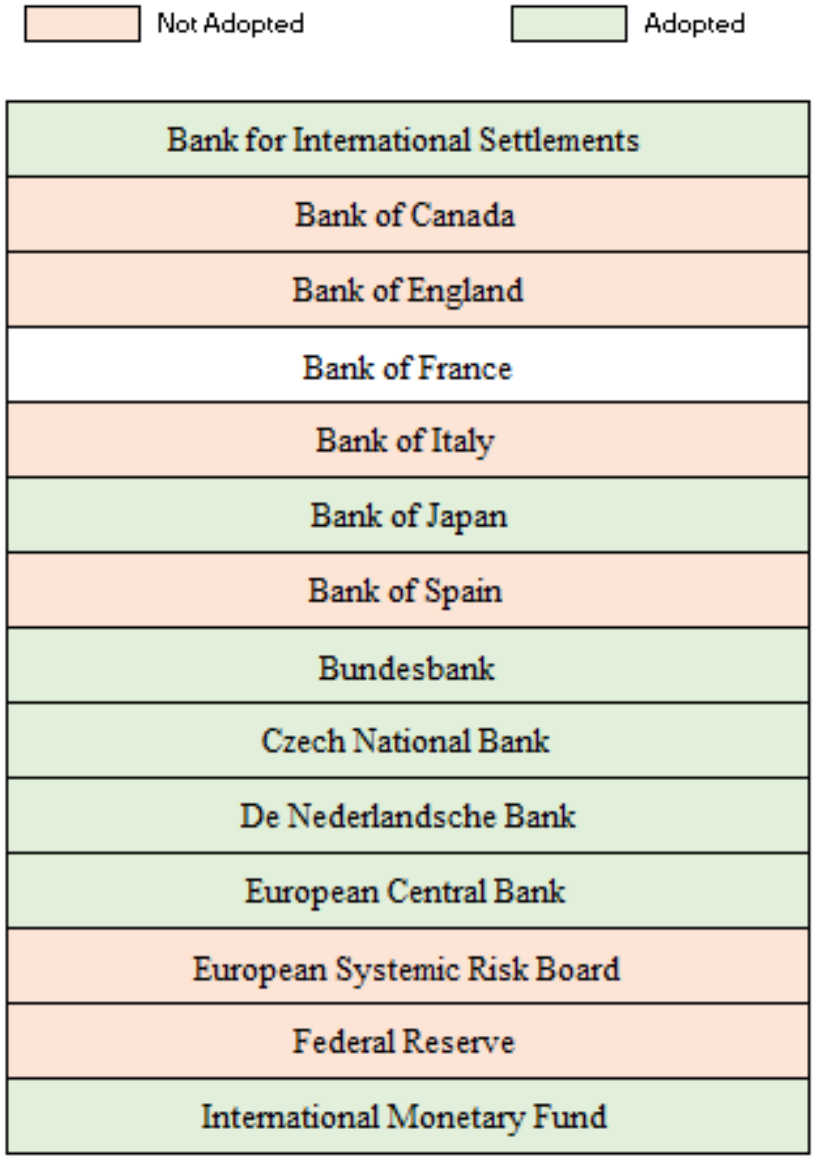
How is GDP-at-risk being used by policy institutions?

How is GDP-at-risk being used by policy institutions?

- Is GDP-at-risk informing policy actions?
- Are central banks' research departments conducting analysis on GDP-at-risk?

Is GDP-at-risk informing policy actions?

The use of GDP-at-risk and related concepts in FSRs

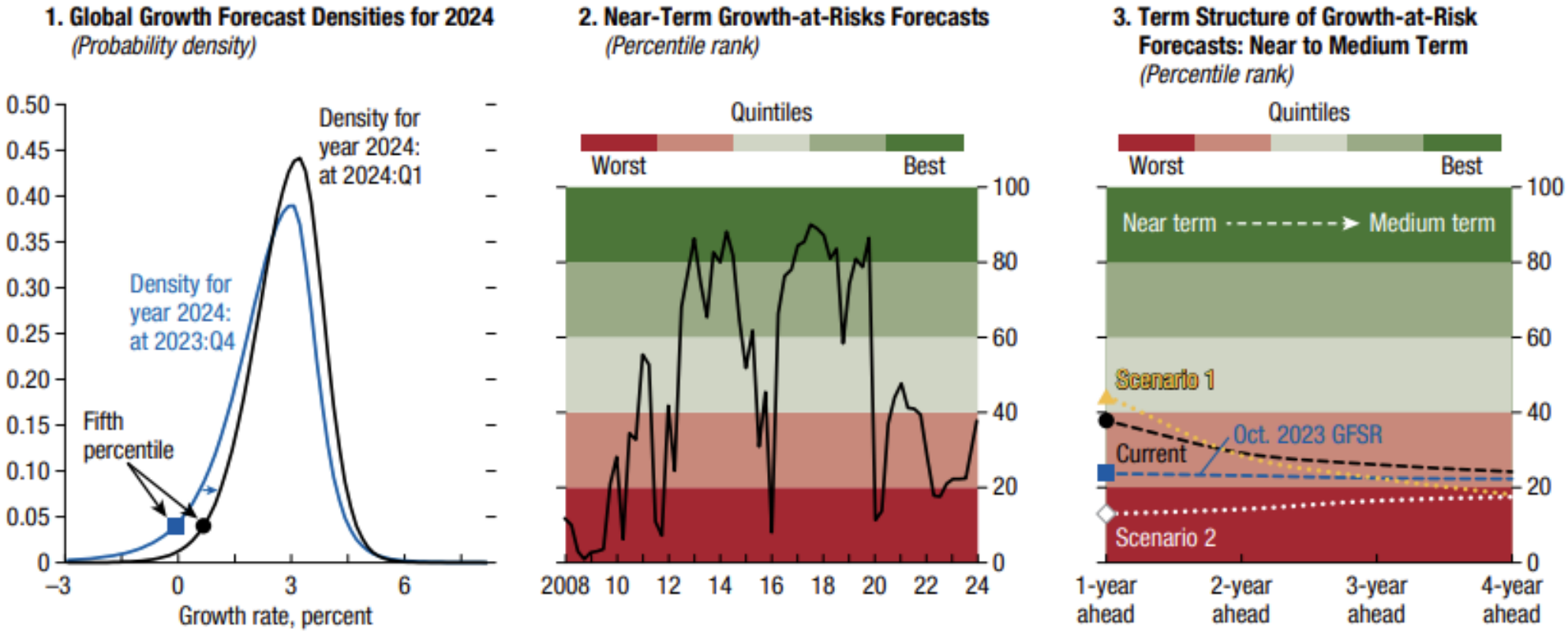


Source: The latest two published Financial Stability Reports (FSRs) up to June 2024.

Notes: The following words included in the search: “Growth at risk”, “GDP at risk”, “at risk”, and “tail”. Authors’ judgement applied. The Bank of France has not published an FSR since March 2021 and has been excluded.

Figure 1.9. Global Growth-at-Risk

While downside risks over the near term have receded some, these remain relatively elevated for the medium term; reflecting an intertemporal risk trade-off as financial conditions ease (and downturn in credit growth plateaus).

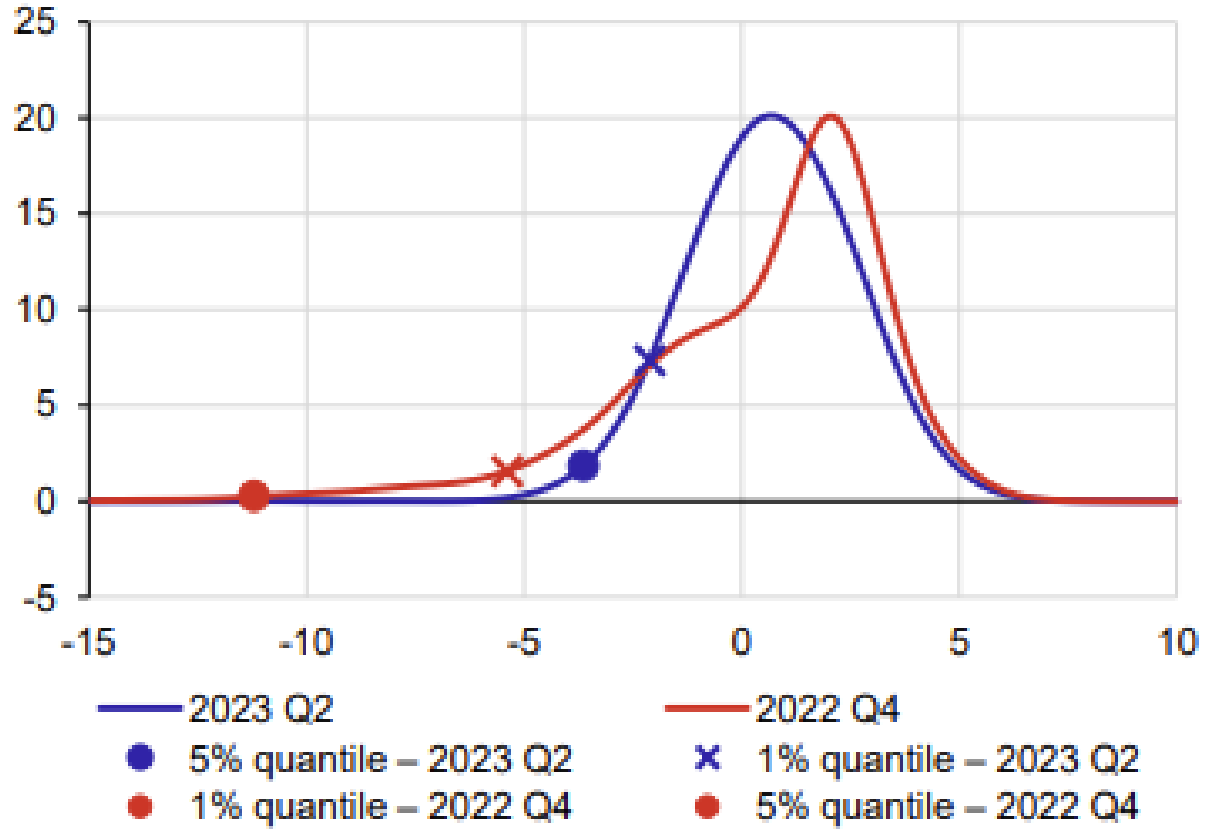


Sources: Bank for International Settlements; Bloomberg Finance L.P.; Haver Analytics; IMF, International Financial Statistics database; and IMF staff calculations.
Note: The mode (that is, the most likely outcome) of the forecast density estimate accords with the October 2023 *World Economic Outlook* forecast for year 2024, as of the third quarter of 2023. In panel 2, the black line traces the evolution of the fifth percentile threshold (the growth-at-risk metric) of near-term growth forecast densities. The color of the shading depicts the percentile rank for the growth-at-risk metric one year ahead. Panel 3 depicts the term structure of growth-at-risk, starting from the near term and tracing out to the medium-term horizon, four years ahead. GFSR = *Global Financial Stability Report*; Q = quarter.

Source: Global Financial Stability Report (page 12) produced by the International Monetary Fund in April 2024.

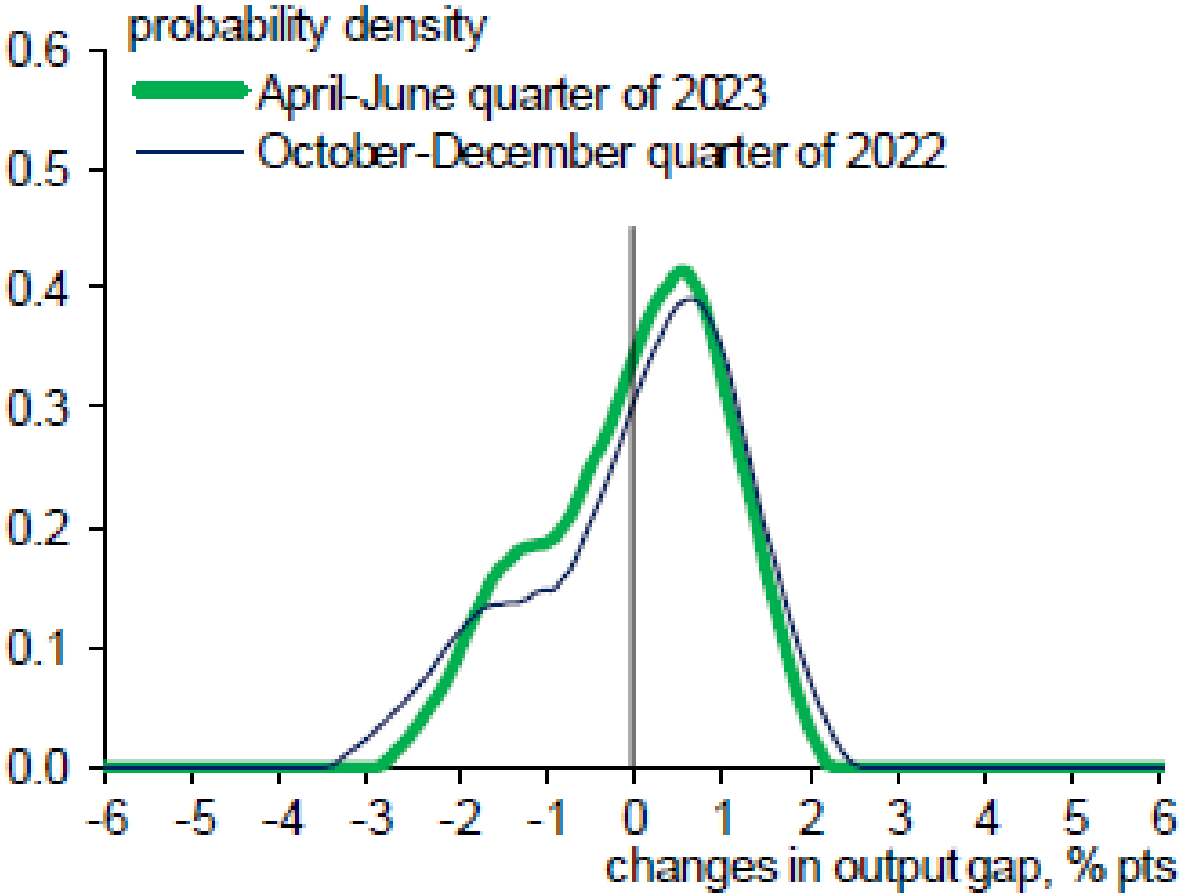
Chart II.14
Risk of adverse economic developments in the Czech Republic

(x-axis: year-on-year growth in %; y-axis: probability density)



Source: Financial Stability Report (page 10) produced by the Czech National Bank in Autumn 2023.

Chart III-3-6: Risks to future economic growth

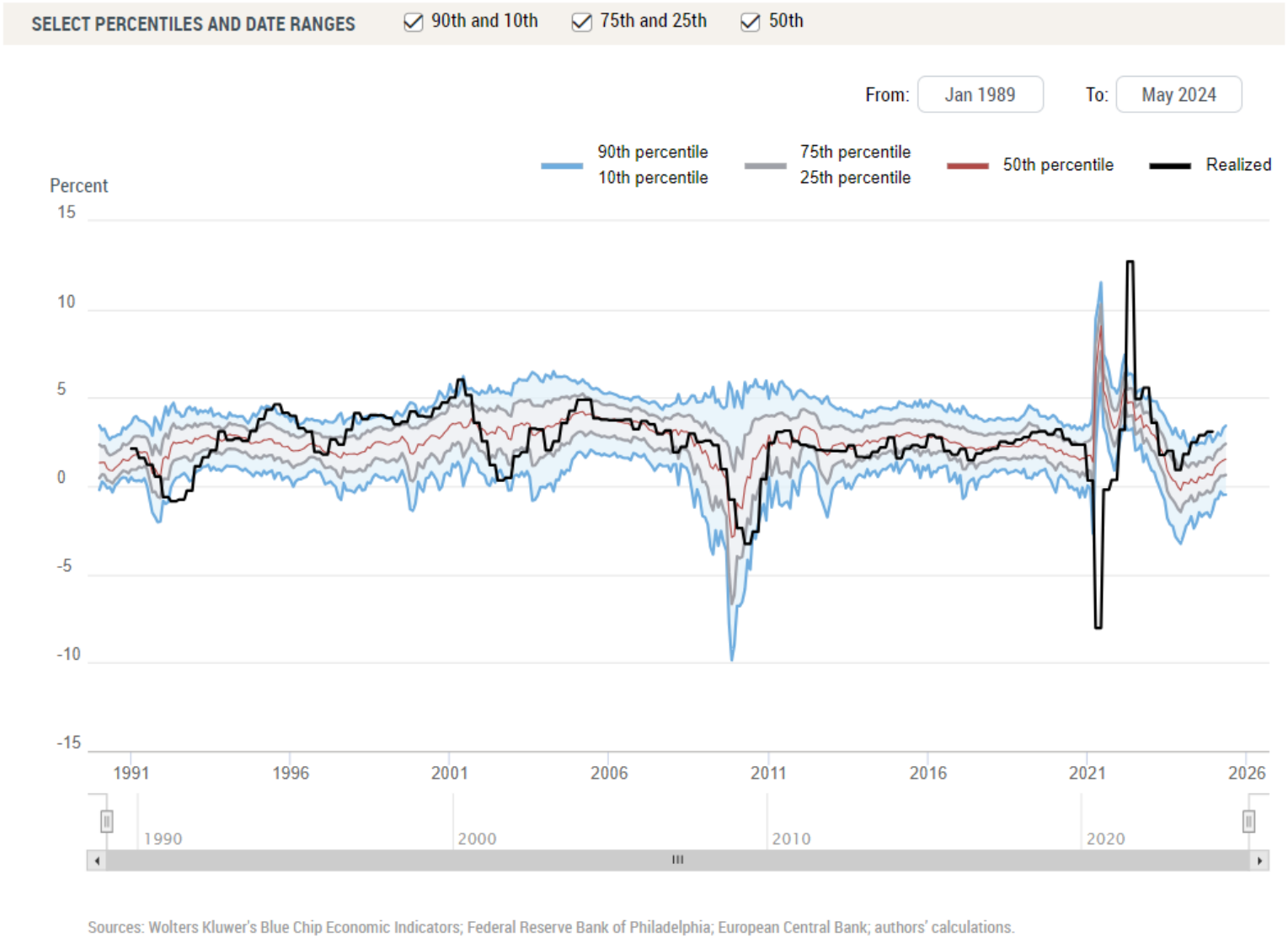


Note: Shows the changes in output gap over the next 3 years. Estimated based on output gap, financial gap, and U.S. NFCI for each time point.

Source: Financial Stability Report (page 29) produced by the Bank of Japan in October 2023.

Latest Release: 10:00 a.m. ET May 15, 2024

Predictive Distribution over Time: Real GDP Growth

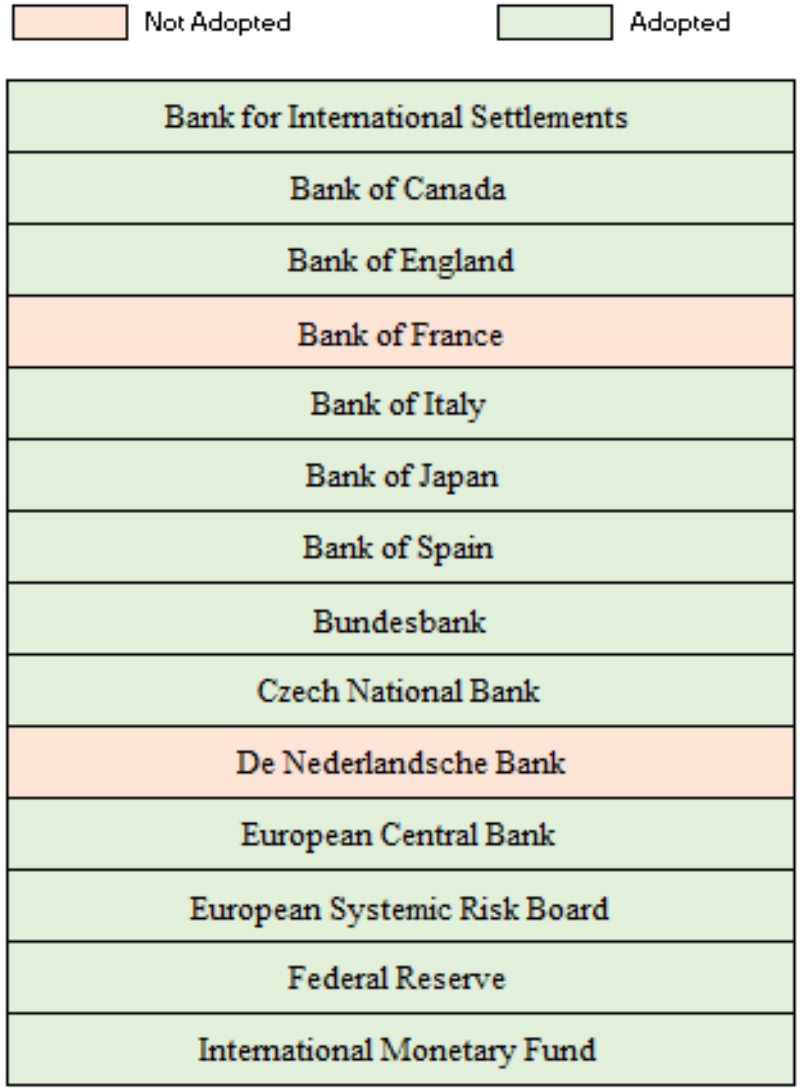


Sources: Wolters Kluwer's Blue Chip Economic Indicators; Federal Reserve Bank of Philadelphia; European Central Bank; authors' calculations.

Source: https://www.newyorkfed.org/research/policy/outlook-at-risk#root:growth-at-risk

Are central banks' research departments conducting analysis on GDP-at-risk?

GDP-at-Risk or related concepts in central bank working papers

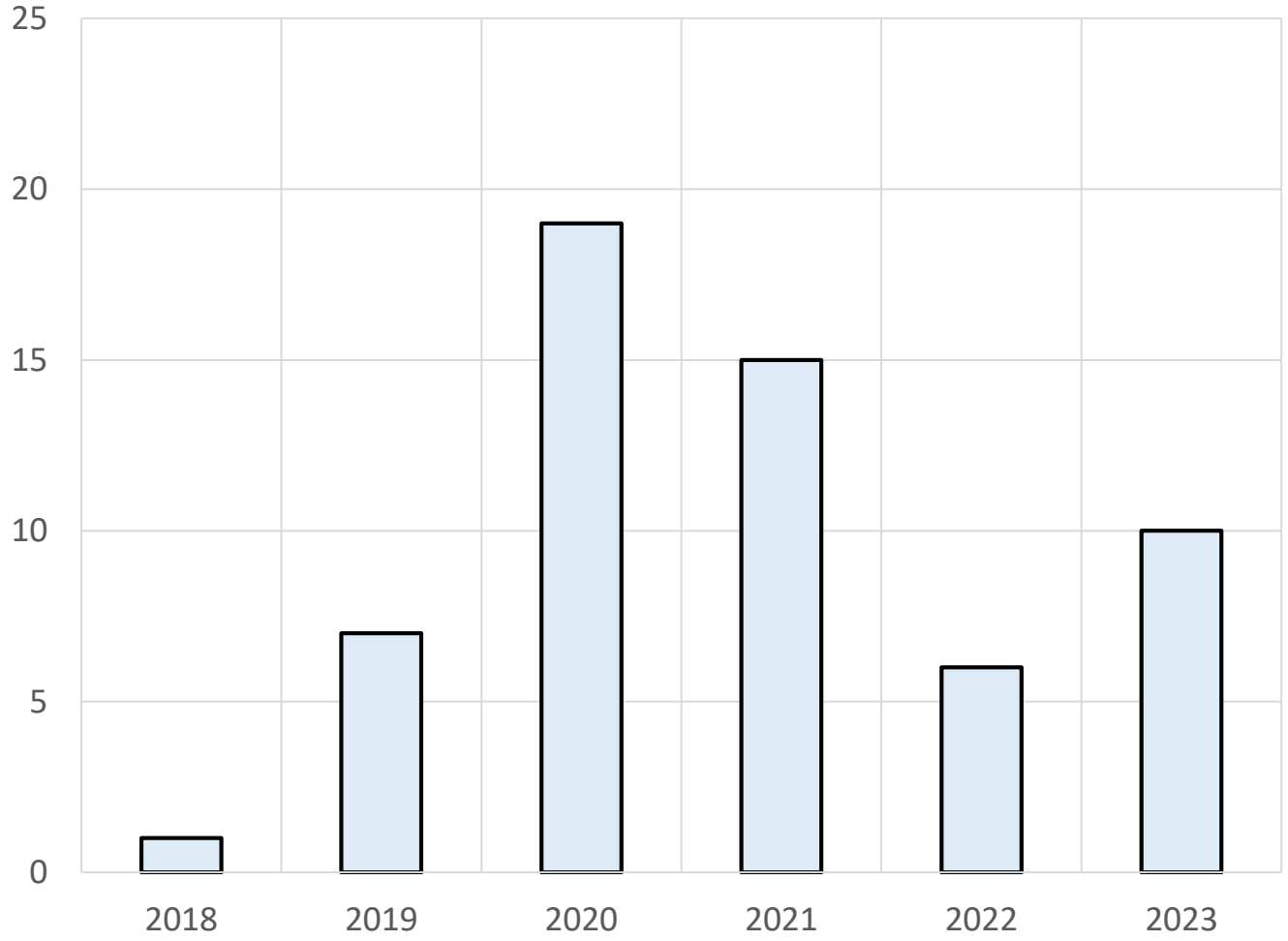


Source: Central bank websites.

Notes: We considered working papers published between Jan-2018 and Dec-2023.
The following words have been considered "growth at risk", "GDP at risk", "at risk" and "tail". Authors' judgement has been applied.
Federal reserve includes both the FED board and the NY FED.

Are central banks' research departments conducting analysis on GDP-at-risk?

The number of research papers published



Source: Central bank websites.

Notes: Data refers to the working paper published in the period between Jan-2018 and Dec-2023. The following terms have been included: "growth at risk", "GDP at risk", "at risk" and "tail". Authors' judgement has been applied.

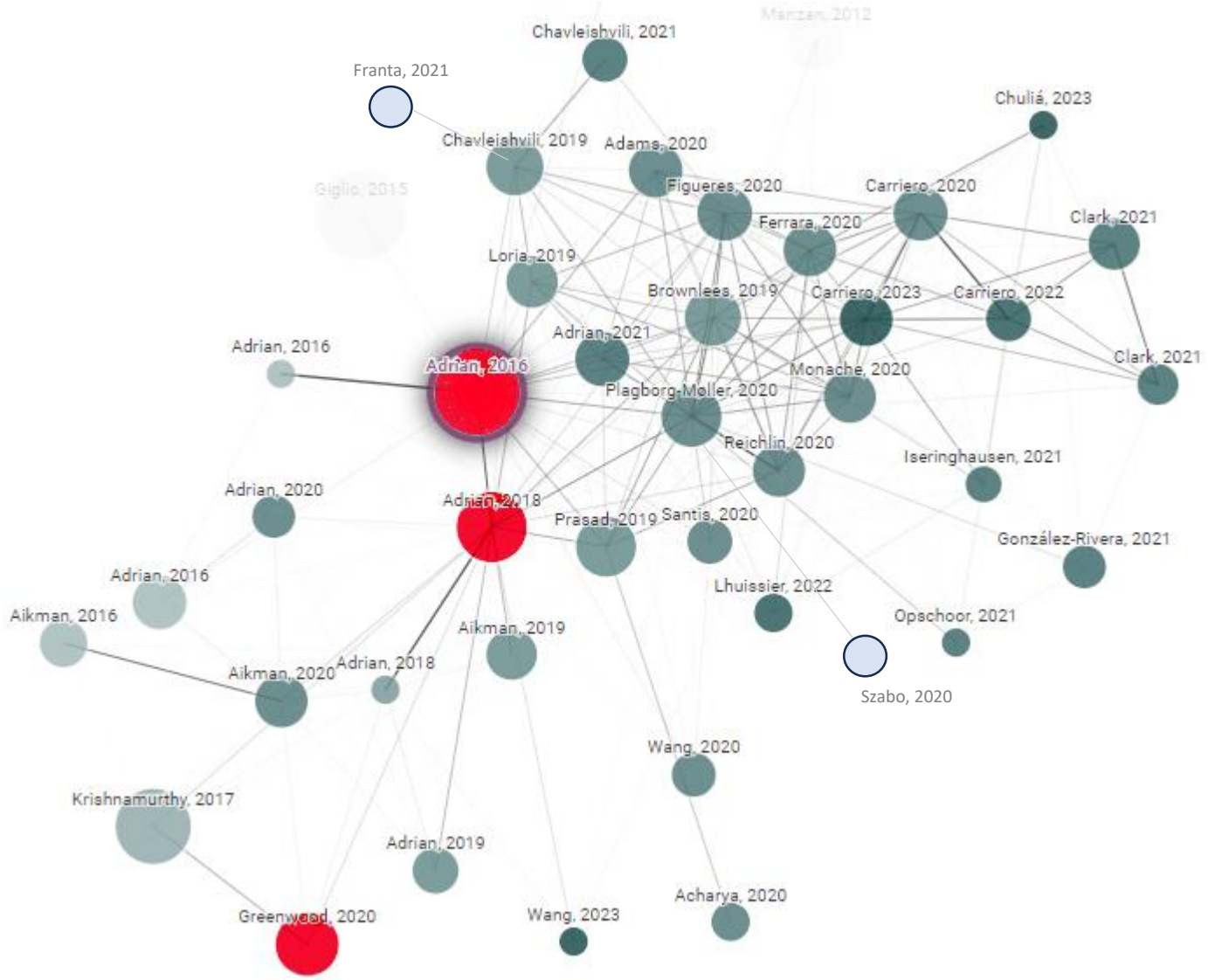
How is GDP-at-risk being used by policy institutions?

Summary

- To date, GDP-at-risk has been a research topic for central bank staff rather than a tool to inform or explain macroprudential policy
  - Since 2019, 57 working papers on this topic have been published in central bank working paper series
- In terms of policy, GDP-at-risk appears in recent FSRs of the IMF, the ECB, the BoJ, and the Czech National Bank
  - Other “at risk” concepts have also been used, including CRE-at-risk, inflation-at-risk, and capital flows-at-risk
- But there appears to be minimal linkage between these measures and actual policy decisions, ie they are not typically referenced in statements of policy

What advancements have been made in modelling GDP-at-risk?

Network map of research linked to Adrian et al (2016)



Source: Connected paper (https://www.connectedpapers.com/) and authors' own calculations.
Last update: May 2024.

What advancements have been made in modelling GDP-at-risk?

Various methodological approaches have been applied

- The most common method remains quantile regression and panel quantile regression
- Other approaches:
  - Q-VAR (Chavleishvili and Magnanelli (2019))
  - Expectile regression (Busetti et al. (2020))
  - AdaLASSO (Szendrei and Varga (2023))
  - Quantile random forest and GARCH (Kipriyanov (2022))
  - Deep neural network quantile regression (Chronopoulos et al. (2023))
- For a comparison of these different methods, see Brownless and Souza (2021) and Kipriyanov (2022)

See Škrinjarić (2024), "GaR for macropru policy stance assessment: a survey", https://www.bankofengland.co.uk/working-paper/2024/growth-at-risk-for-macroprudential-policy-stance-assessment-a-survey

What advancements have been made in modelling GDP-at-risk?

Large literature considering alternative explanatory variables

- The most common regressor is a measure of financial conditions such as the Chicago Fed's measure and the ECB's CISS; other papers use measures of realised market vol
- Other measures that have been analysed:
  - Global financial conditions (BoE)
  - Credit growth (Adrian et al (2019)
  - systemic risk indicators (Lang et al. (2019))
  - bank equity capital ratios (Aikman et al. (2019), Boyarchenko et al (2019))
- For a comparison across several measures: De Nicolo and Lucchetta (2017) and Szendrei and Varga (2023)

What advancements have been made in modelling GDP-at-risk?

The impact of macroprudential policy on GaR

- Some researchers have found that macroprudential policies lower expected growth rates but ameliorate tail risk
  - Sanchez and Röhn (2016) and Galan and Rodriguez-Moreno (2020)
- Others found that macropru policies have no discernible impact on expected growth, but they tend to reduce the variance of the growth distribution
  - Fernandez-Gallardo et al. (2023) and Franta and Gambacorta (2020)
- Some researchers have found that the impacts vary significantly by policy measure
  - Franta and Gambacorta (2020) found that tightening LTVs narrows reduces the variance of GDP but tighter provisioning rules shift the left-tail only.

Some new empirical results

Empirical exercise

Household and corporate debt vulnerabilities and macroprudential policy

- How do vulnerabilities in the household and corporate sectors affect the predicted density of GDP growth?
  - How do these effects vary by horizon?
  - How nonlinear are the effects?
  - Do these play out as “risk effects” or as “distribution shifters”?
- What can macroprudential policy do to mitigate these risks?

- **We integrate the Greenwood et al (2020) “R-Zones” approach into a GDP-at-Risk framework**

Greenwood et al (2020) "R-zones"

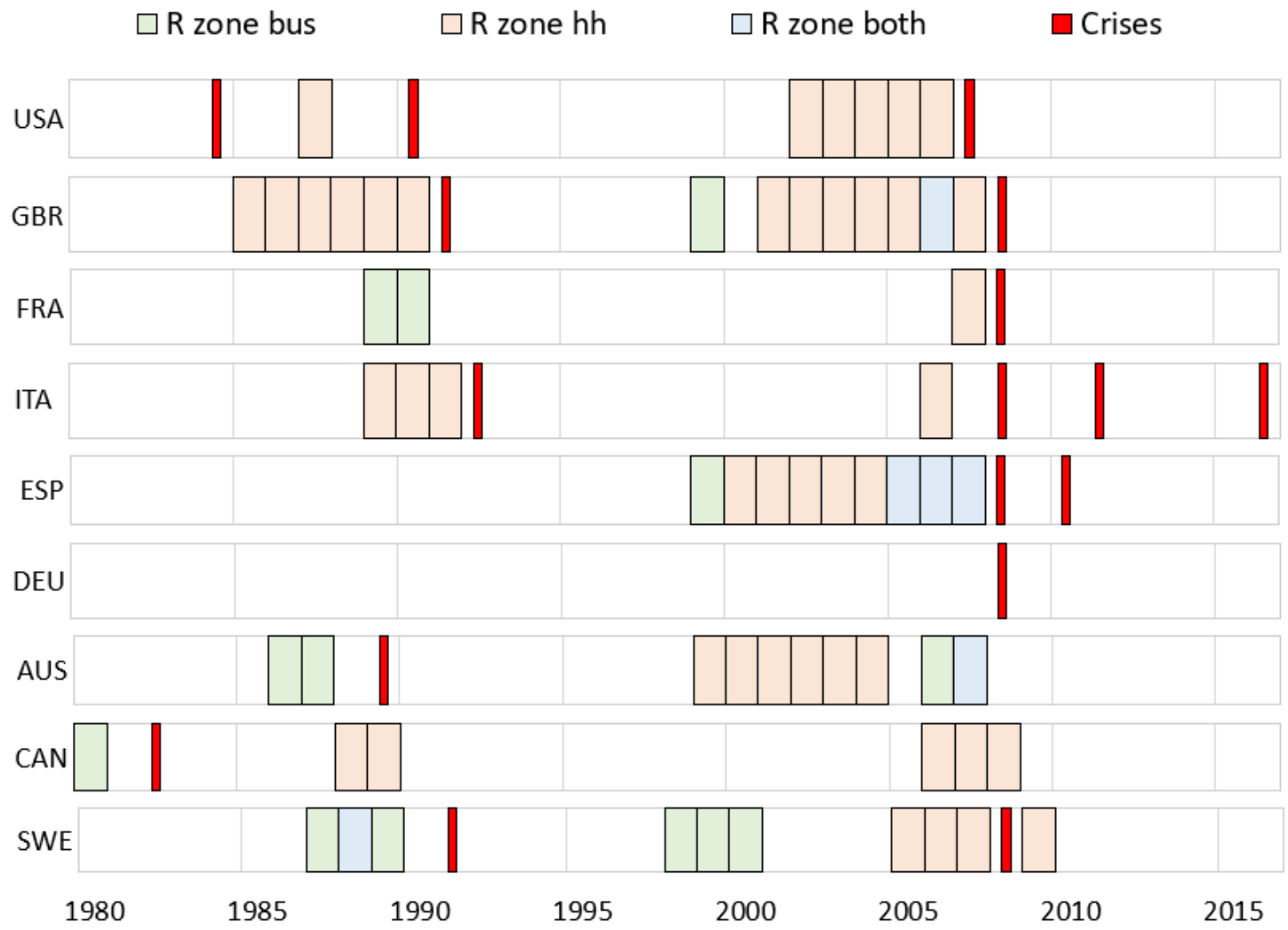
The approach

- The idea in a nutshell is to set thresholds that define an "overheated" credit markets or "R-zone"
- R-zones are defined as follows:
  - $\text{R\_zone}_{i,t} = \text{High\_debt\_growth}_{i,t} \text{ x } \text{High\_price\_growth}_{i,t}$
  - $\text{High\_debt\_growth}_{i,t} = 1\{\Delta_3 (\text{Debt / GDP})_{i,t} > 80^{\text{th}} \text{ pctl}\}$
  - $\text{High\_price\_growth}_{i,t} = 1\{\Delta_3 \log (\text{price})_{i,t} > 66.6^{\text{th}} \text{ pctl}\}$
- Two R-zones:
  - Household credit markets → household debt and house prices
  - Business credit markets → business debt and equity prices

Greenwood et al (2020) “R-zones”

Key findings

- The authors find that conditional on entering an R-zone, the Prob(Crisis with 3 years) > 40%!
- Policymakers have time to react and take remedial actions: predictability is strongest at the 2-year and 3-year horizons.



Source: Greenwood et al. (2020) and authors' own computations. Latest observation: 2016
Notes: R-zones are computed until 2012. The household R-zone is a dummy variable that activates when the 3-year growth in household credit is above the 80th pct. and the 3-year delta log house price is above the 66th pct. The business R-zone is a dummy variable that activates when the 3-year growth in business credit is above the 80th pct. and the 3-year delta log equity price is above the 66th pct. Thresholds are computed using all countries (43 countries) for the period before 2012. Crises are defined according to Baron, Verner, and Xiong (2021).

R-zones and GDP-at-Risk

Market volatility

- Model specification

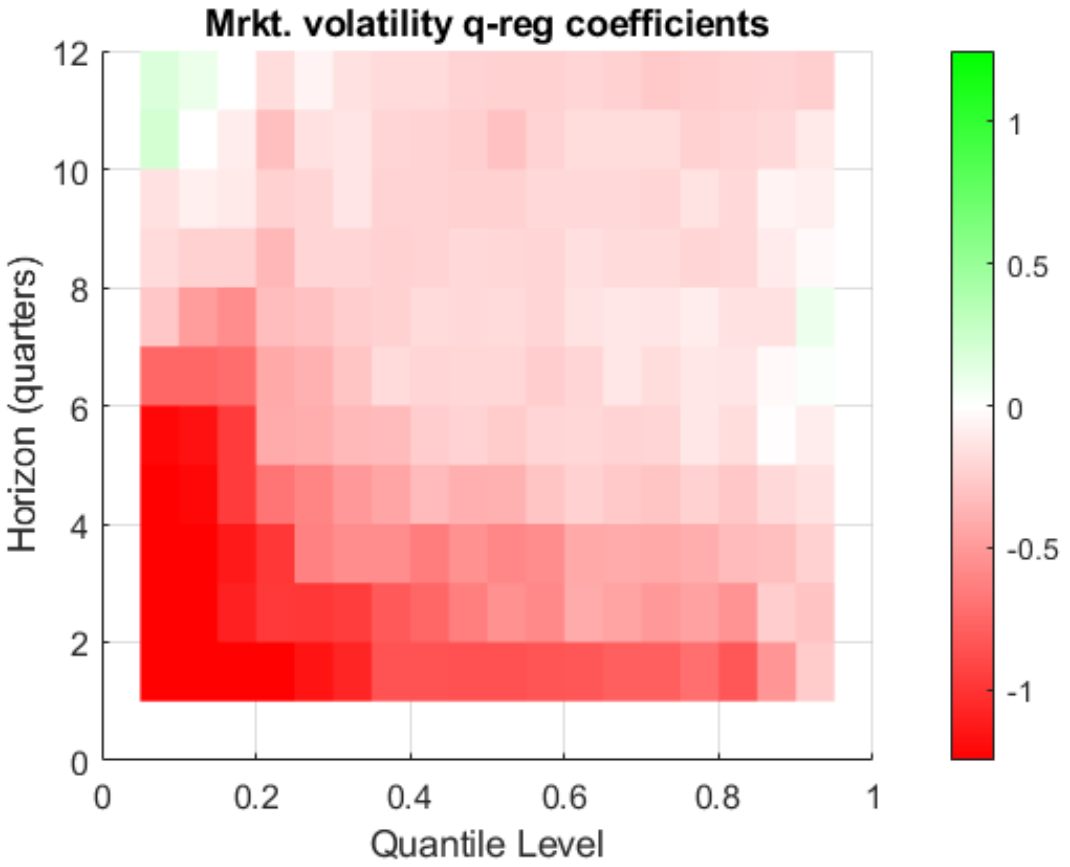
$$y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\ \mathrm{mkt\_vol}_{i,t} + \beta_{\tau,2}^{h}\ y_{i,t} + \epsilon_{i,t+h}$$

R-zones and GDP-at-Risk

Market volatility

- Model specification

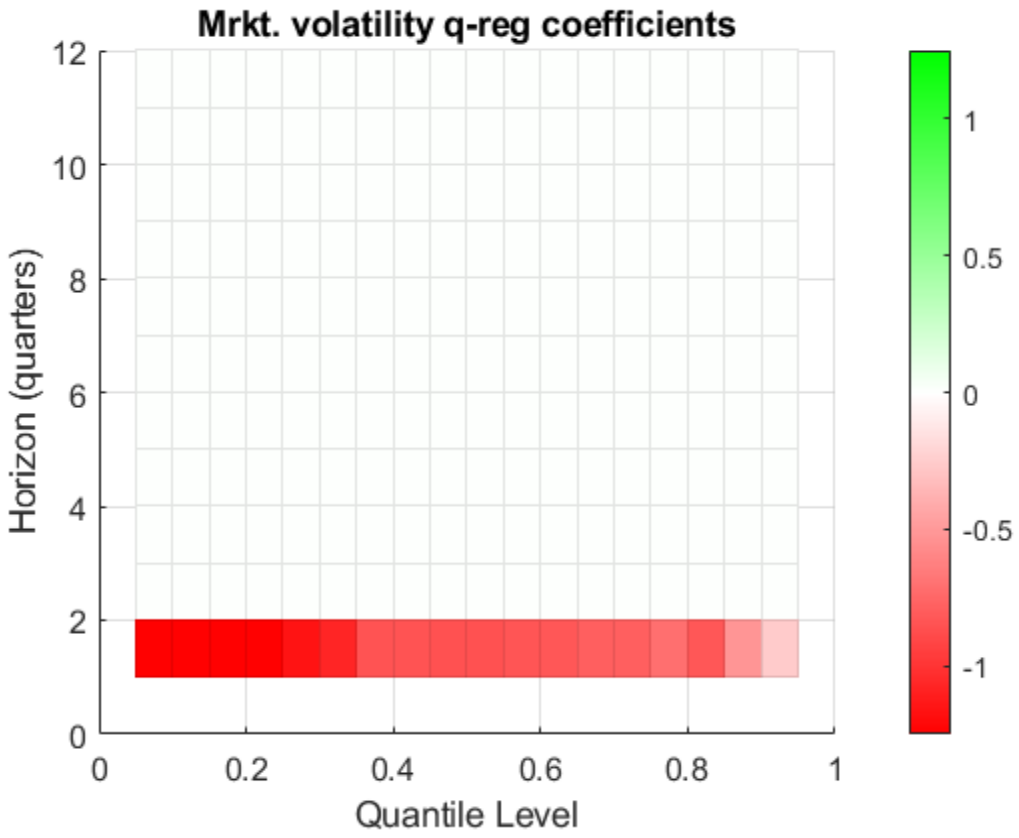
$$y_{i,t+h} = \alpha^{h}_{\tau} + \boldsymbol{\beta^{h}_{\tau,1}}\ \mathrm{mkt\_vol}_{i,t} + \beta^{h}_{\tau,2}\ y_{i,t} + \epsilon_{i,t+h}$$



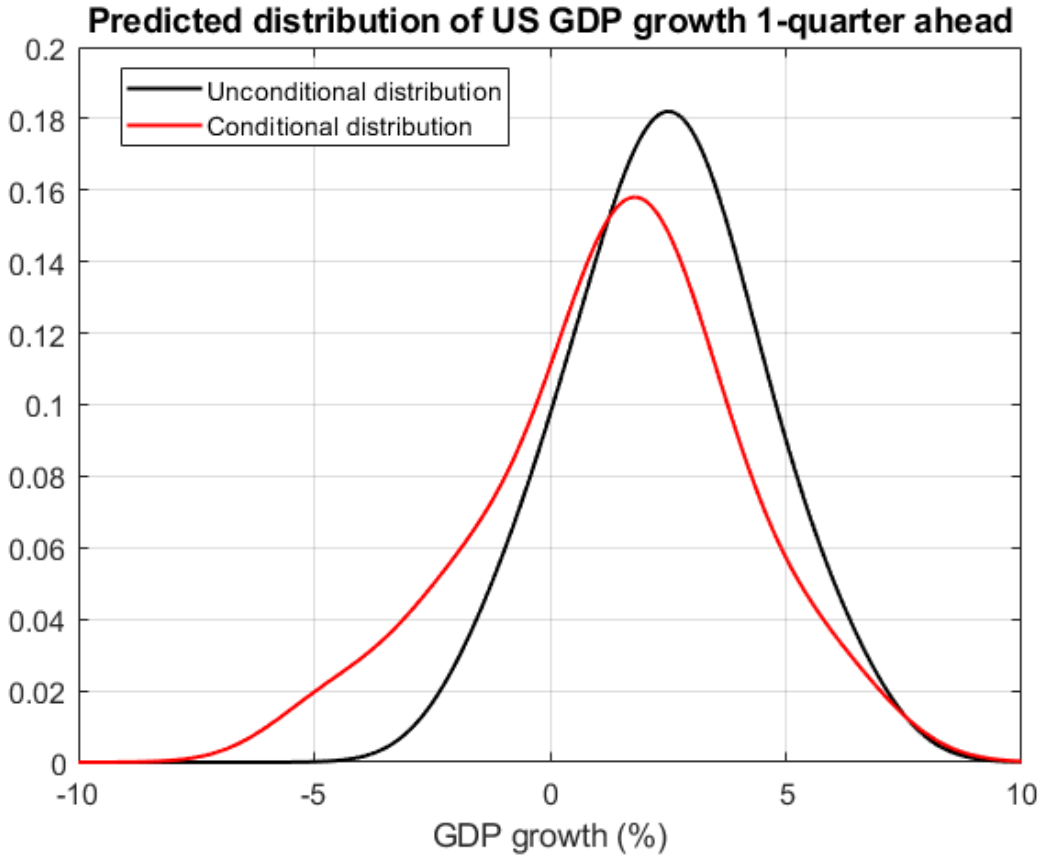
Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. The coefficients correspond to a 2 standard deviation shock to market volatility.

R-zones and GDP-at-Risk

Market volatility



Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Coloured row represent 1 quarter ahead quantile regressions coefficients.

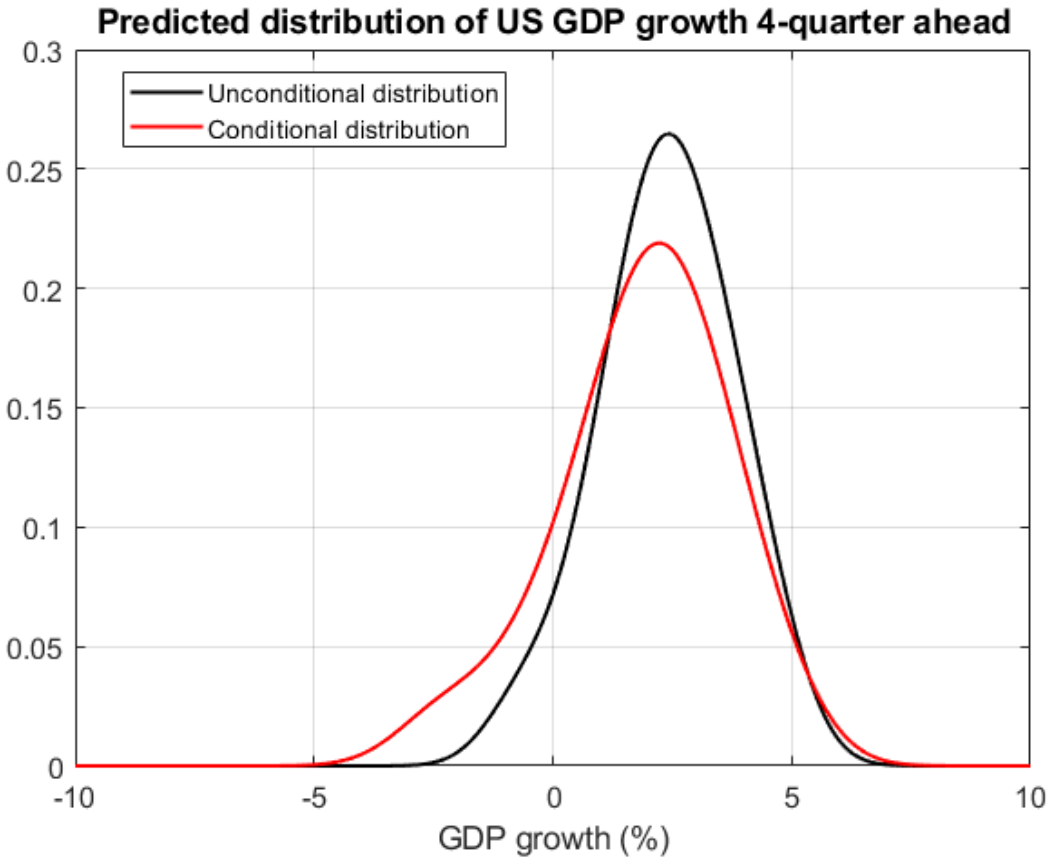


Source: author's own computations.
Notes: Distribution refers to annualized 1-q. ahead GDP growth for US. For the uncond. distribution, the avg. value of current GDP growth and the avg. value of market volatility have been used. For the cond. distribution, the avg. value of current GDP growth and the avg. value of market volatility + 2 s.d have been used.

R-zones and GDP-at-Risk

Market volatility

Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Coloured row represent 4 quarter ahead quantile regressions coefficients.

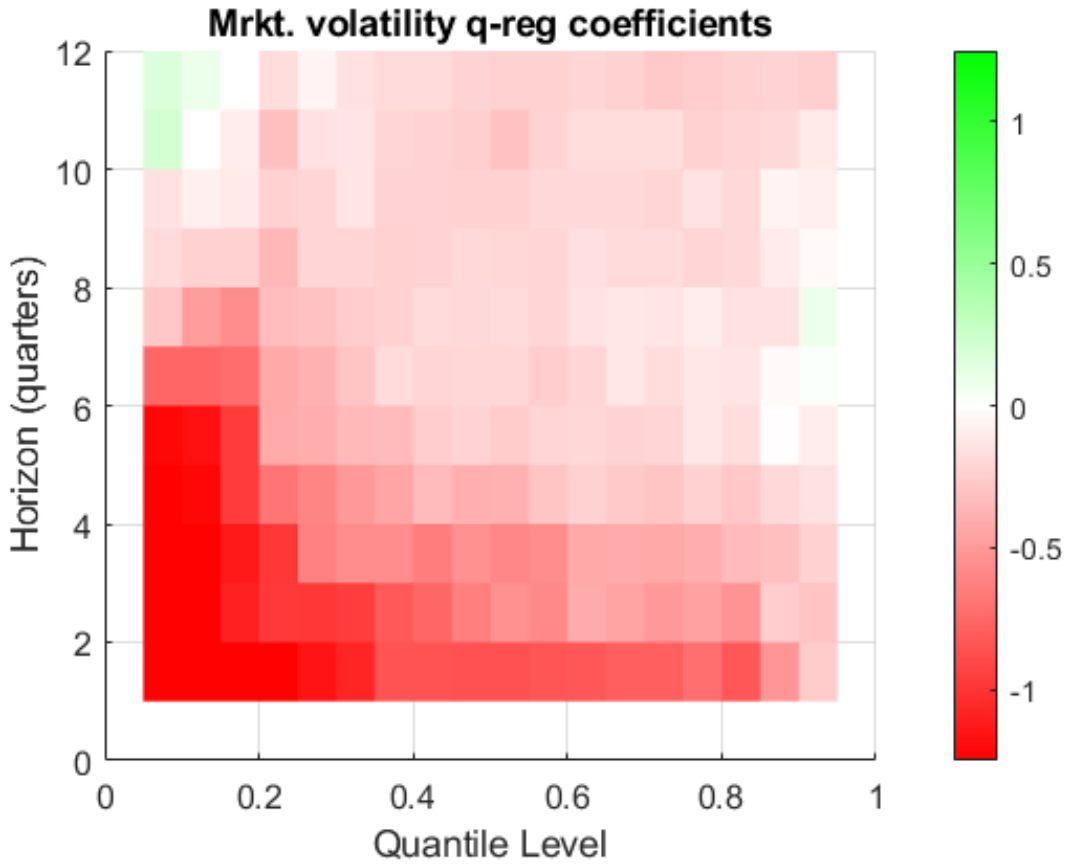


Source: author's own computations.
Notes: Distribution refers to annualized 4-q. ahead GDP growth for US. For the uncond. distribution, the avg. value of current GDP growth and the avg. value of market volatility have been used. For the cond. distribution, the avg. value of current GDP growth and the avg. value of market volatility + 2 s.d have been used.

R-zones and GDP-at-Risk

Market volatility

- Main takeaways:
  - Deteriorating financial conditions are associated with an increase in the conditional volatility and a decline in the conditional mean of the GDP distribution
  - Lower quantiles vary with financial conditions while the upper quantiles are stable more over time
  - The influence in the left tails is pronounced in the short term, but weakens and eventually disappears in the medium term



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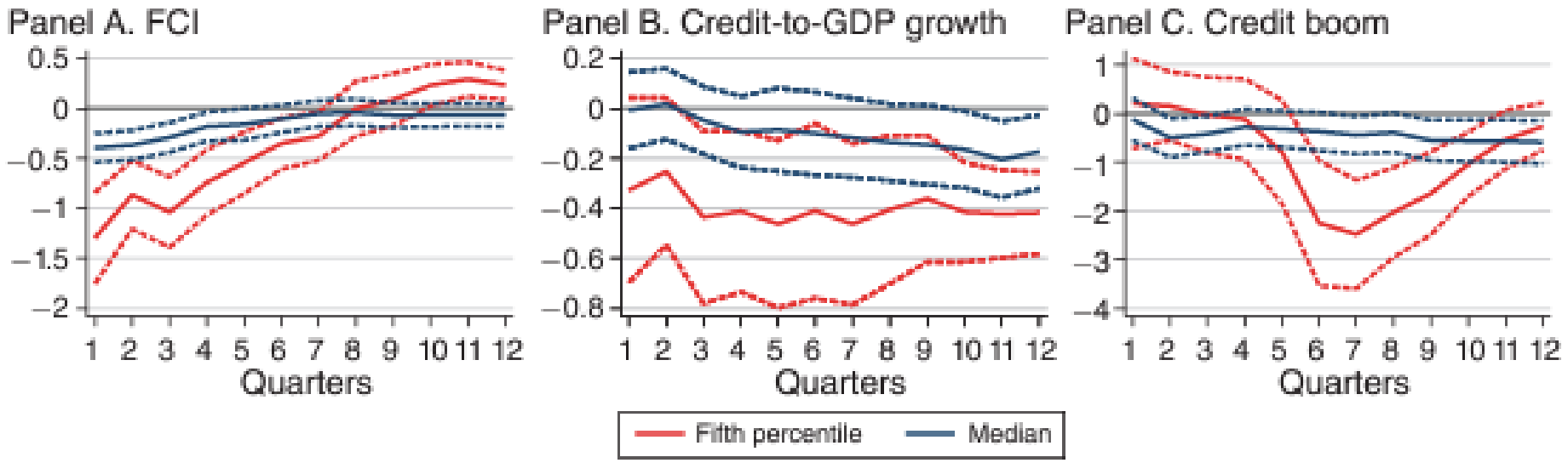


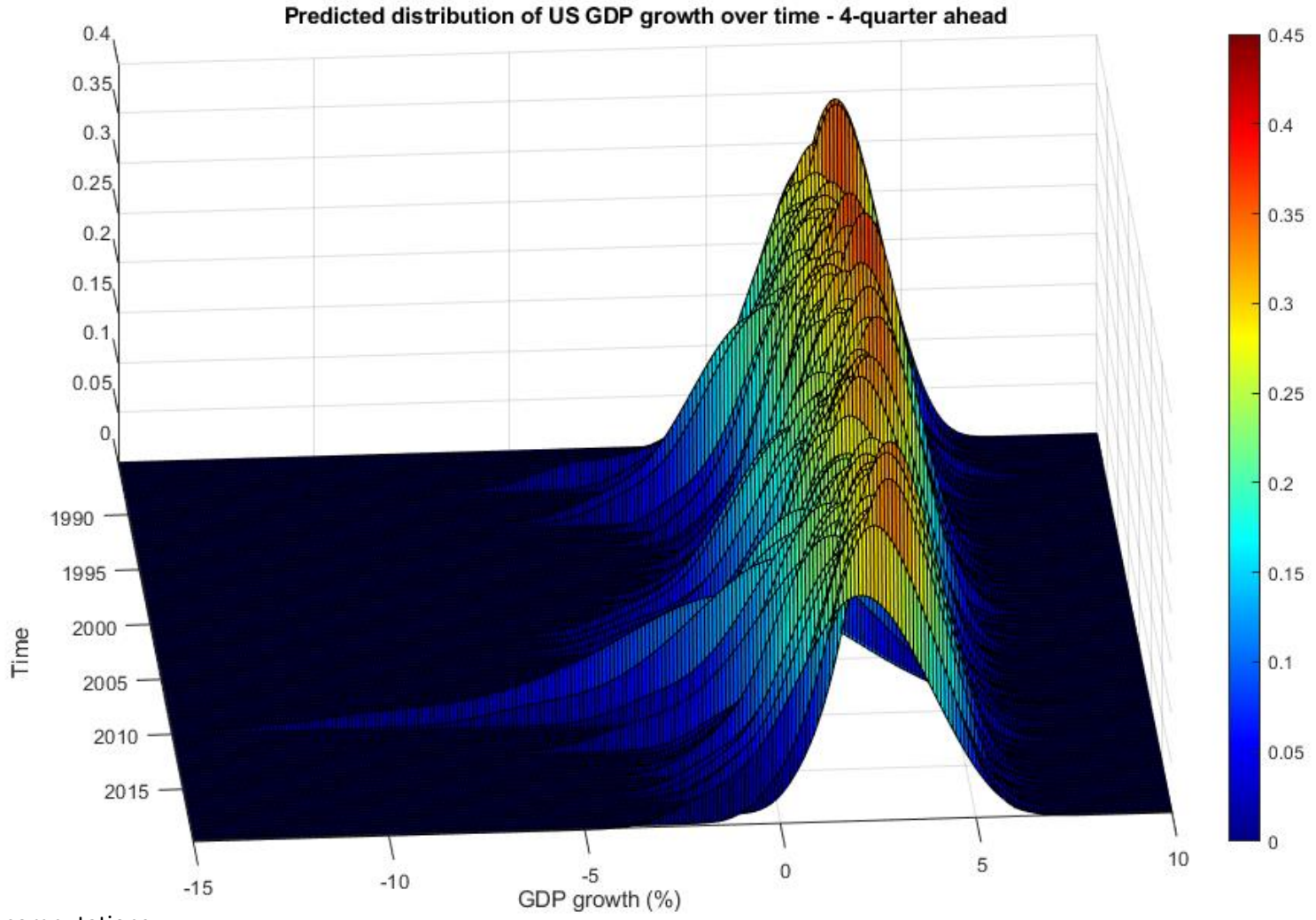
FIGURE 1. ESTIMATED COEFFICIENTS ON FCI, CREDIT GROWTH, AND CREDIT BOOM FOR MEDIAN AND FIFTH PERCENTILE OF REAL GDP GROWTH

Notes: Panel A plots the estimated coefficients on the FCI, panel B plots the estimated coefficients on credit-to-GDP growth, and panel C plots the estimated coefficients on a credit boom indicator, from panel quantile regressions of model 3 with all 3 variables for the median and the fifth percentile 1 to 12 quarters into the future. Real GDP growth (average growth rate for the cumulative period through the quarter at an annual rate) is measured in percent. Higher FCI represents tighter financial conditions. Credit boom is an indicator variable based on the interaction of the loosest three deciles of FCI and highest three deciles of credit-to-GDP growth. Estimates are based on local projection estimation methods, and standard errors are from bootstrapping techniques; bands represent 90 percent confidence intervals. AEs include 11 countries, with data for most from 1973 to 2017.

Source: Adrian et al (2022) "The Term Structure of Growth-at-Risk"

R-zones and GDP-at-Risk

Market volatility



Source: author's own computations.
Notes: Four-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth and Market volatility as conditioning variables. Time variable denotes the period for which outcome are forecasted, not the date when the prediction was generated.

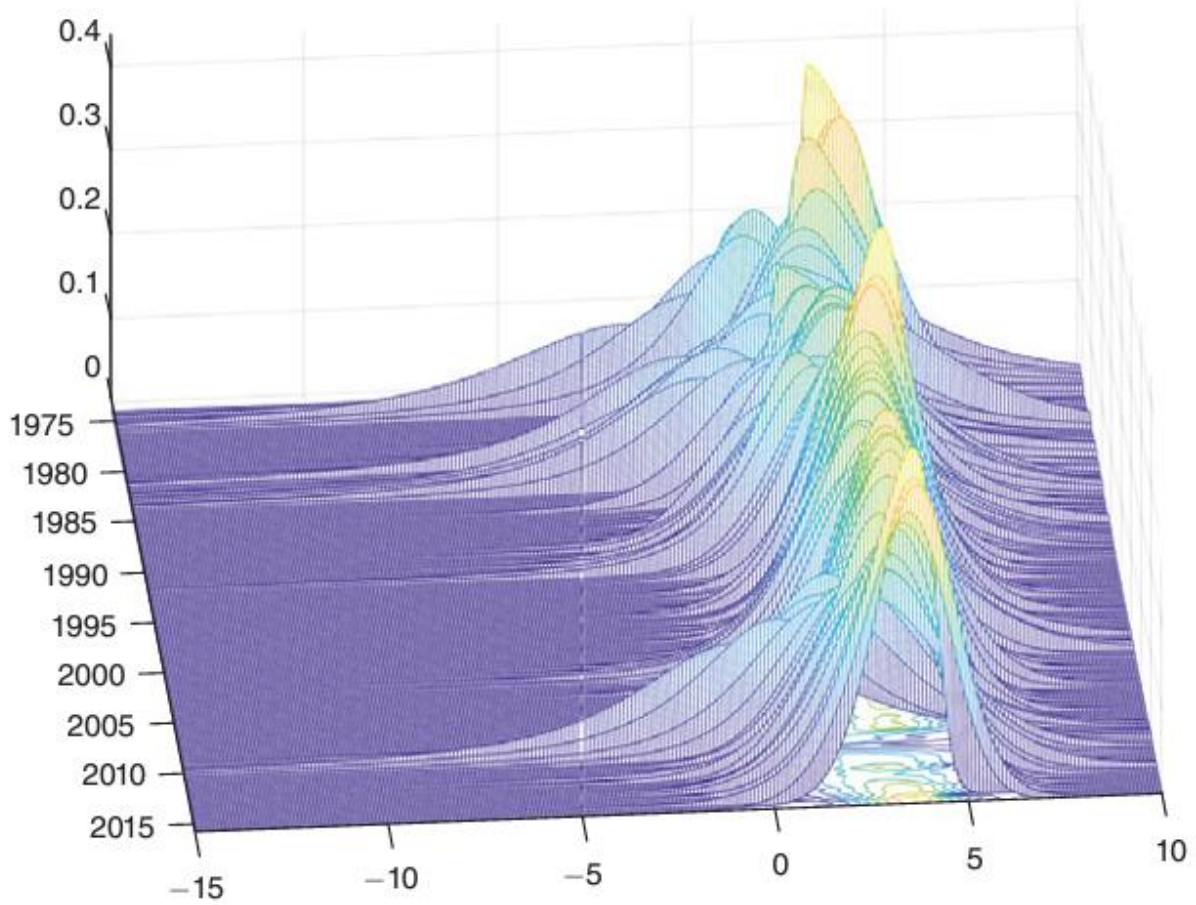


FIGURE 1. DISTRIBUTION OF GDP GROWTH OVER TIME

Note: One-year-ahead predictive distribution of real GDP growth, based on quantile regressions with current real GDP growth and NFCI as conditioning variables.

Source: Adrian et al. (2019), "Vulnerable growth", AER

R-zones and GDP-at-Risk

Household R-zone

- Model specification

$$y_{i,t+h} = \alpha_{\tau}^{h} + \boldsymbol{\beta_{\tau,1}^{h}} \ \text{R zone}^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \ y_{i,t} + \epsilon_{i,t+h}$$

R-zones and GDP-at-Risk

Household R-zone

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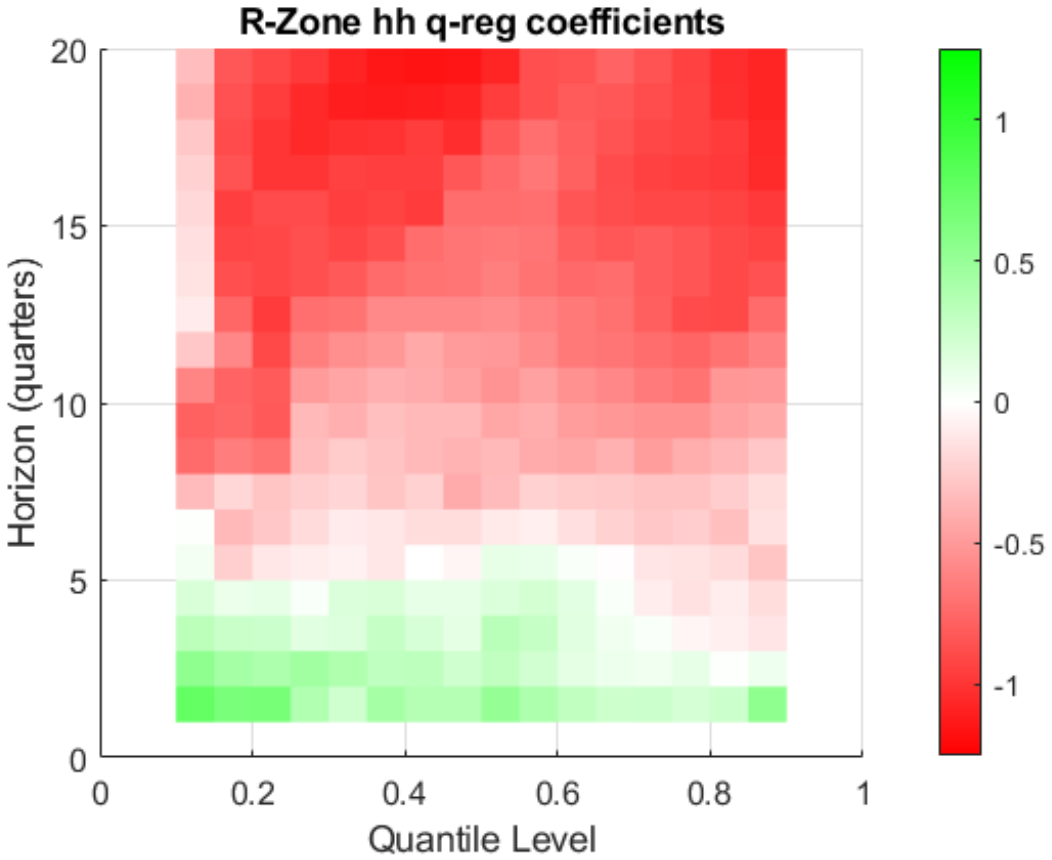
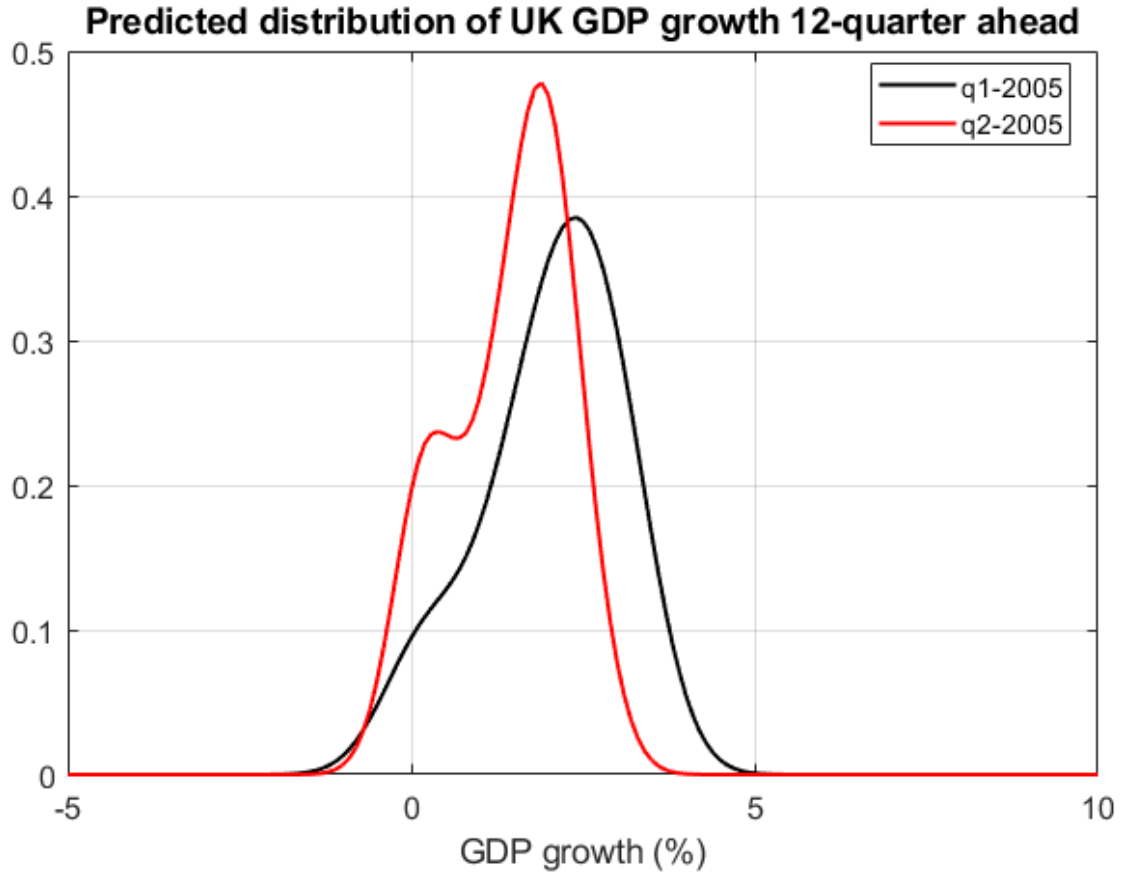


Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Household R-zone

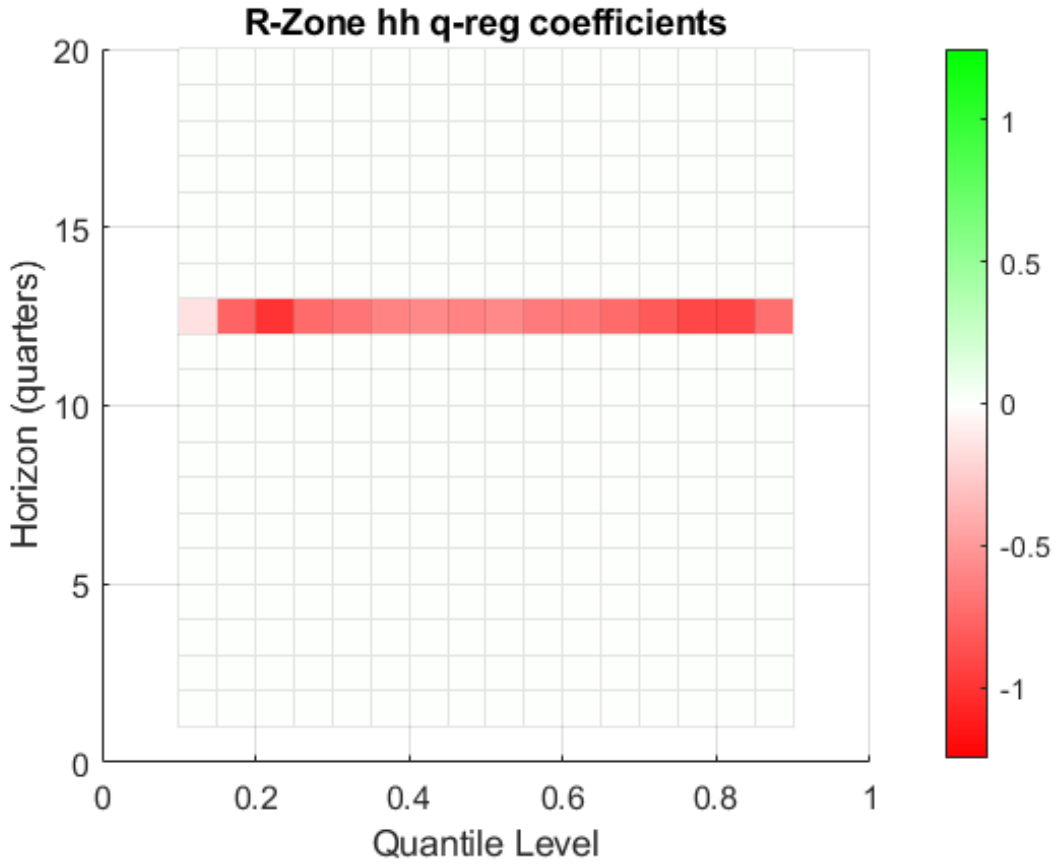
Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Coloured row represent 12 quarter ahead quantile regressions coefficients.



Source: author's own computations.
Notes: Distribution refers to annualized 12-q. ahead GDP growth for UK. Black line represents the forecasted distribution for Q1-2005; household R-zone is not active. Red line represents the forecasted distribution for Q2-2005; household R-zone is active.

R-zones and GDP-at-Risk

Household R-zone



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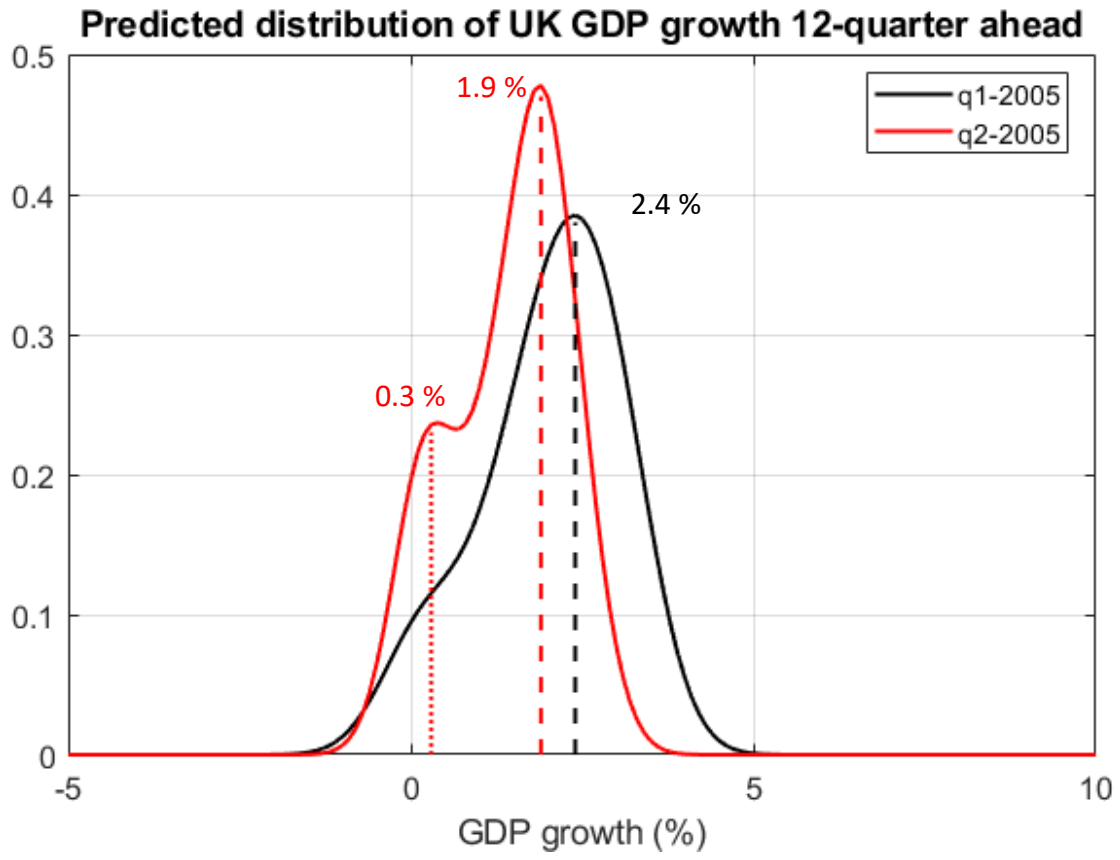
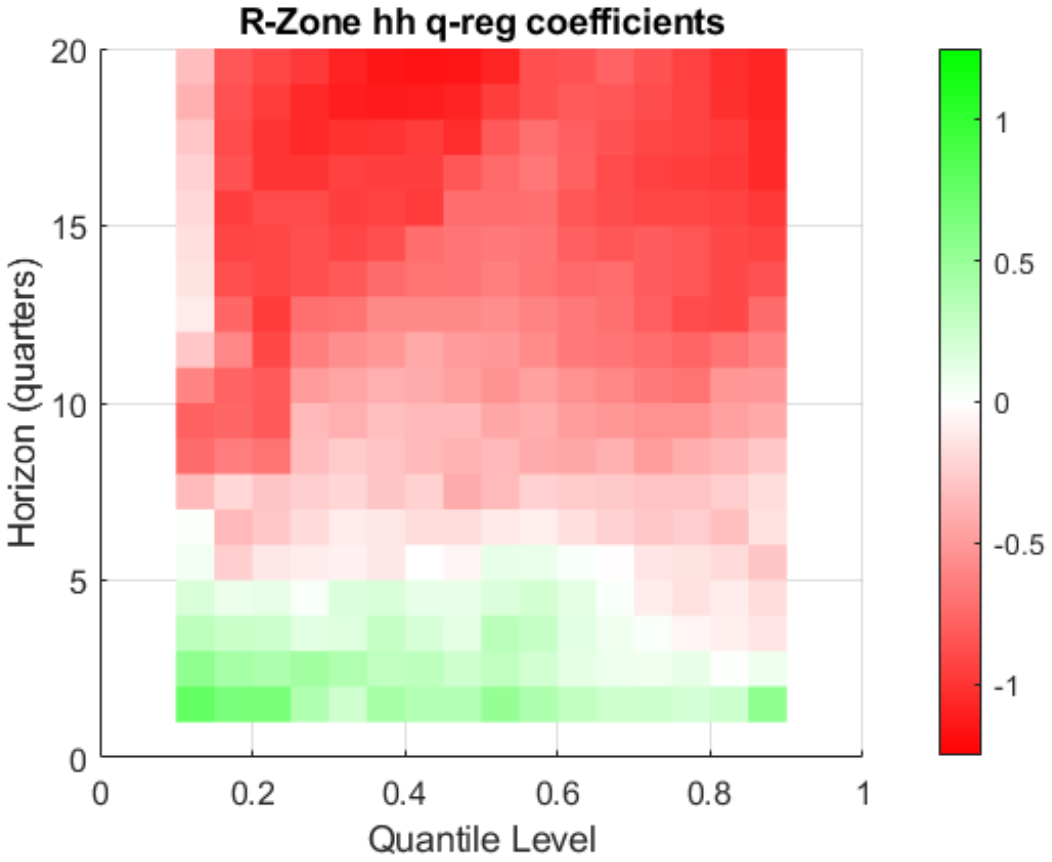


Source: author's own computations.
Notes: Distribution refers to annualized 12-q. ahead GDP growth for UK. Black line represents the forecasted distribution for Q1-2005; household R-zone is not active. Red line represents the forecasted distribution for Q2-2008; household R-zone is active.

R-zones and GDP-at-Risk

Household R-zone

- Main takeaways:
  - Location shifts: An overheated HH credit market shifts the density of GDP growth to right in the short term. But **over the medium term the distribution shifts strongly to the left**
  - Shape shifts: The growth distribution becomes **bimodal**. The lower mode is significantly below the mode of the unconditional distribution

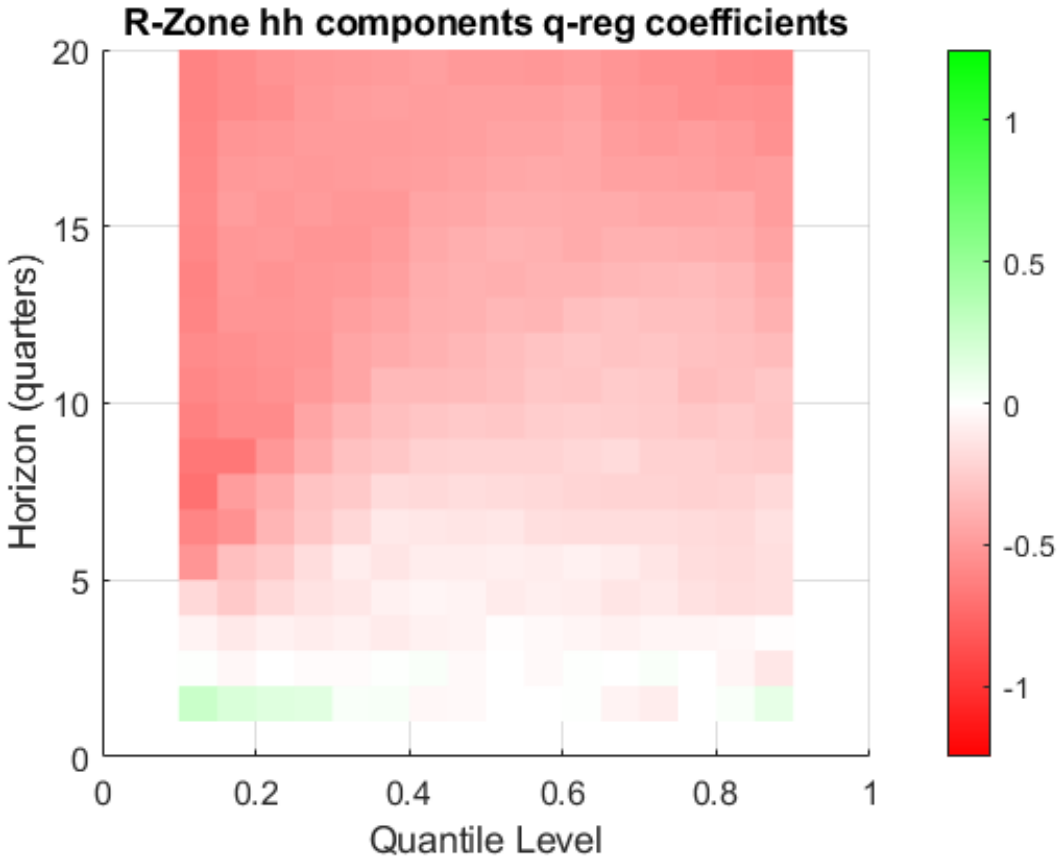


Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Household R-zone versus its components

Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, y_{i,t} + \epsilon_{i,t+h}$



Source: author's own computations.
Notes: The model is:
$y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \Delta_3 \log (price)^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, \Delta_3 (\text{Debt} / \text{GDP})^{hh}{}_{i,t} + \beta_{\tau,3}^{h} \, y_{i,t} + \epsilon_{i,t+h}$
Values for price and debt variables are standardized by country.
Colour represent the value of the sum between price and debt quantile regression coefficients. Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Business R-zone

- Model specification:

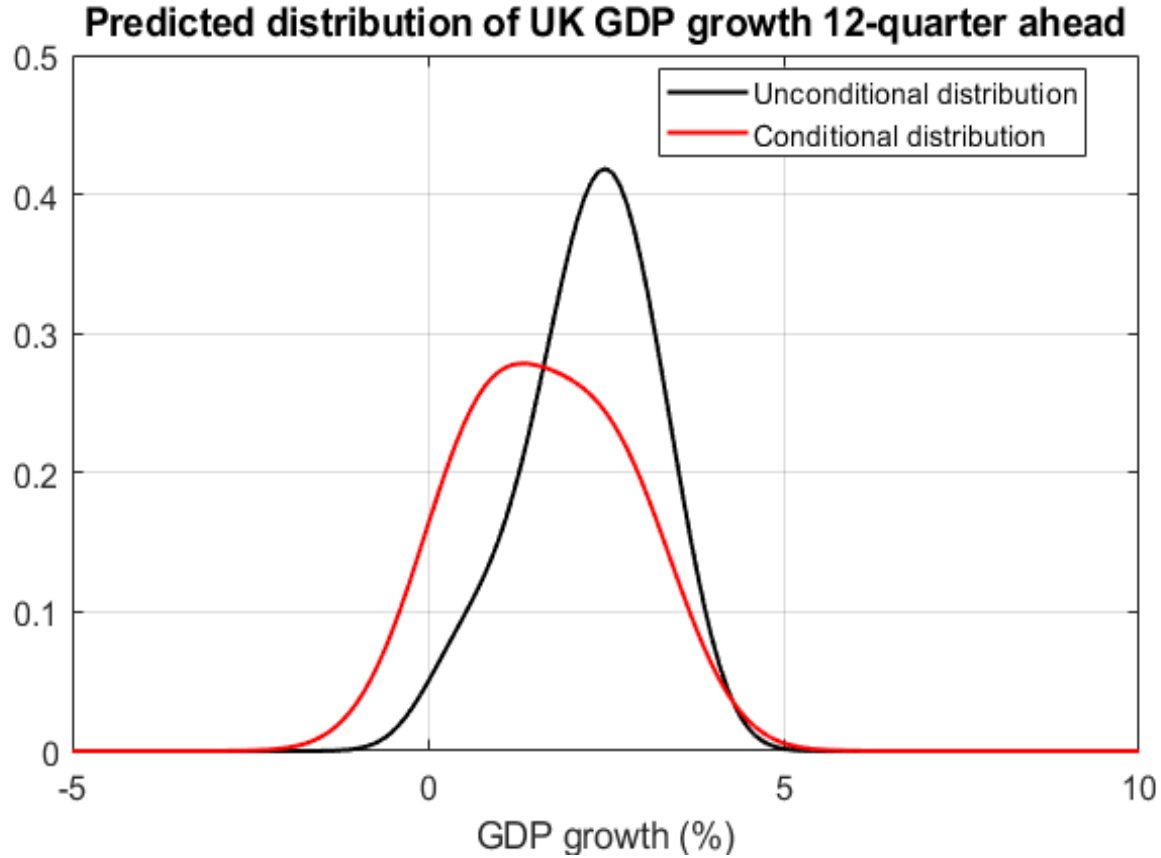
$$y_{i,\,t+h} = \alpha^{h}_{\tau} + \boldsymbol{\beta^{h}_{\tau,1}}\ \mathrm{R\ zone}^{\mathrm{bus}}{}_{i,t} + \beta^{h}_{\tau,2}\ y_{i,\,t} + \epsilon_{i,\,t+h}$$

Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Business R-zone

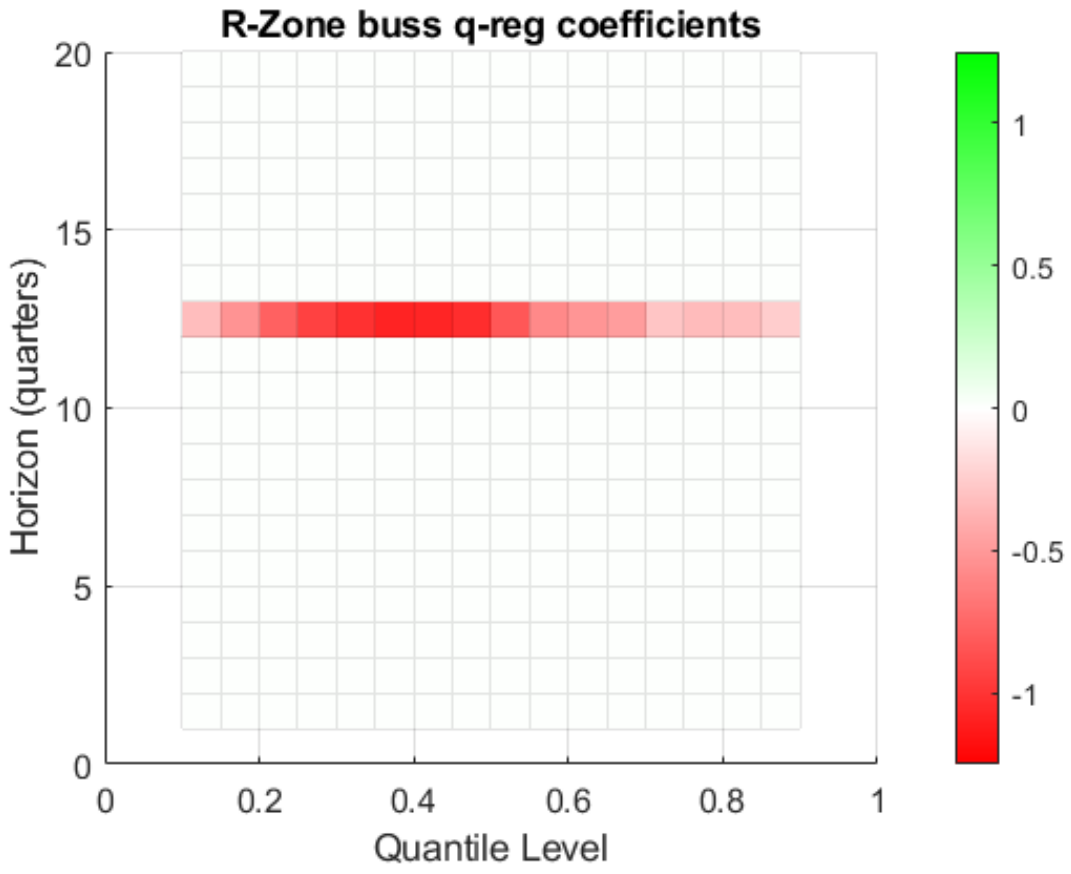
Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Coloured row represent 12 quarter ahead quantile regressions coefficients.



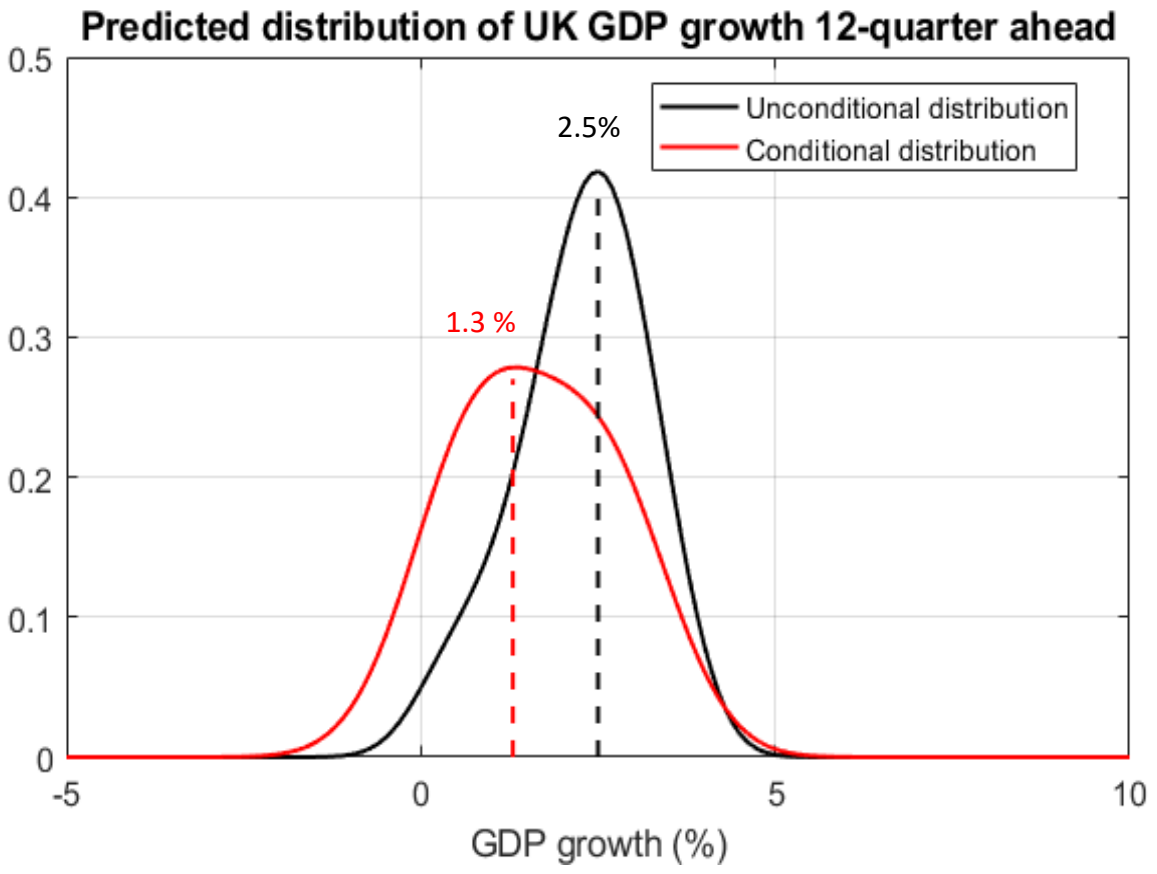
Source: author's own computations.
Notes: Distribution refers to annualized 12-q. ahead GDP growth for UK. For the uncond. distribution, the avg. value of current GDP growth and R-zone buss = 0 have been used. For the cond. distribution, the avg. value of current GDP growth and R-zone buss = 1 have been used.

R-zones and GDP-at-Risk

Business R-zone



Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Coloured row represent 12 quarter ahead quantile regressions coefficients.

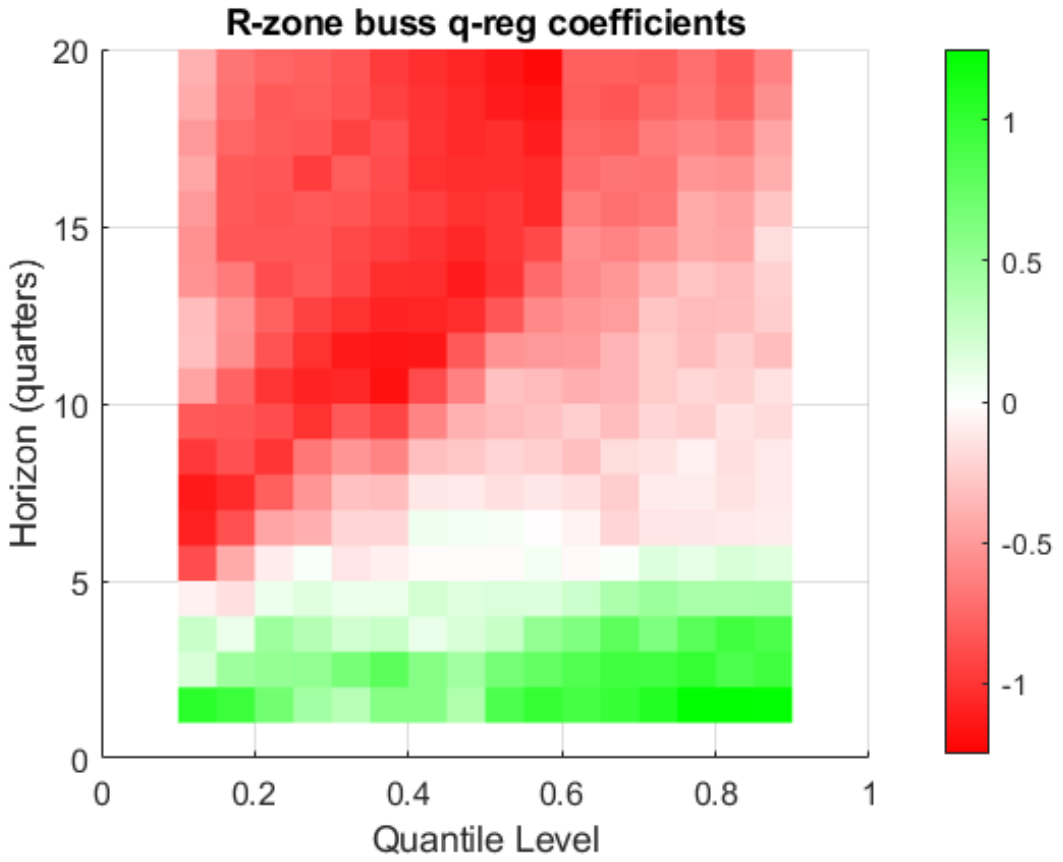


Source: author's own computations.
Notes: Distribution refers to annualized 12-q. ahead GDP growth for UK. For the uncond. distribution, the avg. value of current GDP growth and R-zone buss = 0 have been used. For the cond. distribution, the avg. value of current GDP growth and R-zone buss = 1 have been used.

R-zones and GDP-at-Risk

Business R-zone

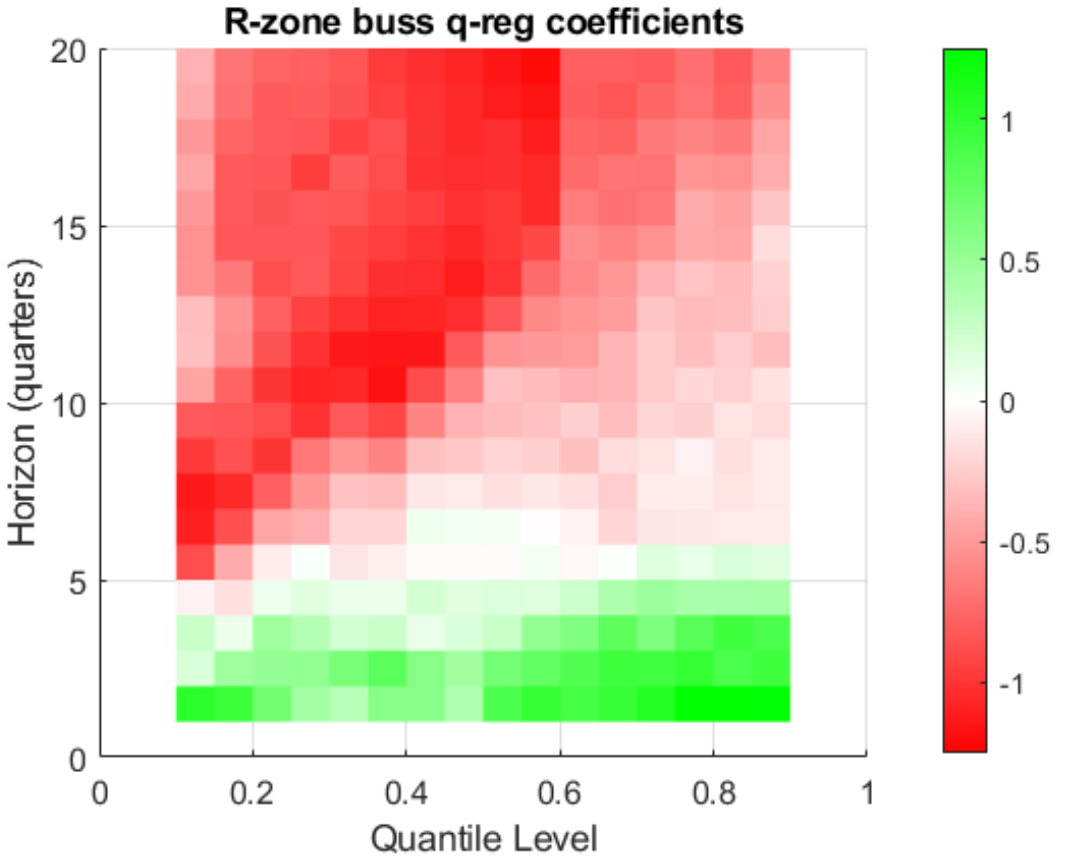
- Main takeaways:
  - An overheated corporate credit market shifts the GDP growth distribution to the right in the short term. But over the medium term it shifts the distribution to the left.
  - The leftward shift initially manifests itself as “tail risk”
  - The mode of the distribution conditional on the R-zone switching on is significantly lower than the unconditional mode



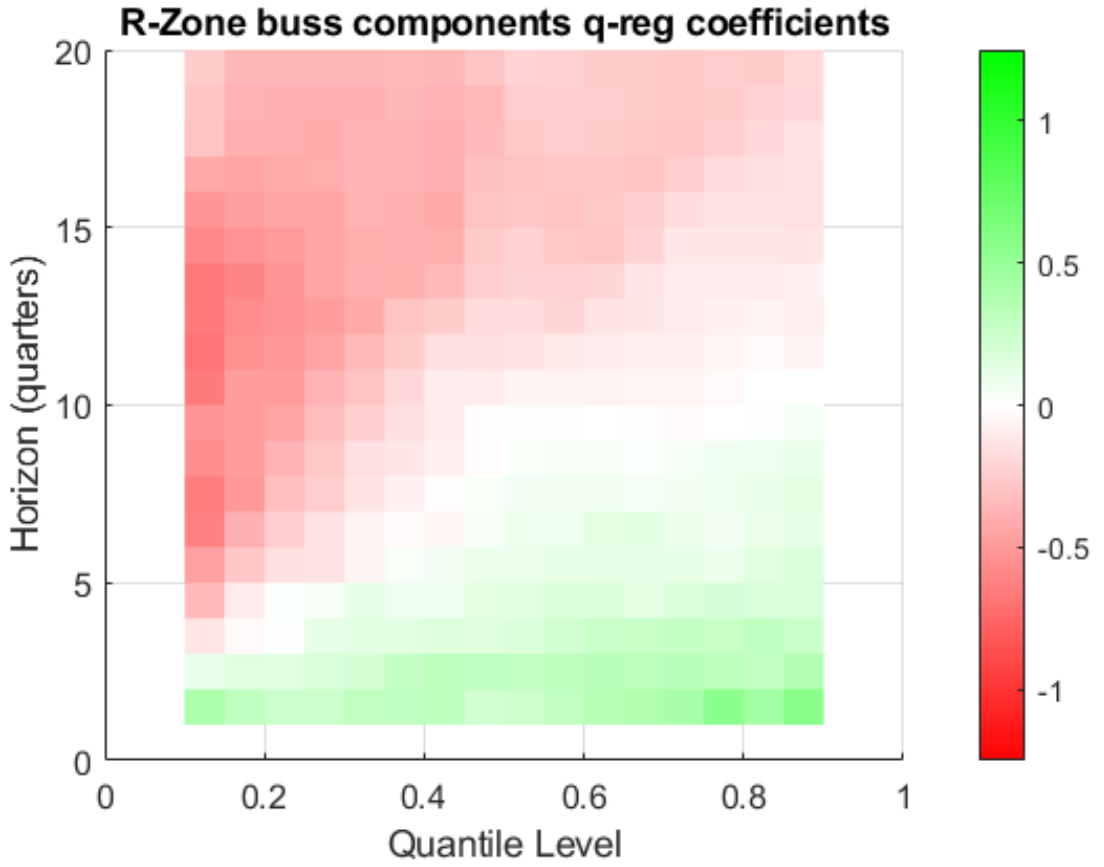
Source: author’s own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Business R-zone versus its components



Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{buss}{}_{i,t} + \beta_{\tau,2}^{h} \, y_{i,t} + \epsilon_{i,t+h}$



Source: author's own computations.
Notes: The model is:
$y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \Delta_3 \log\,(price)^{bus}{}_{i,t} + \beta_{\tau,2}^{h} \, \Delta_3\,(\text{Debt} / \text{GDP})^{bus}{}_{i,t} + \beta_{\tau,3}^{h} \, y_{i,t} + \epsilon_{i,t+h}$
Values for price and debt variables are standardized by country.
Colour represent the value of the sum between price and debt quantile regression coefficients.
Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Household and business R-zones combined

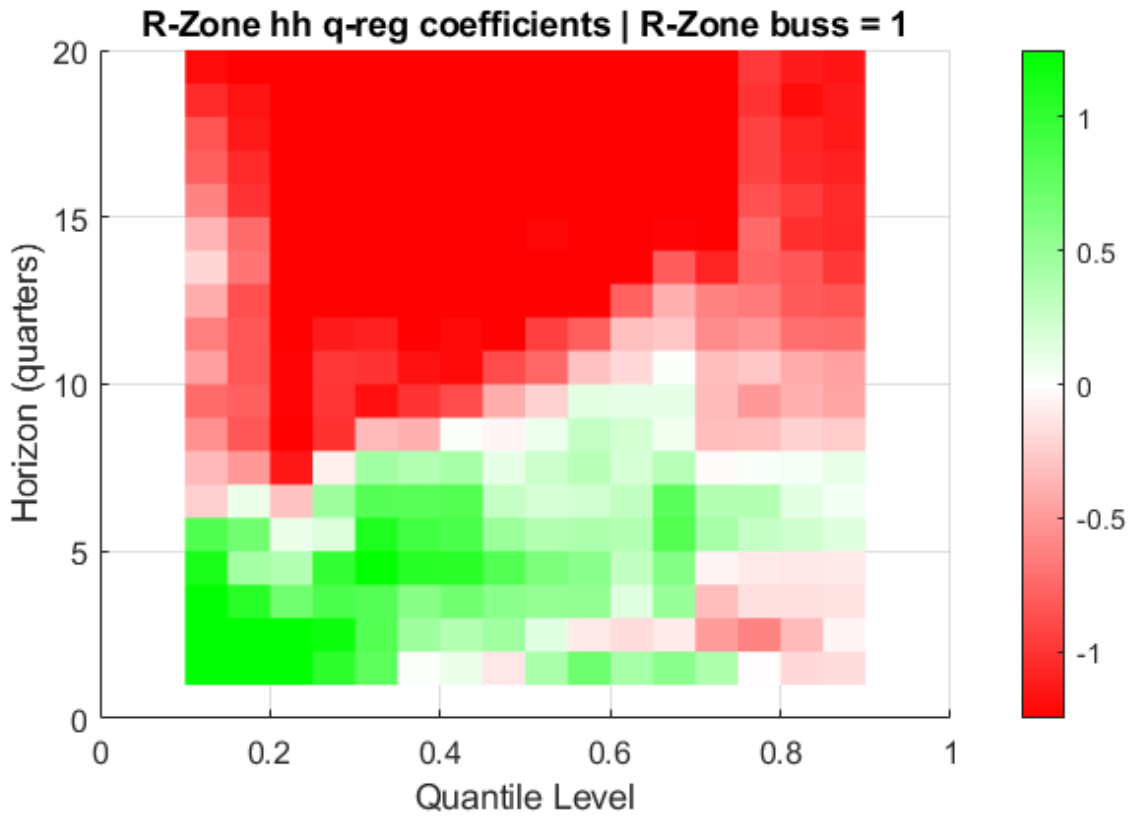
- The model specification is:

$$y_{i,t+h} = \alpha_{\tau}^{h} + \boldsymbol{\beta_{\tau,1}^{h}}\, \text{R zone}^{\text{both}}{}_{i,t} + \boldsymbol{\beta_{\tau,2}^{h}}\, \text{R zone}^{\text{hh}}{}_{i,t} + \boldsymbol{\beta_{\tau,3}^{h}}\, \text{R zone}^{\text{bus}}{}_{i,t} + \beta_{\tau,\mathbf{4}}^{h}\, y_{i,t} + \epsilon_{i,t+h}$$

R-zones and GDP-at-Risk

Nonlinear interactions

This is the effect of switching on the household R-Zone if the business R-Zone is also overheated

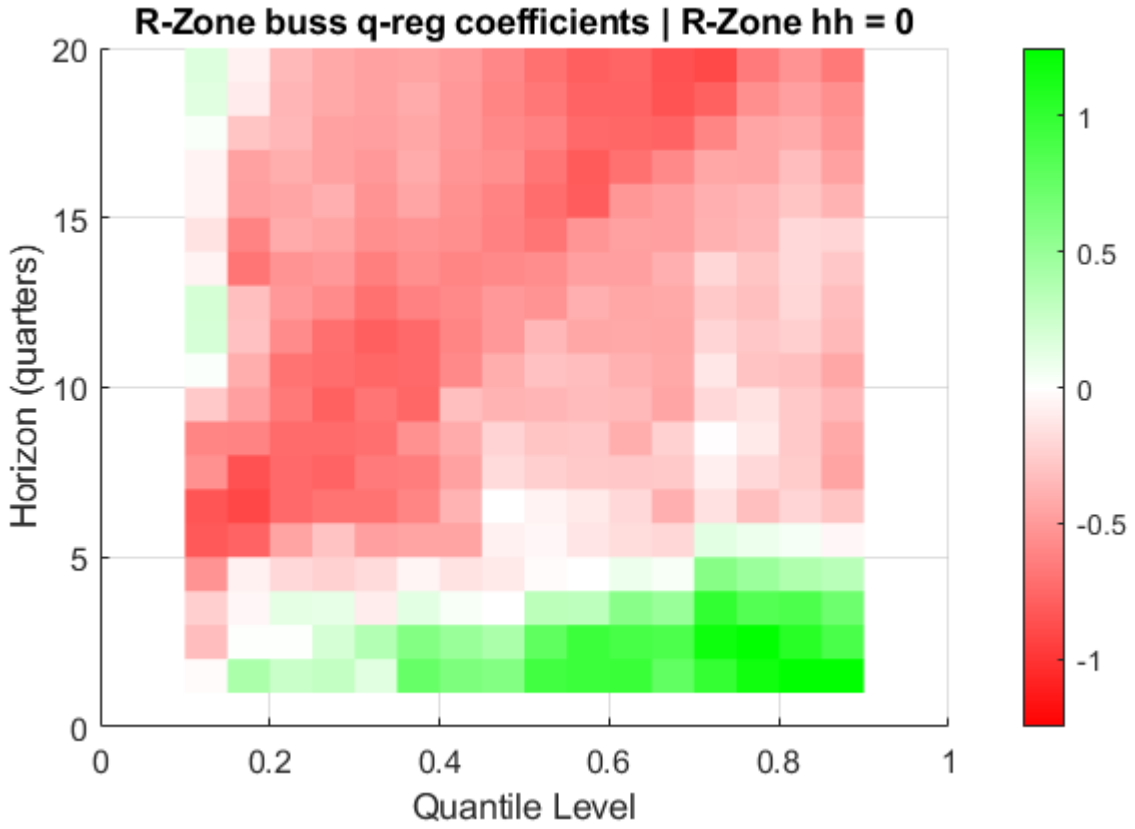


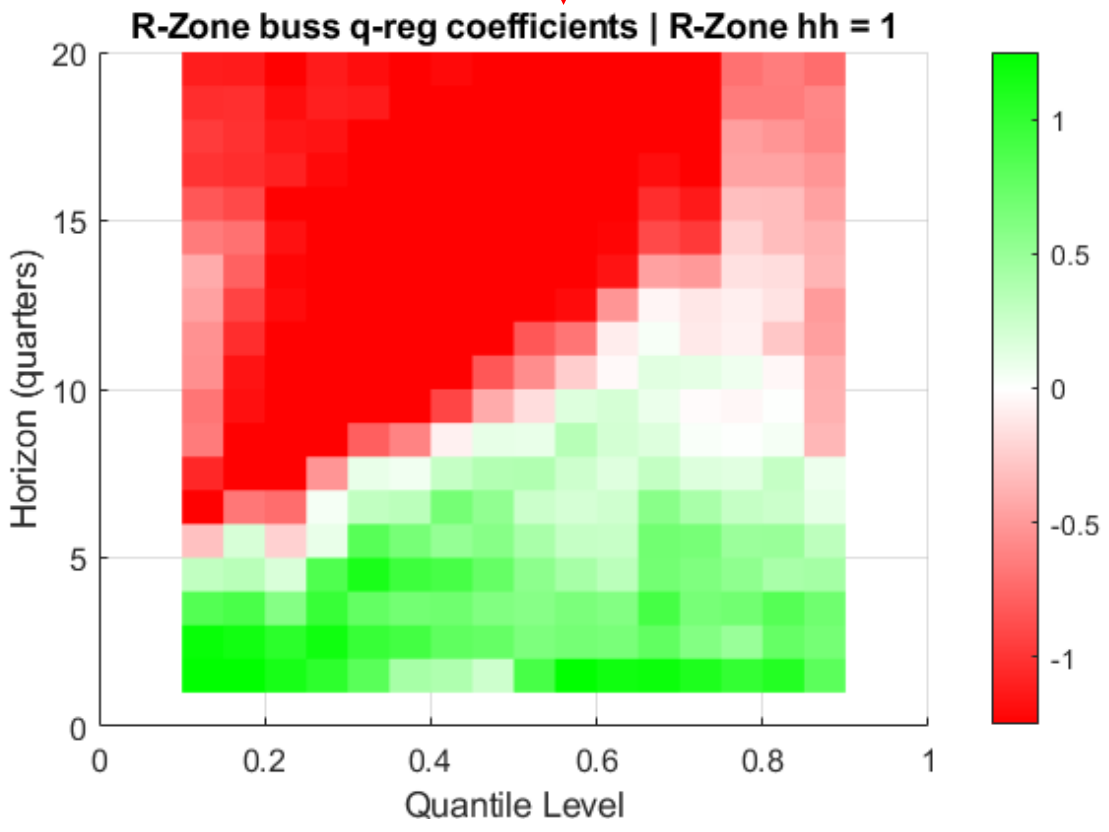
Notes: Chart on the lhs exhibits $\beta^h_{\tau,2}$; chart on the rhs exhibits the sum of $\beta^h_{\tau,1}$ and $\beta^h_{\tau,2}$.
Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Nonlinear interactions

This is the effect of switching on the business R-Zone if the household R-Zone is also overheated

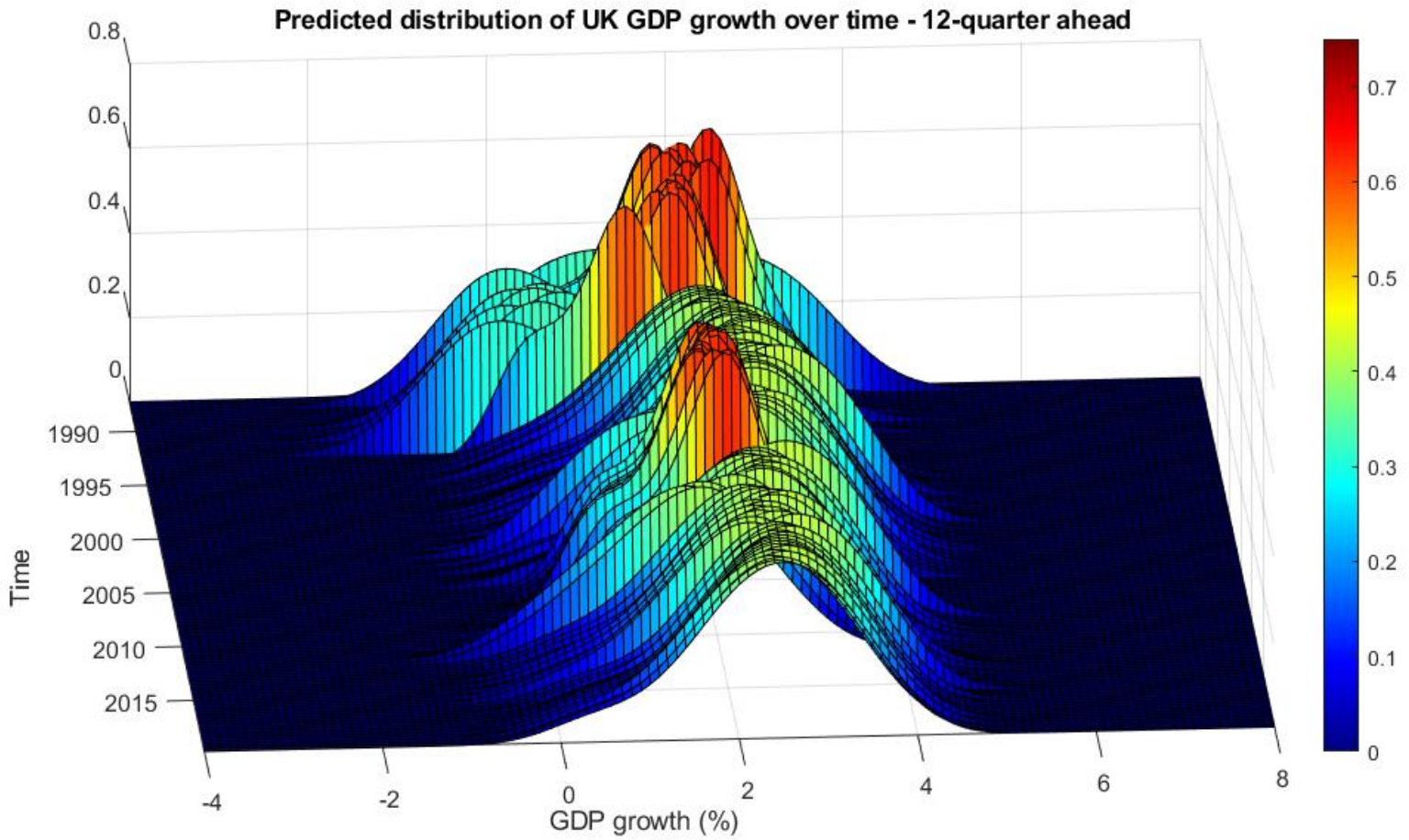




Notes: Chart on the lhs exhibits $\beta^h_{\tau,3}$; chart on the rhs exhibits the sum of $\beta^h_{\tau,1}$ and $\beta^h_{\tau,3}$.
Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.

R-zones and GDP-at-Risk

Nonlinear interactions



Source: author's own computations.
Notes: annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables.
Time variable denotes the period for which outcome are forecasted, not the date when the prediction was generated.

Macroprudential policy, R-zones and GDP-at-Risk

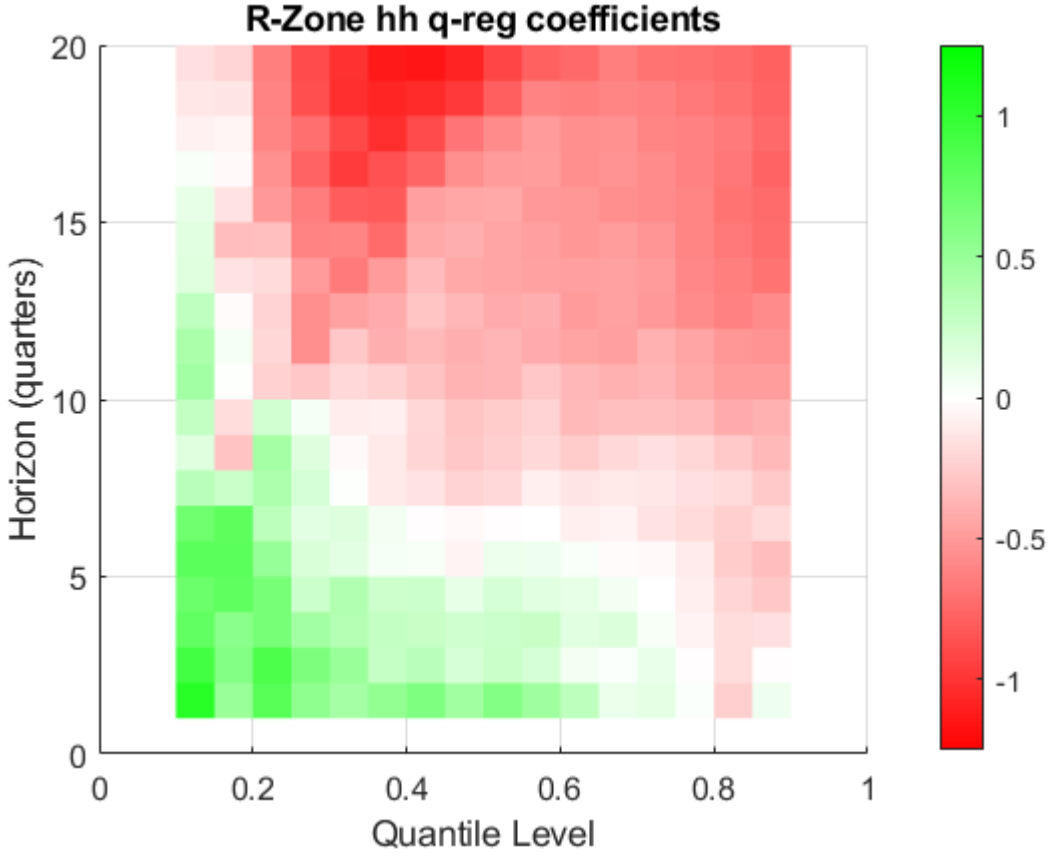
The IMF's IMaaP database of macropru actions

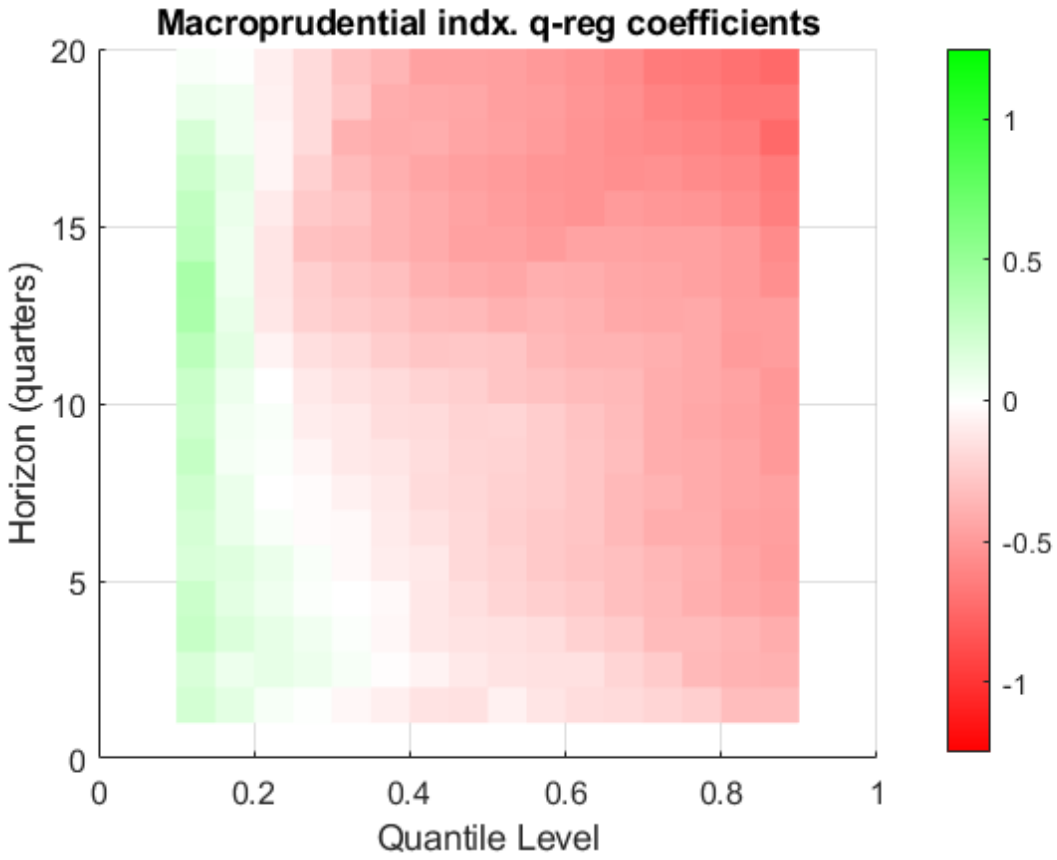
- We use the IMF's IMaaP database to measure macroprudential policy
- The full dataset covers 134 countries for the period between 1990m1 and 2021m12 and contains information about 17 macroprudential instruments (dummy-type indices) such as the CCyB, LTV ratios etc
- We apply judgement to the raw data, focusing on 12 macropru instruments that have a closer connection to macropru stance*
  - We also aggregate the monthly index values within the quarter of interest
  - Sum the aggregated quarterly values for all instruments within each quarter
  - Take the cumulative sum of measures applied up to each point in time
  - Standardize our measure by subtracting the overall sample mean and dividing by the overall sample sd.

* The 12 instruments are: CCyB, capital requirements, leverage limits, limits on credit growth, loan restrictions, restriction on foreign currency loans, limits on the LTV limit, limits to the debt service to income or loan to income ratio, tax measure for macroprudential purpose, limits to loan to deposit ratio, limits on FX positions, other macroprudential measures.

Can macroprudential policy mitigate HH R-zone effects?

Effects of switching on macroprudential policy (right)





The model is: $y_{i\,,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\, R\ zone^{hh}{}_{i\,,t} + \beta_{\tau,2}^{h}\, macroprud\_indx_{\,i\,,t} + \beta_{\tau,3}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$

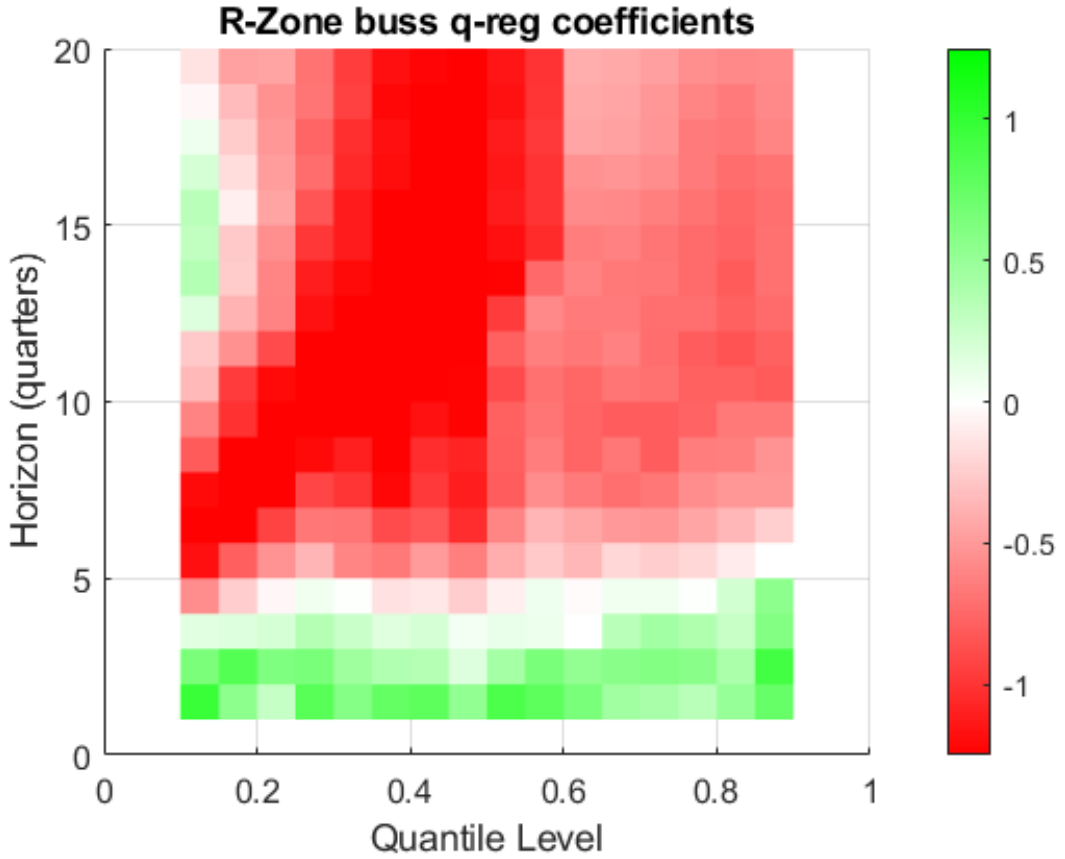
Source: author's own computations.

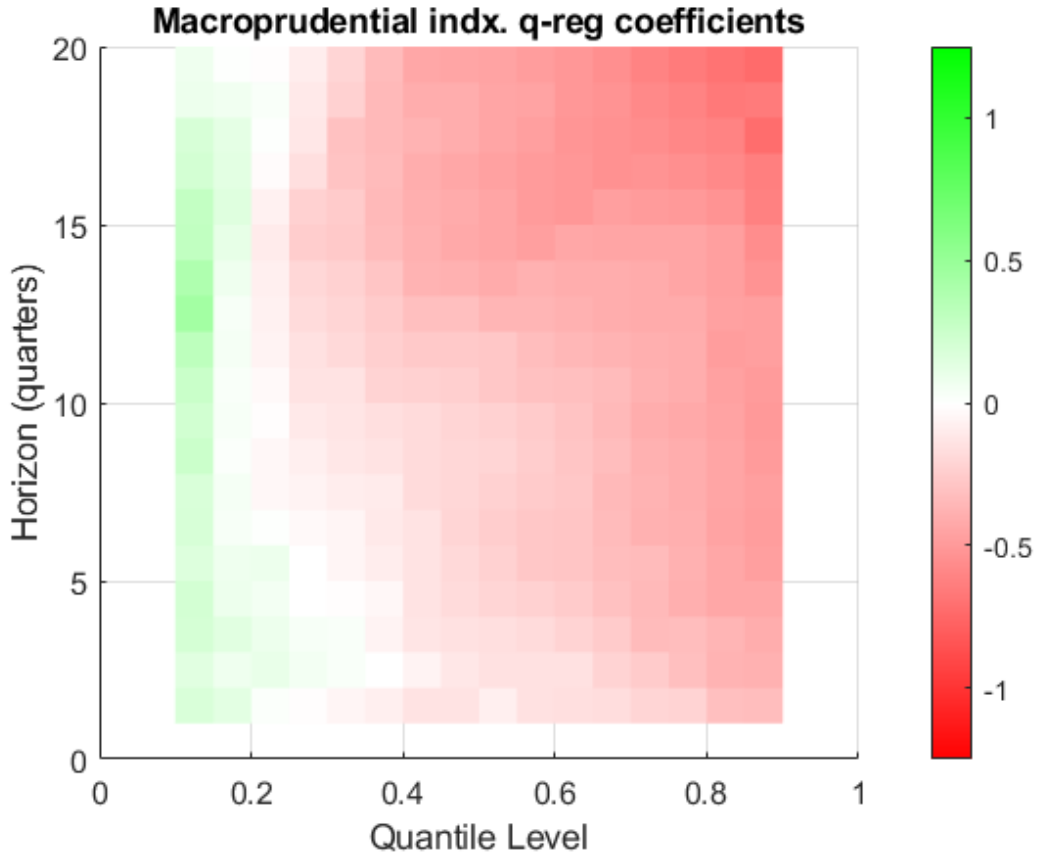
Notes: Chart on the lhs exhibits $\beta_{\tau,1}^{h}$; chart on the rhs exhibits $\beta_{\tau,2}^{h}$.

Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Right hand side chart represent the effect of 1 standard deviation shock to the macroprudential policy index on the dependent variable. Macroprudential index has been constructed using the 12 selected macroprudential instruments.

Can macroprudential policy mitigate business R-zone effects?

Effects of switching on macroprudential policy (right)





The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{buss}{}_{i,t} + \beta_{\tau,2}^{h} \, macroprud\_indx_{i,t} + \beta_{\tau,\mathbf{3}}^{h} \, y_{i,t} + \epsilon_{i,t+h}$

Source: author's own computations.

Notes: Chart on the lhs exhibits $\beta_{\tau,1}^{h}$; chart on the rhs exhibits $\beta_{\tau,2}^{h}$.

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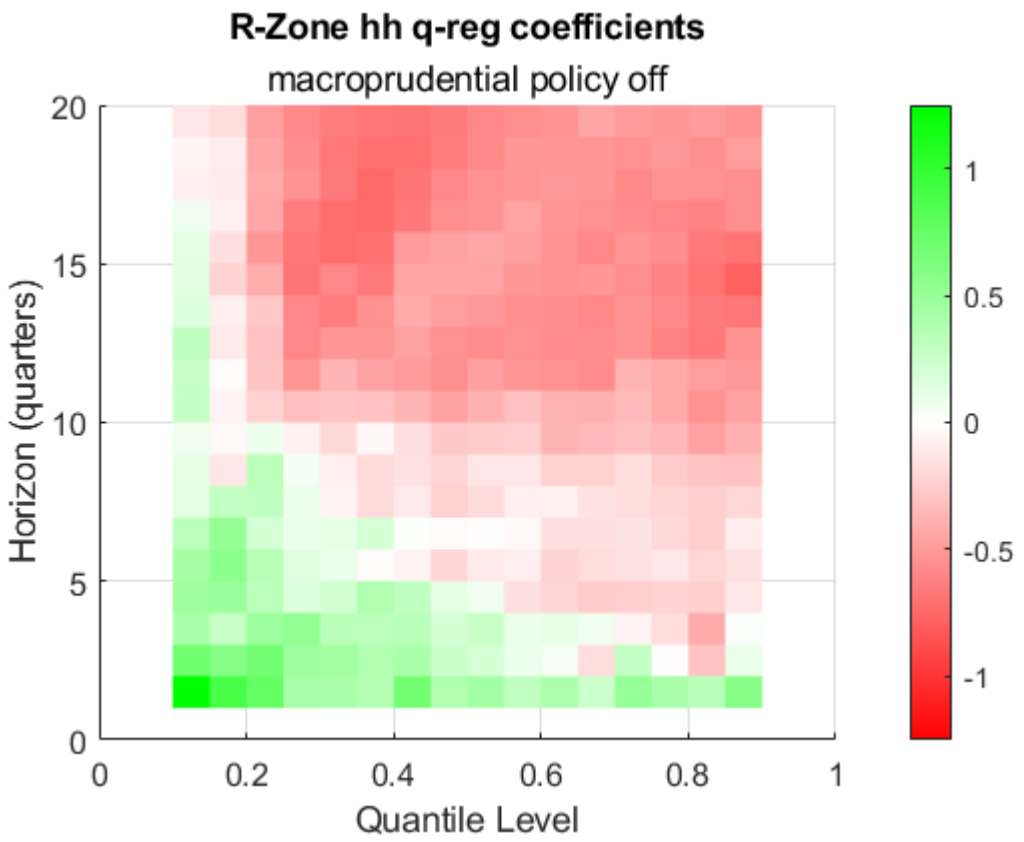
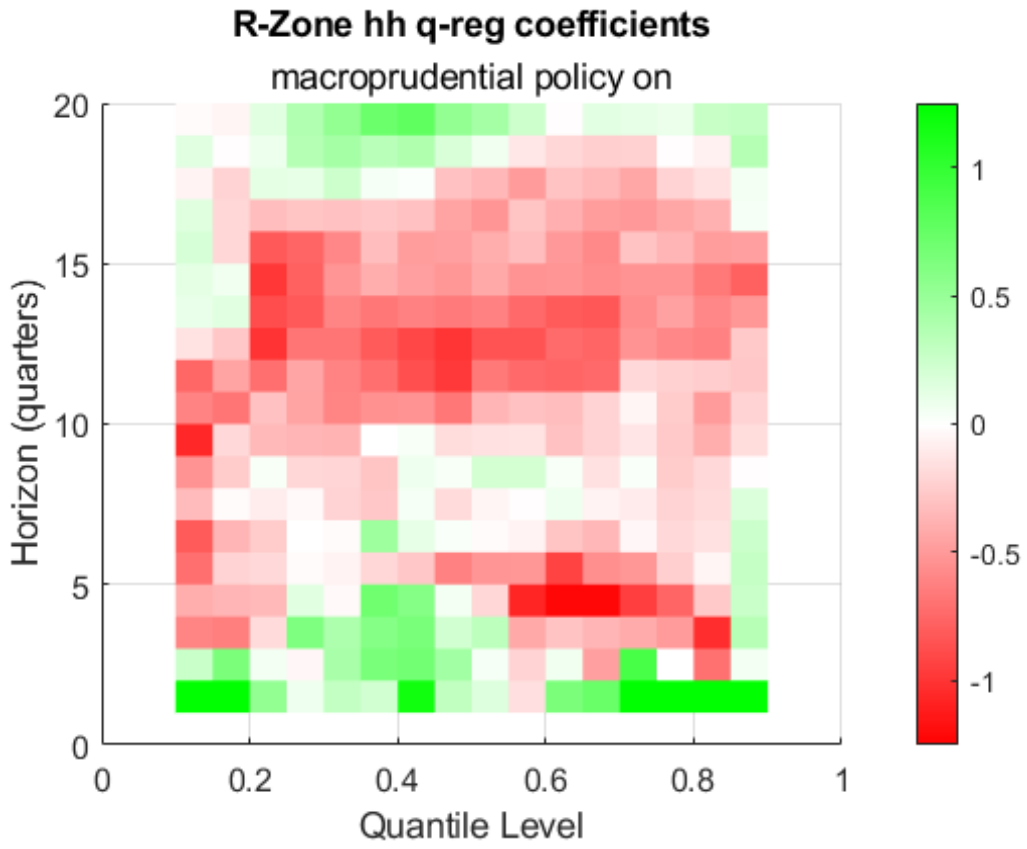
Can macroprudential policy mitigate HH R-zone effects?

The resilience benefits of macroprudential policy





The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, macroprud\_indx_{i,t} + \beta_{\tau,3}^{h} \, (macroprud\_indx_{i,t} * R\,zone^{hh}{}_{i,t}) + \beta_{\tau,4}^{h} \, y_{i,t} + \epsilon_{i,t+h}$

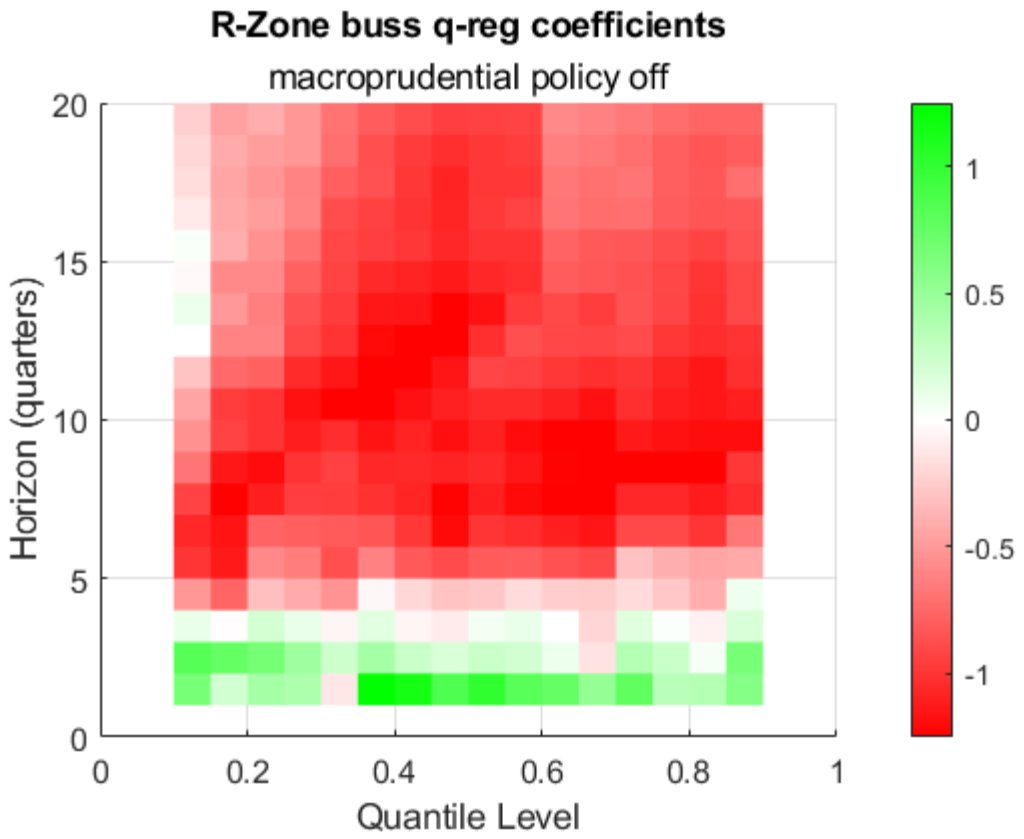
Source: author's own computations.

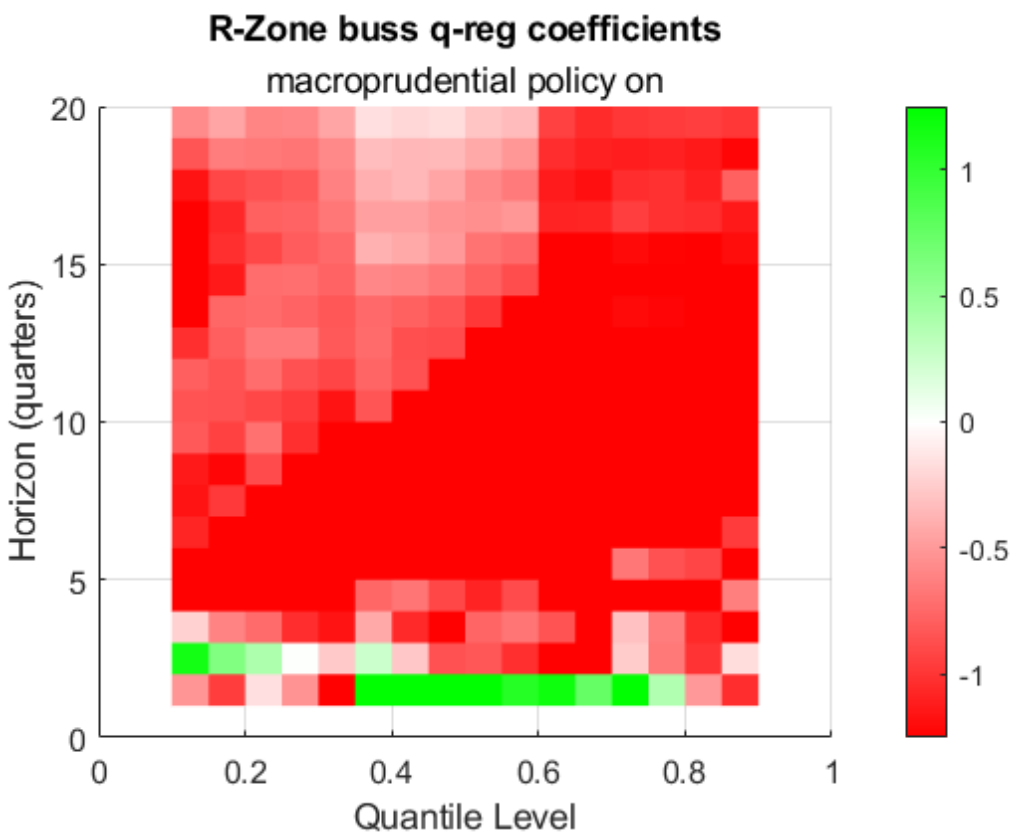
Notes: Chart on the lhs exhibits $\beta_{\tau,1}^{h}$; chart on the rhs exhibits $\beta_{\tau,1}^{h} + \beta_{\tau,3}^{h}$

Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Macroprudential index has been constructed using the 12 selected macroprudential instruments.

Can macroprudential policy mitigate HH R-zone effects?

The resilience benefits of macroprudential policy





The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{buss}{}_{i,t} + \beta_{\tau,2}^{h} \, macroprud\_indx_{i,t} + \beta_{\tau,\mathbf{3}}^{h} \, (macroprud\_indx_{i,t} * R\,zone^{buss}{}_{i,t}) + \beta_{\tau,\mathbf{4}}^{h} \, y_{i,t} + \epsilon_{i,t+h}$

Source: author's own computations.

Notes: Chart on the lhs exhibits $\beta_{\tau,1}^{h}$; chart on the rhs exhibits $\beta_{\tau,1}^{h} + \beta_{\tau,\mathbf{3}}^{h}$

Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Macroprudential index has been constructed using the 12 selected macroprudential instruments.

R-zones and GDP-at-Risk

Summary of the effects of macroprudential policy

- We find that tightening macroprudential policy reduces both the mean and variance of the predicted density of GDP growth
- But the impacts are modest relative to R-zone effects
  - Macropru policy may need to act very aggressively in these circumstances
- We find that resilience benefits of previously applied macroprudential policies are unclear
  - The effects of R-zones are not mitigated in cases where macropru has previously been applied

Some thoughts for researchers and policy advisors

Some thoughts for researchers and policy advisors

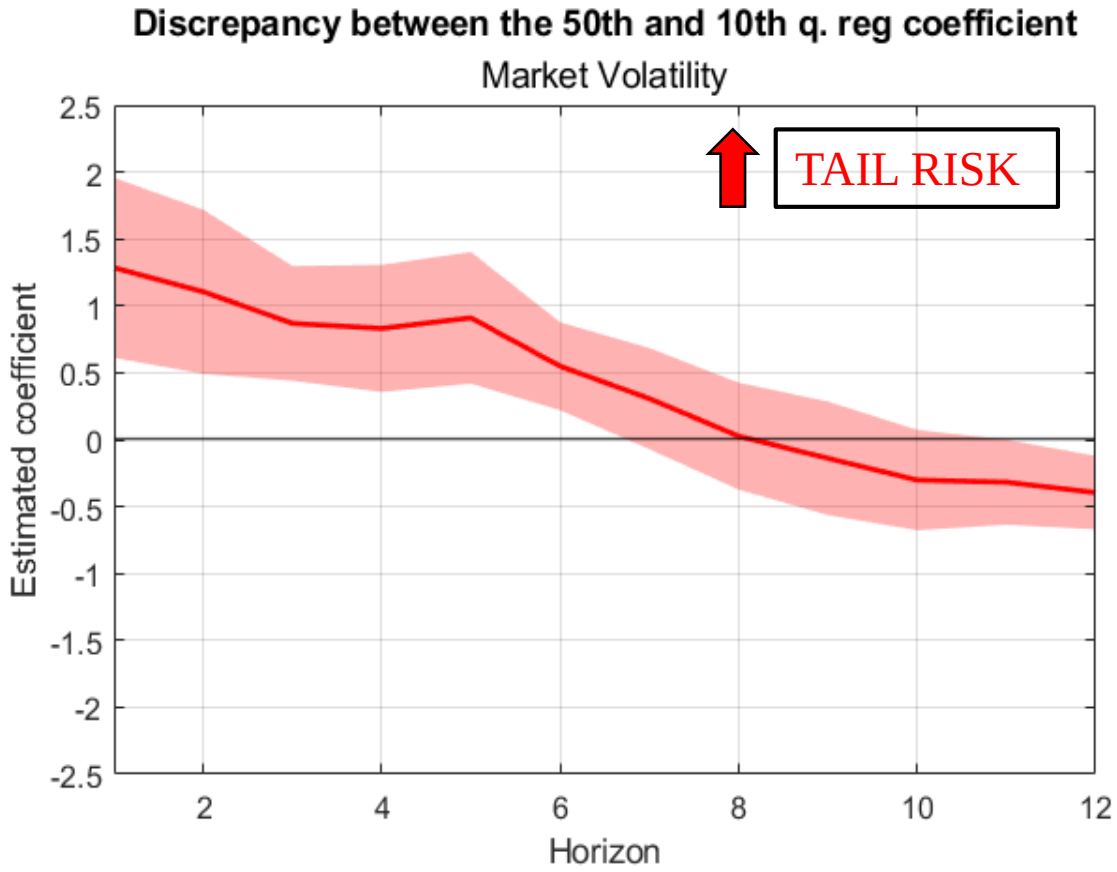
- What do the empirical results here imply for macroeconomic policy?
- Is ‘finance-at-risk’ a better target for macroprudential policy than GDP-at-risk?
- Can we integrate GDP-at-risk in the setting of macropru tools like the CCyB?

What do the empirical results imply for macro policy?

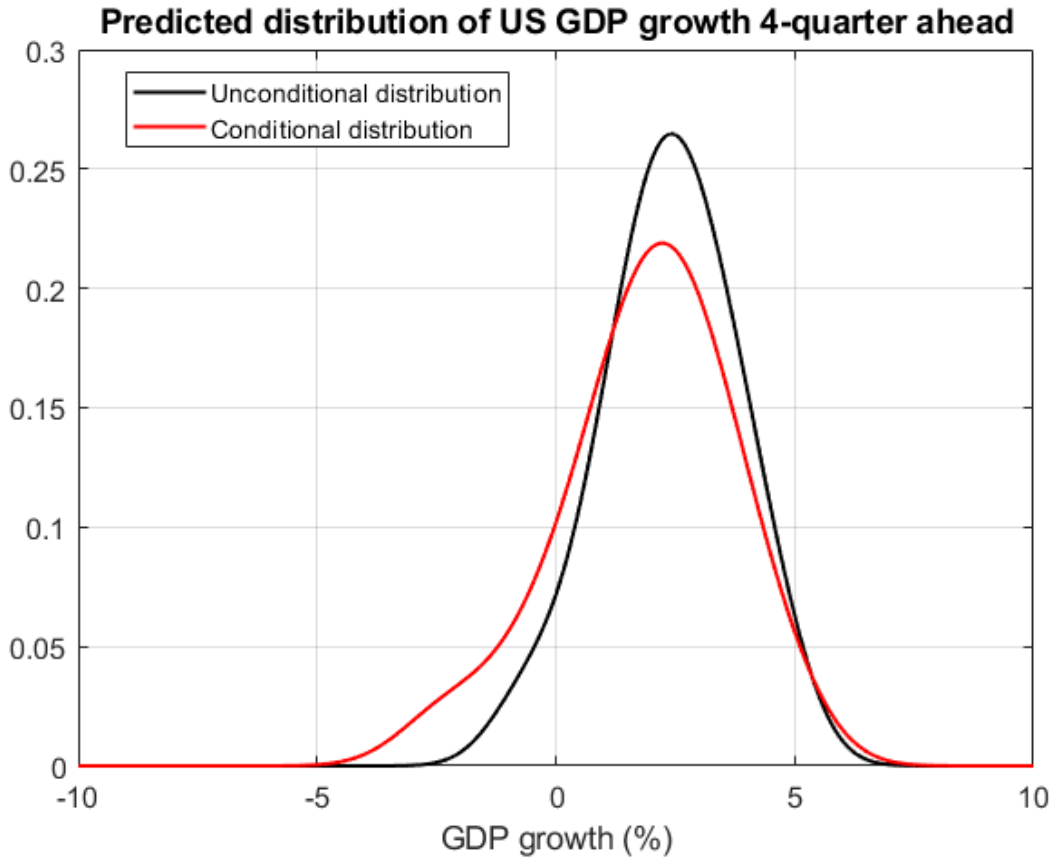
- The ESRB has proposed a measure of "median-to-tail distance" (MTD) as an indicator of macropru stance
  - The gap between the 50th quantile and the 5th or 10th quantile
- Suarez (2021) similarly proposes focusing on quadratic deviations of GaR from expected growth as a metric of society's preference for financial stability
- Why?
  - "…as documented in recent empirical work, the financial factors and policy tools on which macroprudential policy focuses affect the conditional low quantiles of the true growth distribution in a stronger and more clearly identifiable manner than its conditional variance." Suarez (2021)

What do the empirical results imply for macro policy?

Jumps in market vol increase the MTD metric



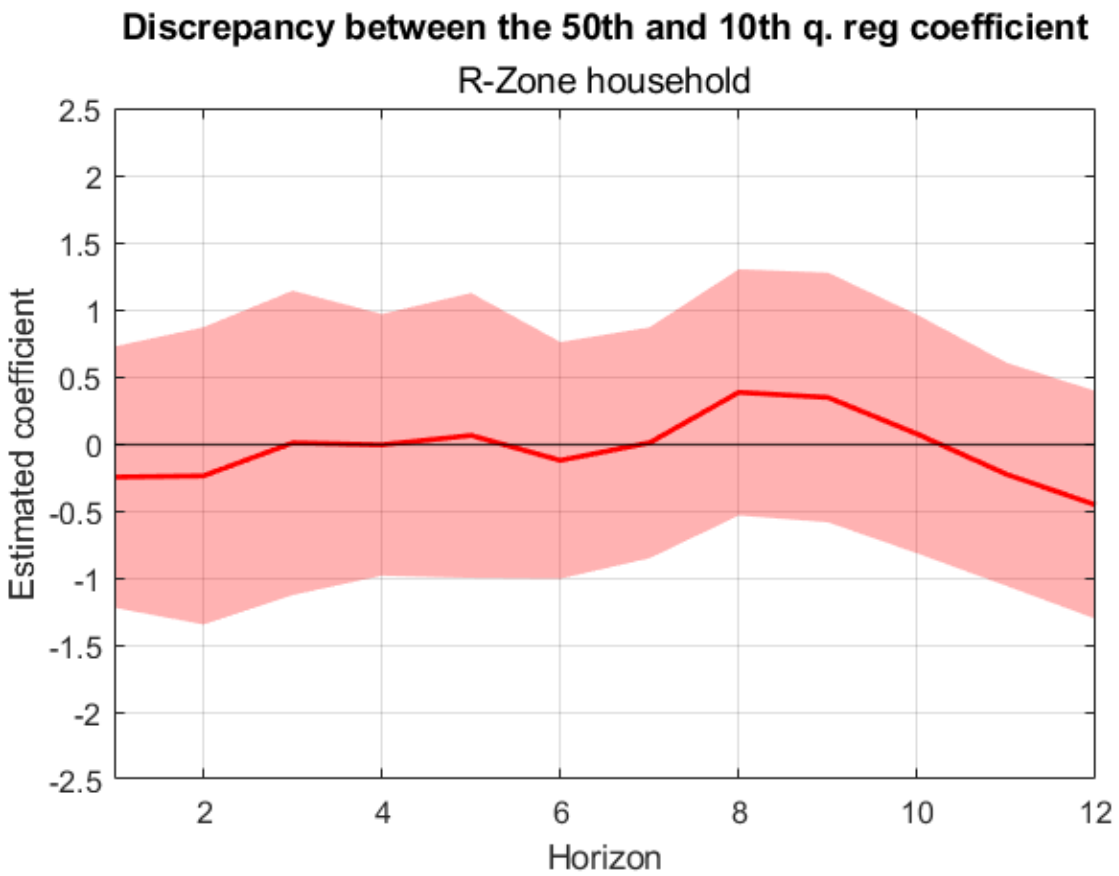
Source: authors' own computations
Notes: Chart shows the discrepancy between the estimated coefficient for the 50th percentile and the 10th percentile on market volatility obtained from the following regression: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\ mrk\_vol_{i,t} + \beta_{\tau,2}^{h}\ y_{i,t} + \epsilon_{i,t+h}$
The confidence bands represent the estimated coefficients plus or minus 2 standard deviations.



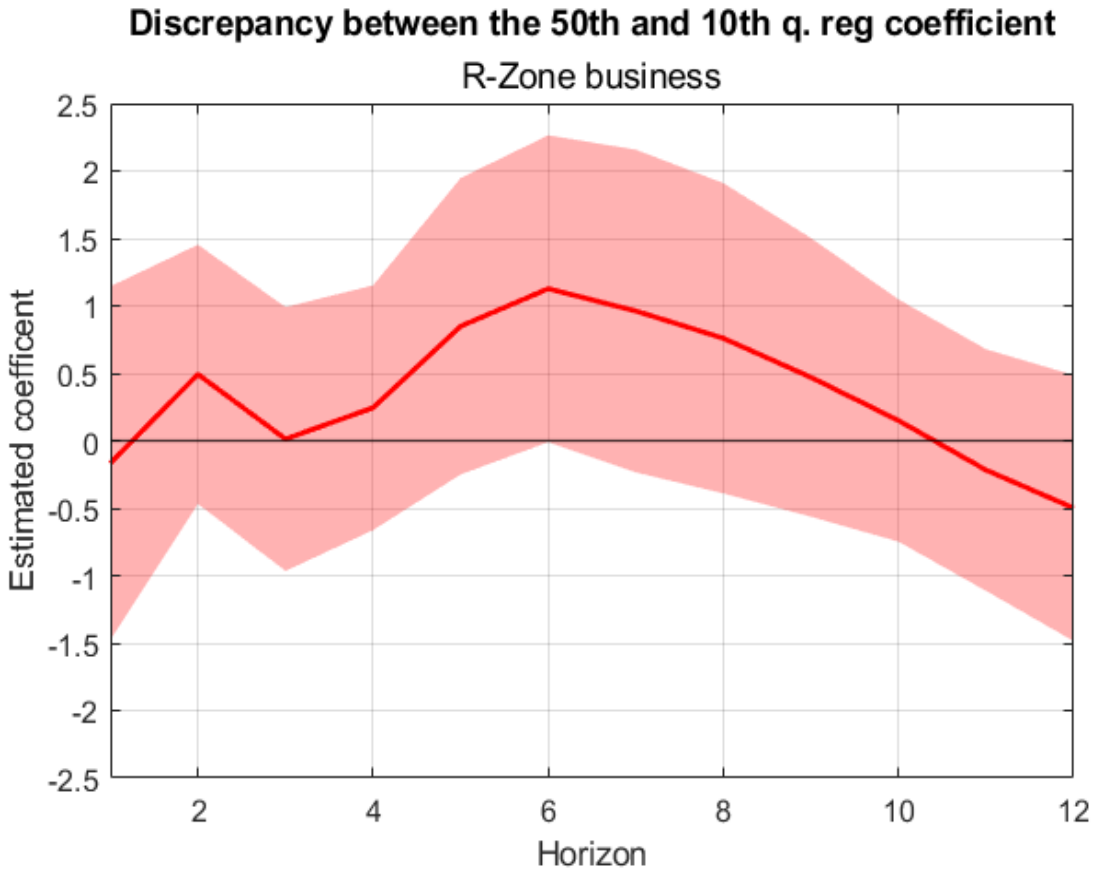
Source: author's own computations.
Notes: Distribution refers to annualized 4-q. ahead GDP growth for US. For the uncond. distribution, the avg. value of current GDP growth and the avg. value of market volatility have been used. For the cond. distribution, the avg. value of current GDP growth and the avg. value of market volatility + 2 s.d have been used.

What do the empirical results imply for macro policy?

But R-zones do not increase the MTD metric



Source: authors' own computations
Notes: Chart show the discrepancy between the estimated coefficient for the 50th percentile and the 10th percentile on Household R-zone obtained from the following regression: $y_{i\,,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\ R\ zone^{hh}{}_{i\,,t} + \beta_{\tau,2}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$
The confidence bands represent the estimated coefficients plus or minus 2 standard deviations.



Source: authors' own computations
Notes: Chart show the discrepancy between the estimated coefficient for the 50th percentile and the 10th percentile on Business R-zone obtained from the following regression: $y_{i\,,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\ R\ zone^{buss}{}_{i\,,t} + \beta_{\tau,2}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$
The confidence bands represent the estimated coefficients plus or minus 2 standard deviations.

What do the empirical results imply for macro policy?

Macroprudential policy or monetary policy?

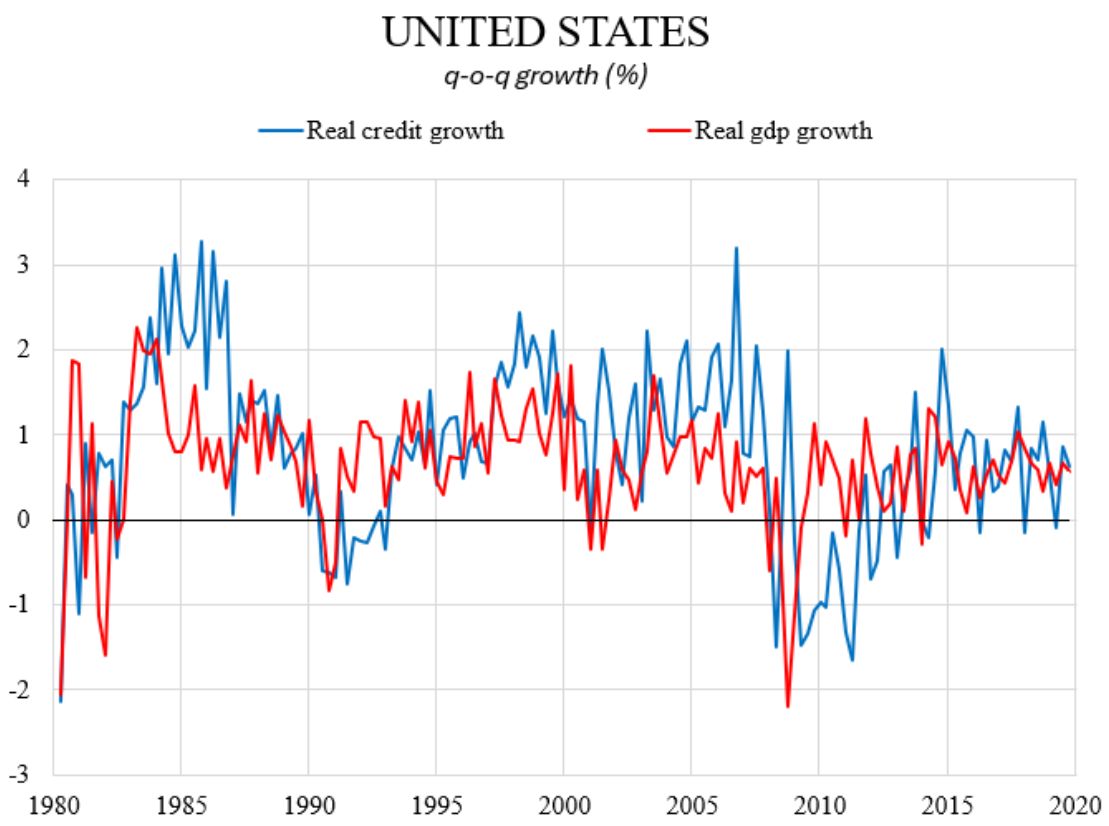
- Is the event of entering an R-zone a problem that falls to macroprudential policy?
- Or is it something that requires a monetary policy response (ie more accommodative policy) given that the entire predicted growth distribution deteriorates?
- Is macropru effective in these circumstances? Our (preliminary) empirical results give mixed messages

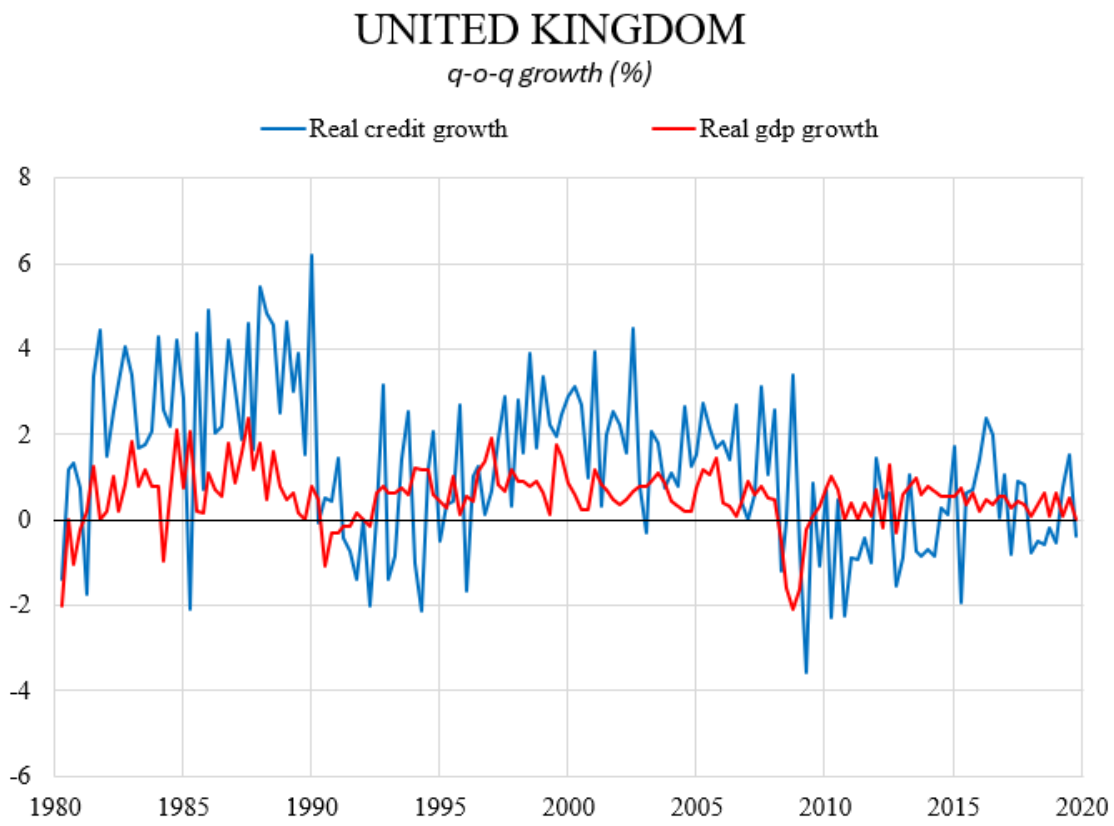
Is ‘finance-at-risk’ a better target?

- Finance-at-risk has some obvious advantages as a metric for macroprudential policy
- GDP is influenced by a range of factors, including things that have nothing to do with macroprudential policy
- It’s natural to think of the goal of macroprudential policy as being about ensuring sufficient resilience so that we avoid material disruptions to the supply of credit (eg Rosengren’s definition of financial stability)
- …of course we can’t observe the supply of credit directly so finance-at-risk is not perfect either

Is ‘finance-at-risk’ a better target?

Potential issues

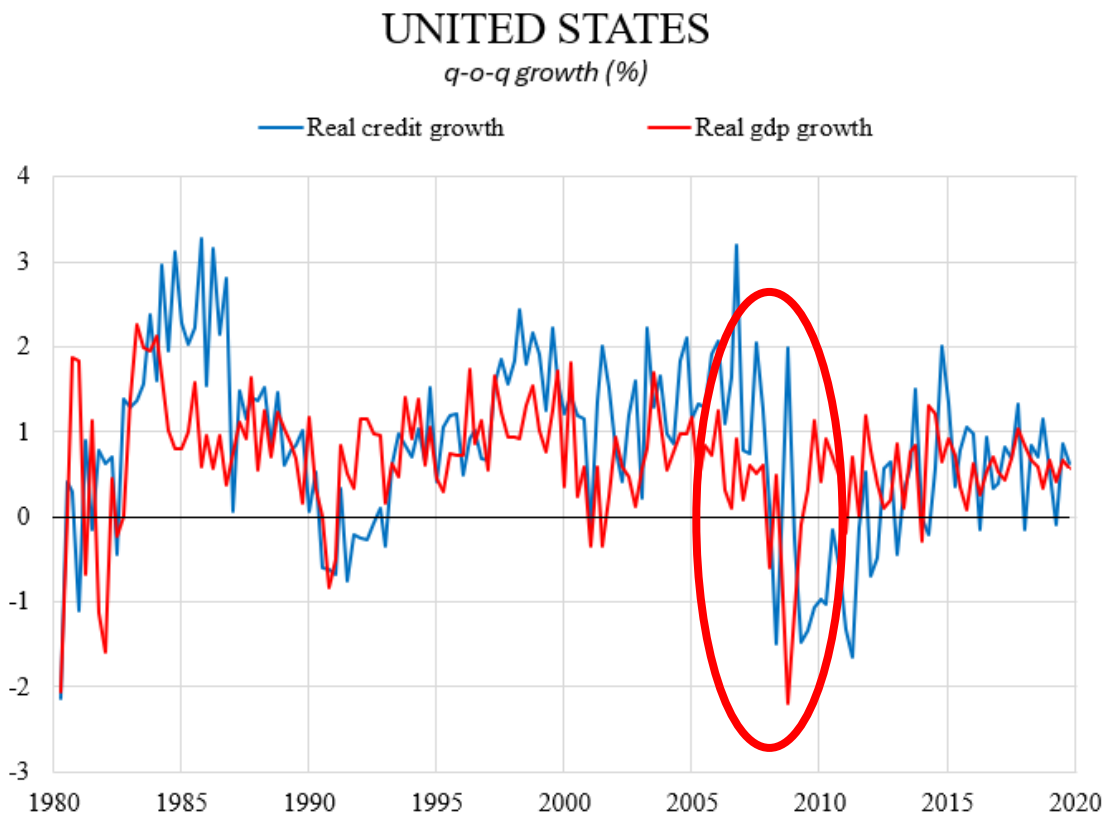


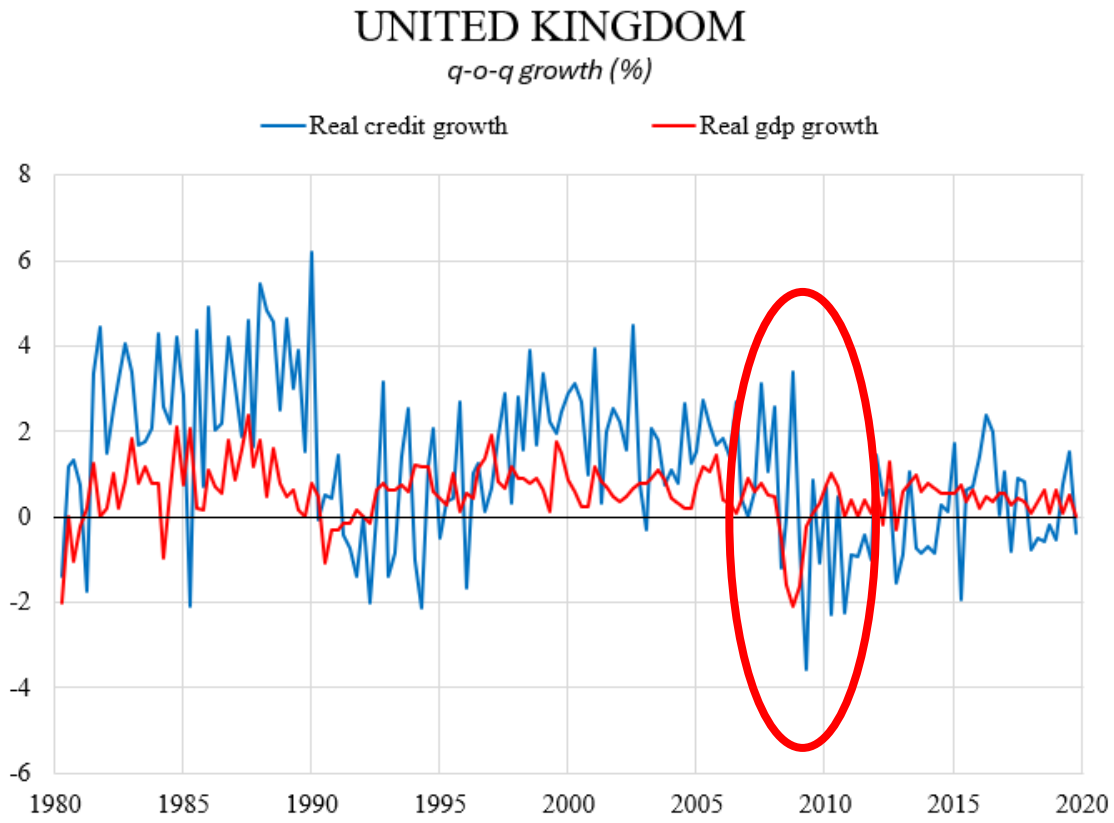


Source: OECD, BIS and author’s own computations.
Last observation: 2019-Q4

Is ‘finance-at-risk’ a better target?

Potential issues





Source: OECD, BIS and author’s own computations.
Last observation: 2019-Q4

Can we integrate GDP-at-risk in setting the CCyB?

- How well does the following policy reaction function for the CCyB perform?

$$\mathrm{CCyB}_t = \begin{cases} \overline{\mathrm{CCyB}} & \text{if GaR} \leq \text{normal level} \\ \alpha + \beta \mathrm{GaR}_t + \gamma \mathrm{CCyB}_{t-1} & \text{if GaR} > \text{normal level} \\ 0 & \text{if credit spread} > \bar{s} \end{cases}$$

- Potentially interesting questions:
  - What values of CCyBbar and beta maximise welfare?
  - How aggressive should we be in “switching off” the CCyB?
  - If we took account of likely lags in the decision making and policy impact process, how would this change our answers?

Can we integrate GDP-at-risk in setting the CCyB?

A simple model based on Aikman, Bluwstein and Karmakar (2024)

- A quick summary of the model:
  - A New Keynesian-style semi-structural model with two-way feedback to a financial sector
  - There are 3 nonlinear constraints: ELB; bank capital; debt-service burdens
  - To estimate GDP-at-Risk, we simulate the model a large number of times using an agnostic empirical distribution of shocks. The observable state variables tell us how close the economy is to “tipping point” thresholds, driving GaR
  - The constraints interact: eg as you get closer to the ELB, the economy experiences more credit crunch episodes and vice versa

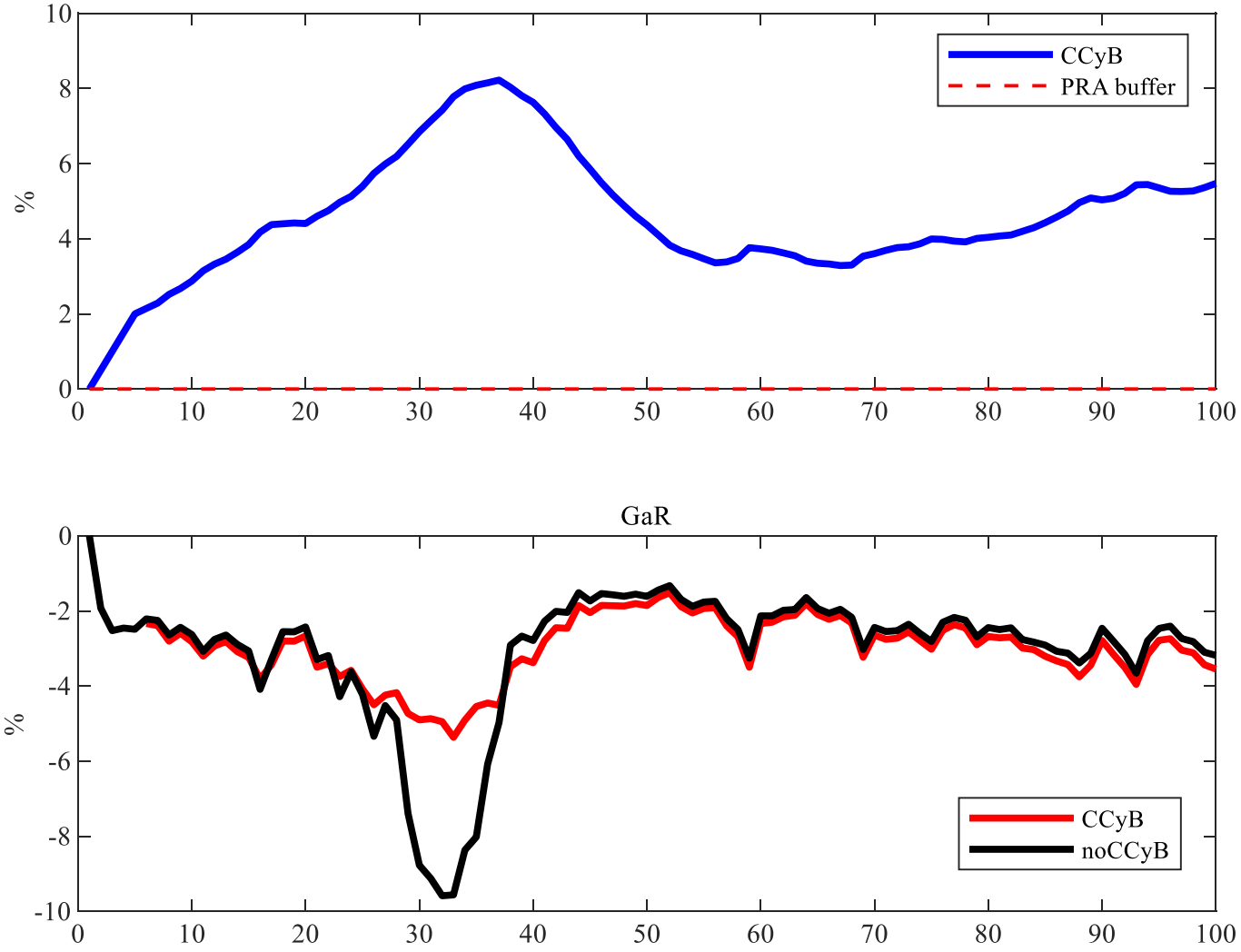
Can we integrate GDP-at-risk in setting the CCyB?

A simple model based on Aikman, Bluwstein and Karmakar (2024)

- We've integrated a rule like this for the CCyB in this model
- Increasing the CCyB creates more headroom vis-à-vis the debt deleveraging threshold (provided the CCyB is released when needed)
- Increasing the CCyB also shifts the bank credit supply curve inwards, raising loan spreads and reducing GDP all else equal
  - These costs come mainly from the change in capital ratios

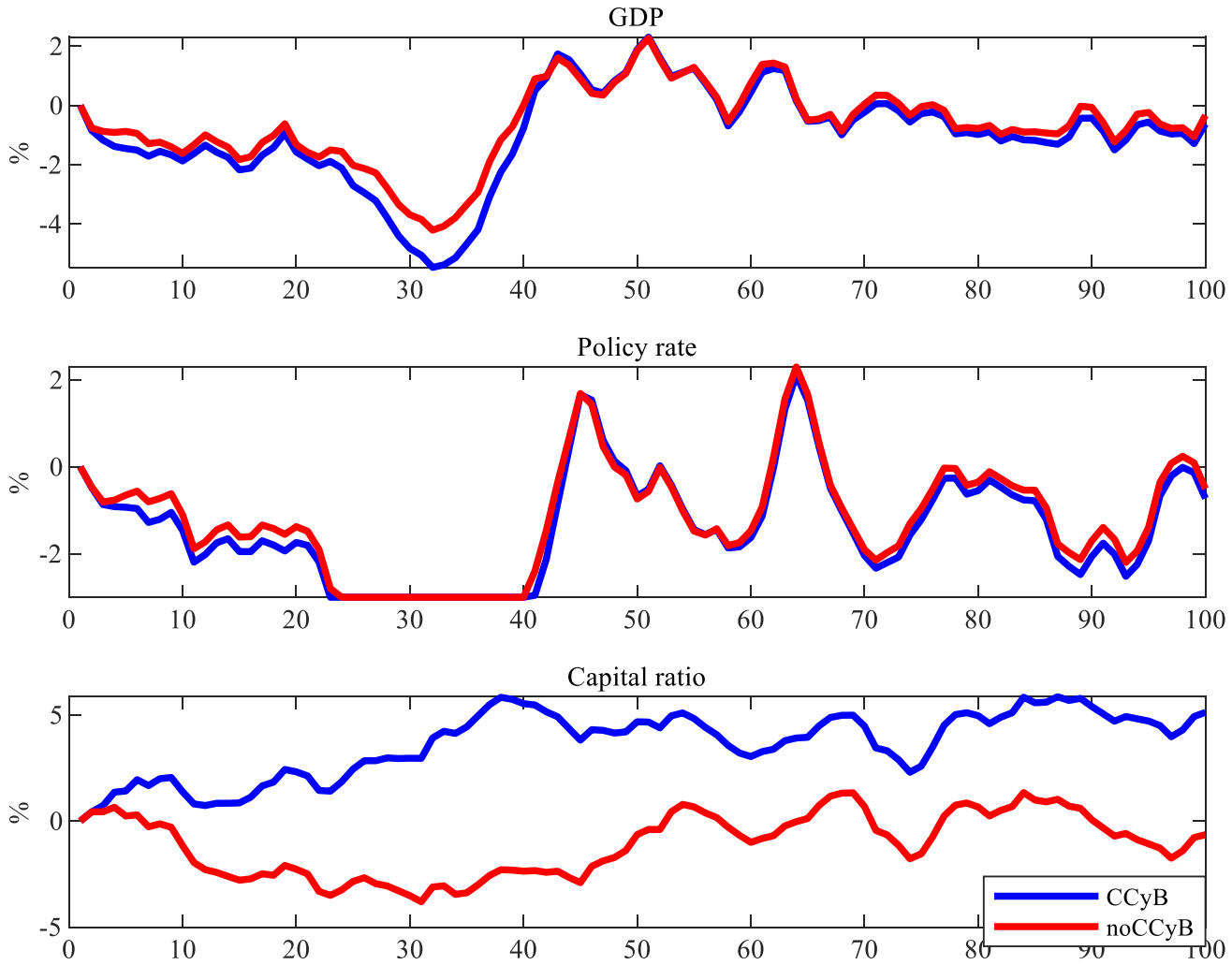
Can we integrate GDP-at-risk in setting the CCyB?

CCyB reduces risk



Can we integrate GDP-at-risk in setting the CCyB?

But this can come with GDP costs (especially at the ELB)



Conclusion

- It’s vital that we research and analysis on the objectives of macroprudential policy
- In this respect, it’s encouraging to see the progress being made on GDP-at-risk, mainly at policy institutions
  - Despite appearances in some FSRs, for the time being this (appropriately) remains a research topic
- My results corroborate the finding that tighter financial conditions lead to a deterioration in GDP-at-risk, with no substantial impact on upper quantiles of the distribution
- I also find that when credit markets seriously overheat, the entire distribution of predicted future growth shifts leftwards, with some evidence of bimodality

Conclusion

- I suggest three areas warrant attention by researchers and policy advisors:

- What do the empirical results here imply for macroeconomic policy? Does a leftward lurch in the growth distribution warrant a monetary policy response?
- Is ‘finance-at-risk’ a better target for macroprudential policy than GDP-at-risk?
- Can we integrate GDP-at-risk in the setting of macropru tools like the CCyB? If we do, what should be the balance between neutral settings and GaR sensitivity?

Appendix

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- Adrian, Tobias, et al. "The term structure of growth-at-risk." American Economic Journal: Macroeconomics 14.3 (2022): 283-323
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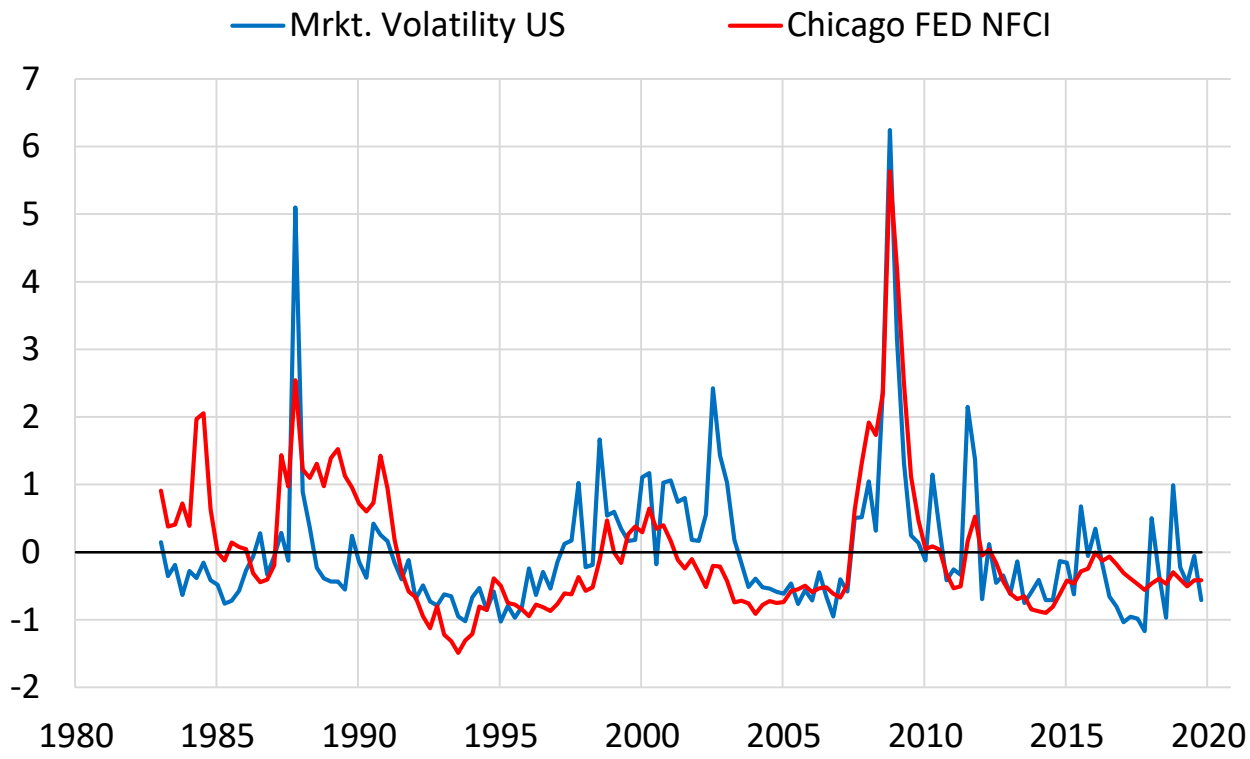
Empirical application – Model (II)

- **Step 2** predicted distribution of GDP growth:

$$\hat{f}(y) = \frac{1}{\tau h} \sum_{j=1}^{\tau} K\left(\frac{y - y_j}{h}\right)$$

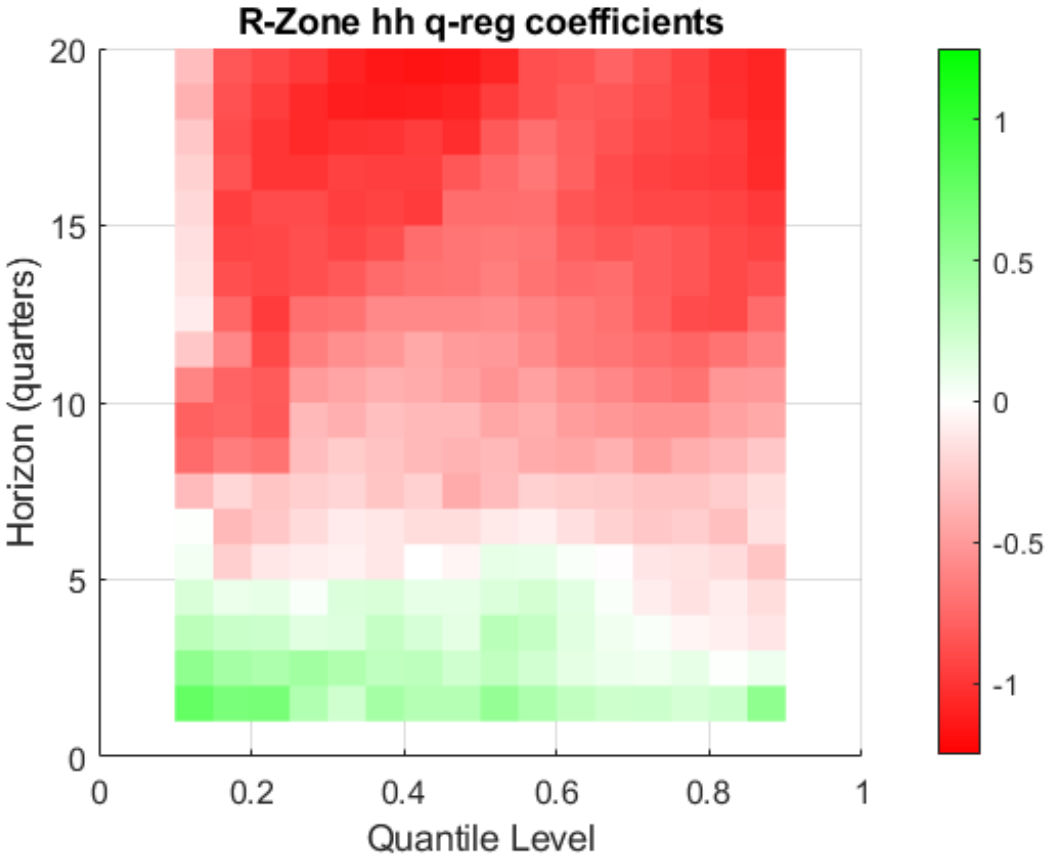
- Where:
  - $f(y)$ is the density f at a given point y
  - $K(\bullet)$ is the gaussian kernel
  - h is a smoothing parameter called bandwidth
  - τ is the total number of quantiles estimated in step 1

Empirical application
Market volatility US vs Chicago Fed's NFCI

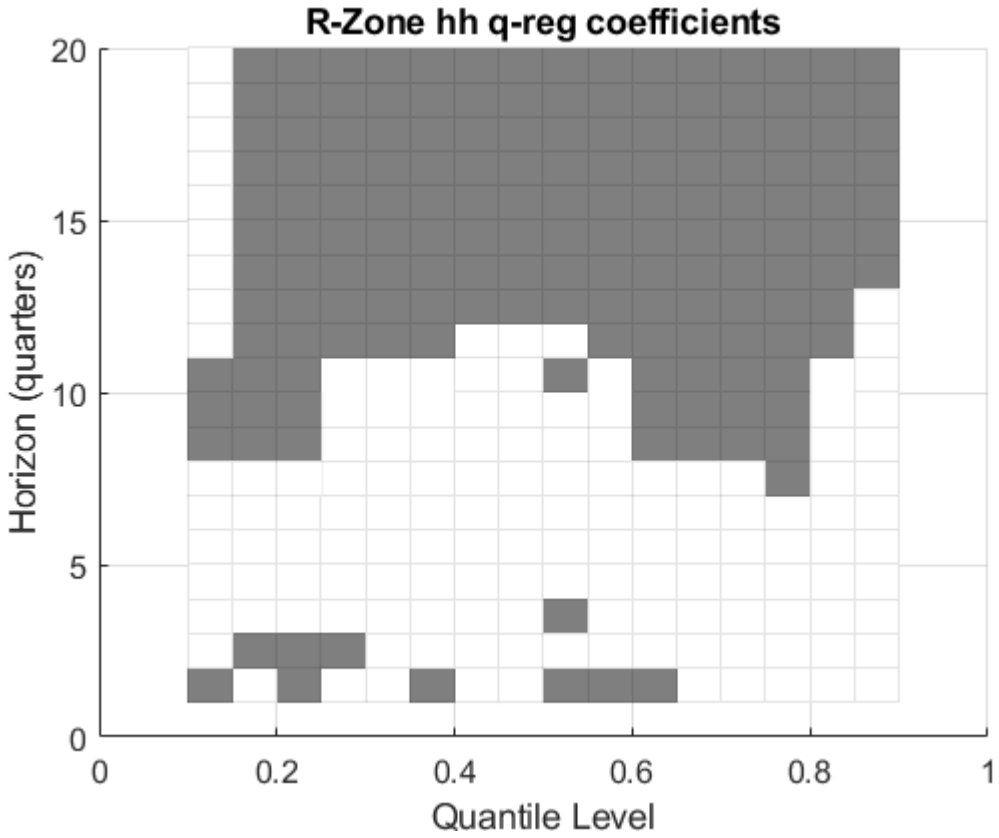


Source: FRED, Bloomberg and authors' own computations.
Latest date: Q4-2019
Notes: series have been standardized based on the observations in the period between Q1-1983 and Q4-2019. The correlation between the two series is 0.7.

Empirical application – Results
Household R-zone – significance of the coefficients



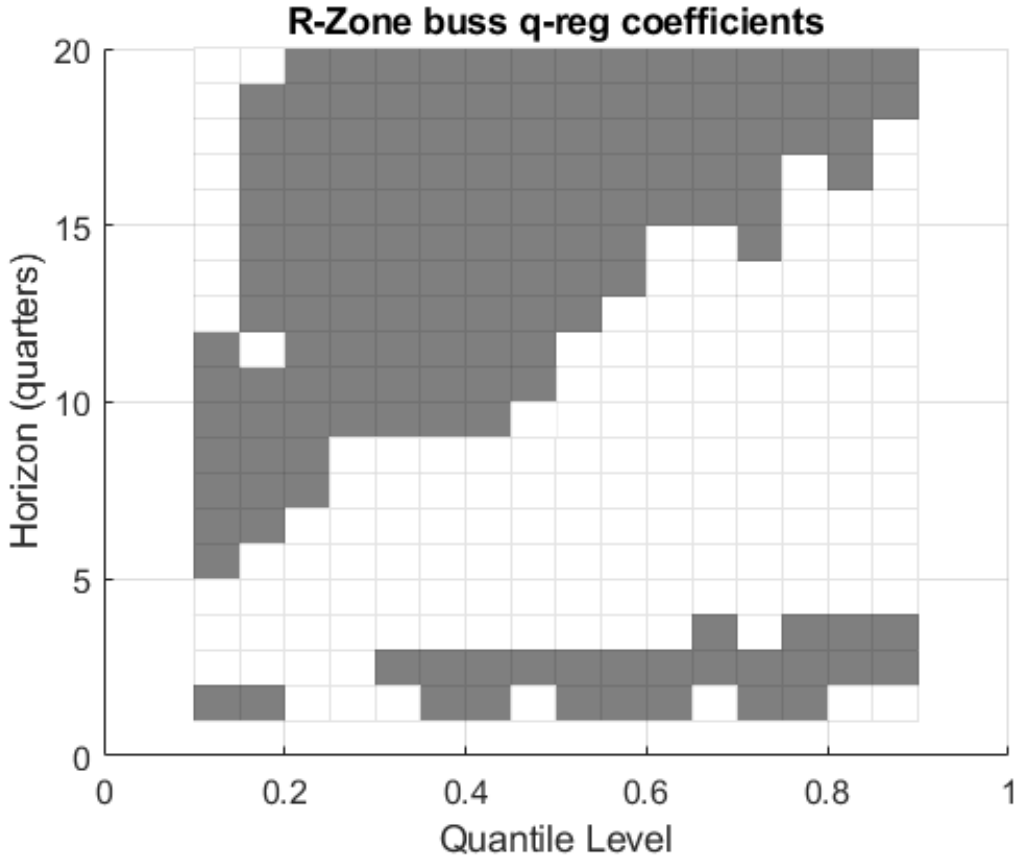
Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, y_{i,t} + \epsilon_{i,t+h}$



Source: author's own computations.
Notes: Grey cells indicate coefficients that are significant at the 10% level.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, y_{i,t} + \epsilon_{i,t+h}$

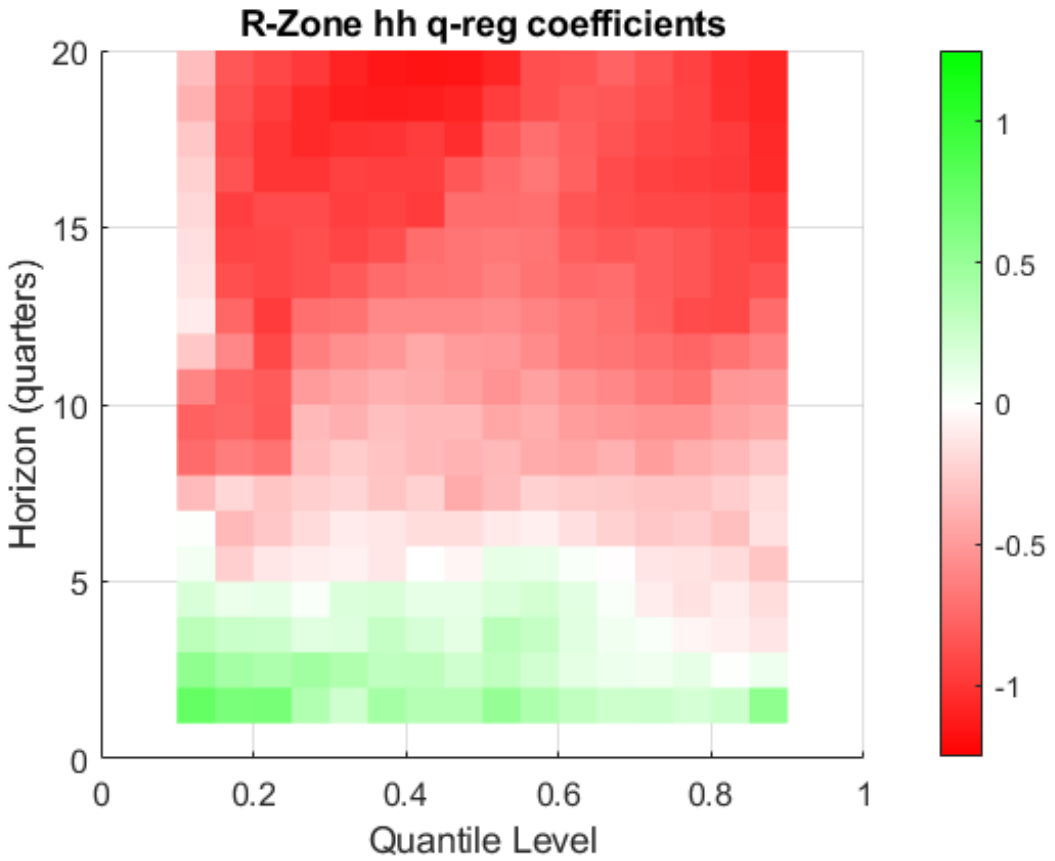
Empirical application – Results
Business R-zone – significance of the coefficients

Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} R\,zone^{bus}{}_{i,t} + \beta_{\tau,2}^{h}\, y_{i,t} + \epsilon_{i,t+h}$

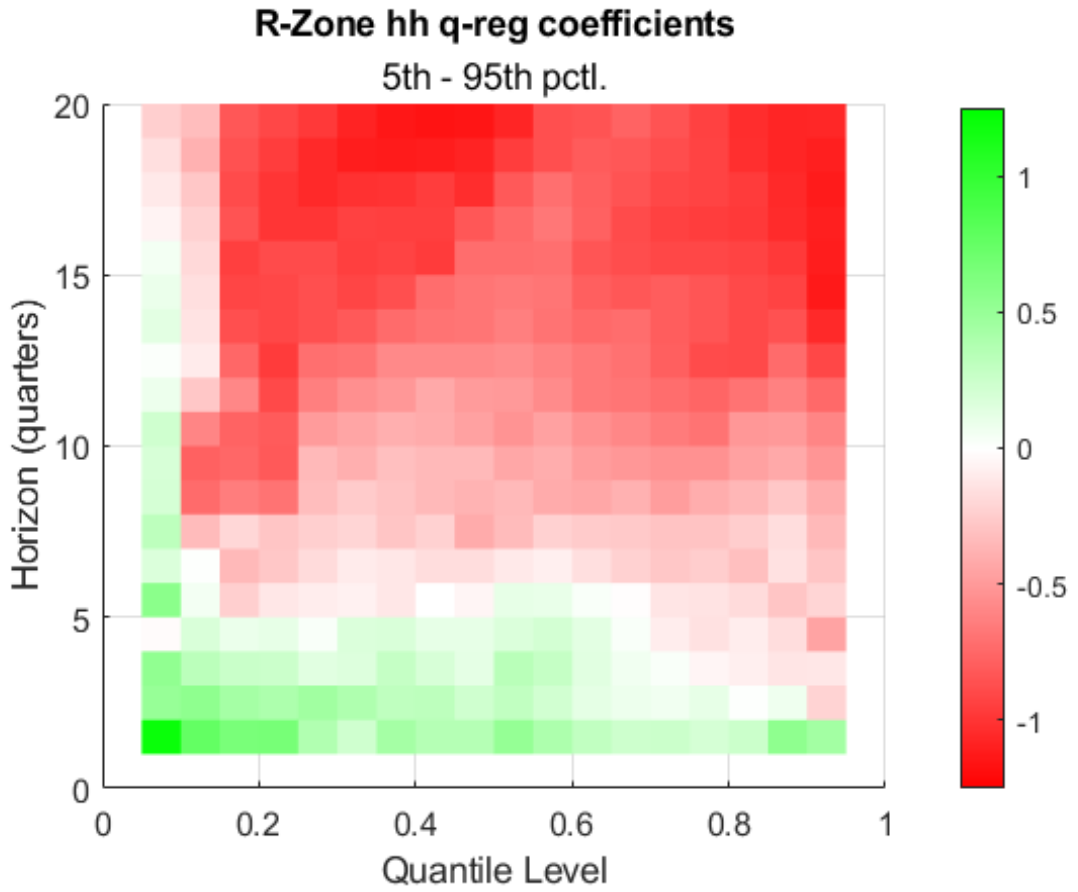


Source: author's own computations.
Notes: Grey cells indicate coefficients that are significant at the 10% level.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} R\,zone^{bus}{}_{i,t} + \beta_{\tau,2}^{h}\, y_{i,t} + \epsilon_{i,t+h}$

Empirical application – Results
Household R-zone – 10th-90th vs 5th-95th



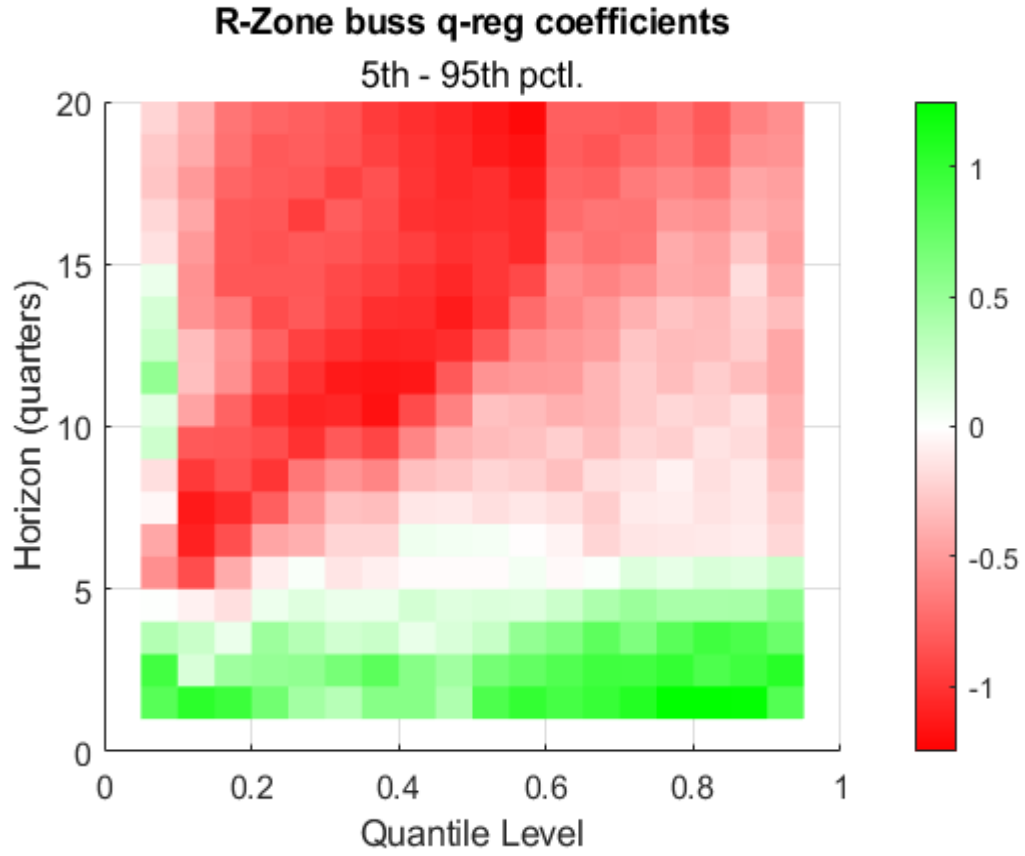
Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, y_{i,t} + \epsilon_{i,t+h}$



Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, y_{i,t} + \epsilon_{i,t+h}$

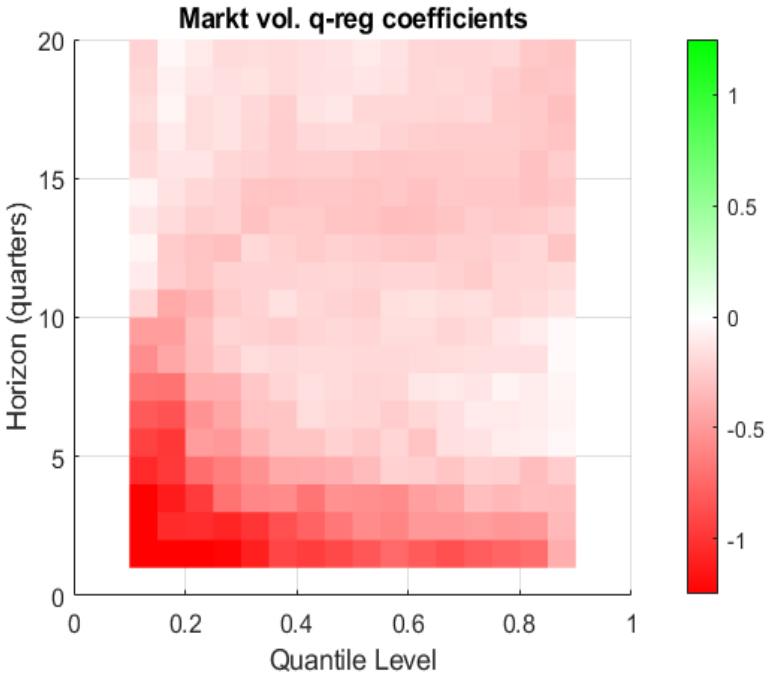
Empirical application – Results
Business R-zone – 10th-90th vs 5th-95th

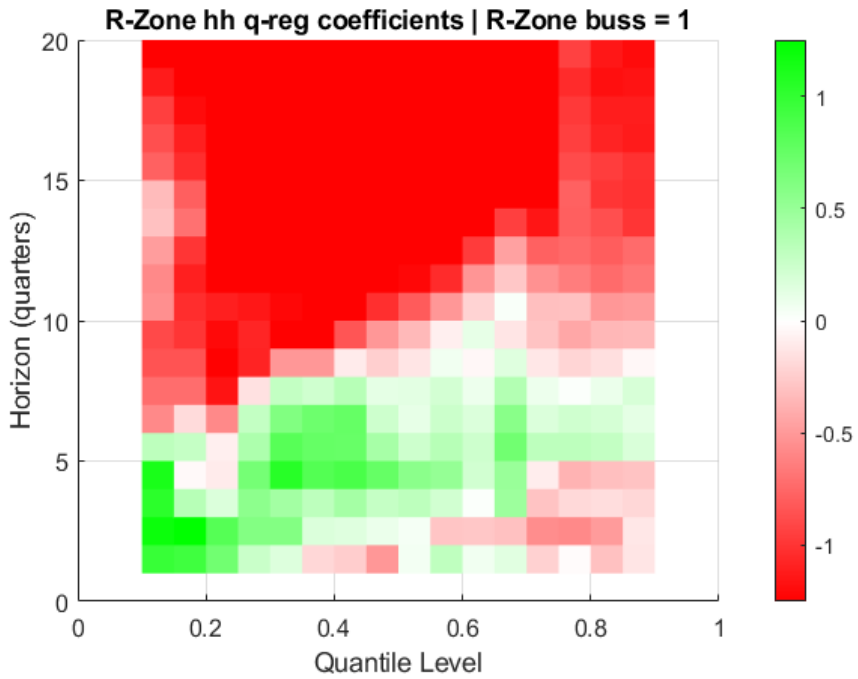
Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i\,,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,\mathbf{1}}^{h}\, R\ zone^{buss}{}_{i\,,t} + \beta_{\tau,\mathbf{2}}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$

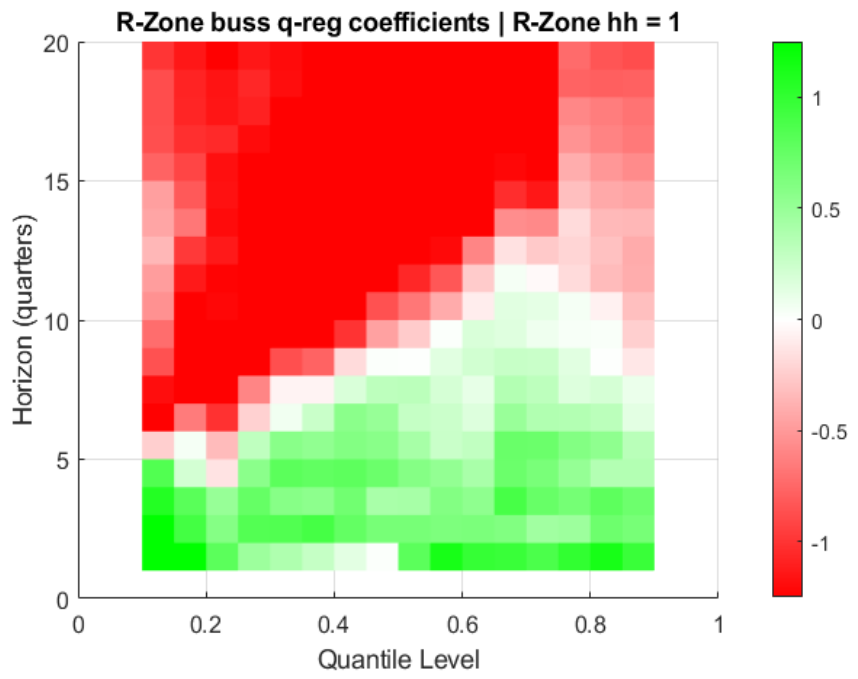


Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i\,,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,\mathbf{1}}^{h}\, R\ zone^{buss}{}_{i\,,t} + \beta_{\tau,\mathbf{2}}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$

Empirical application – Results
Market volatility, household and business R-zones combined

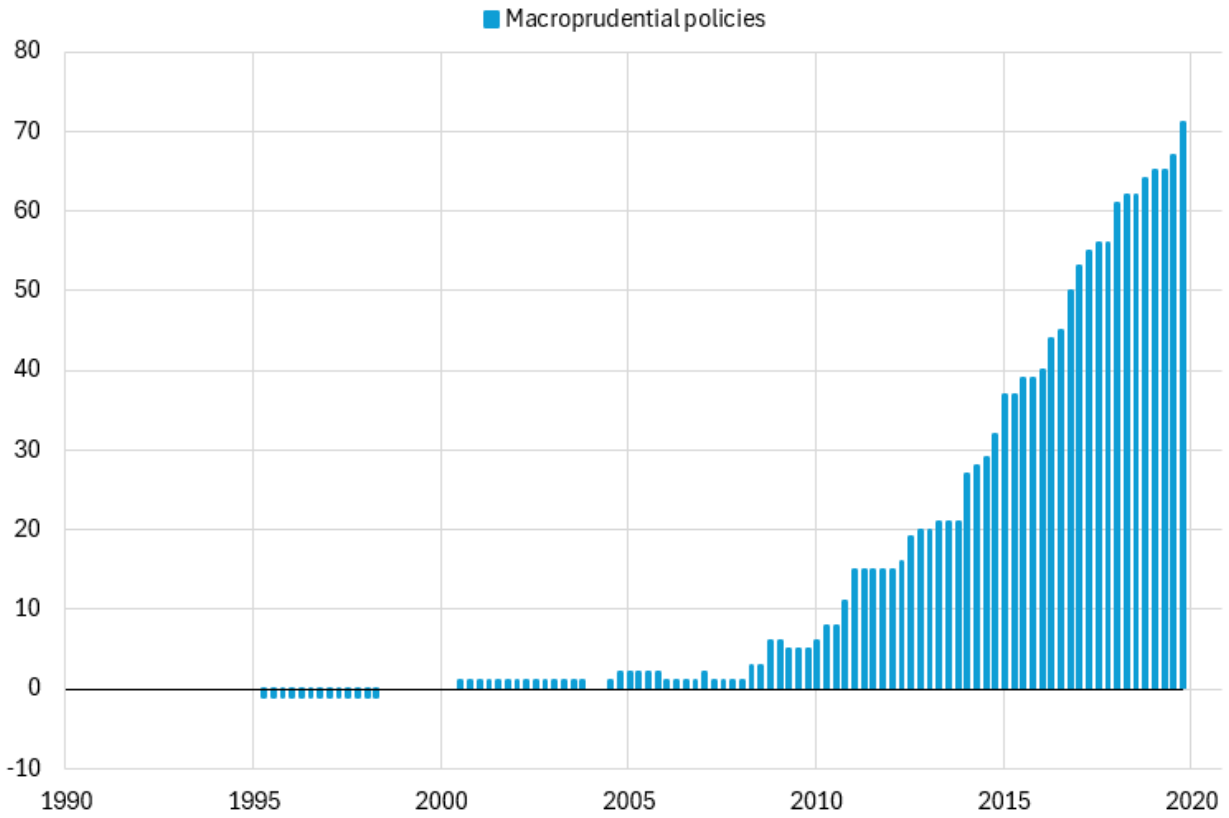






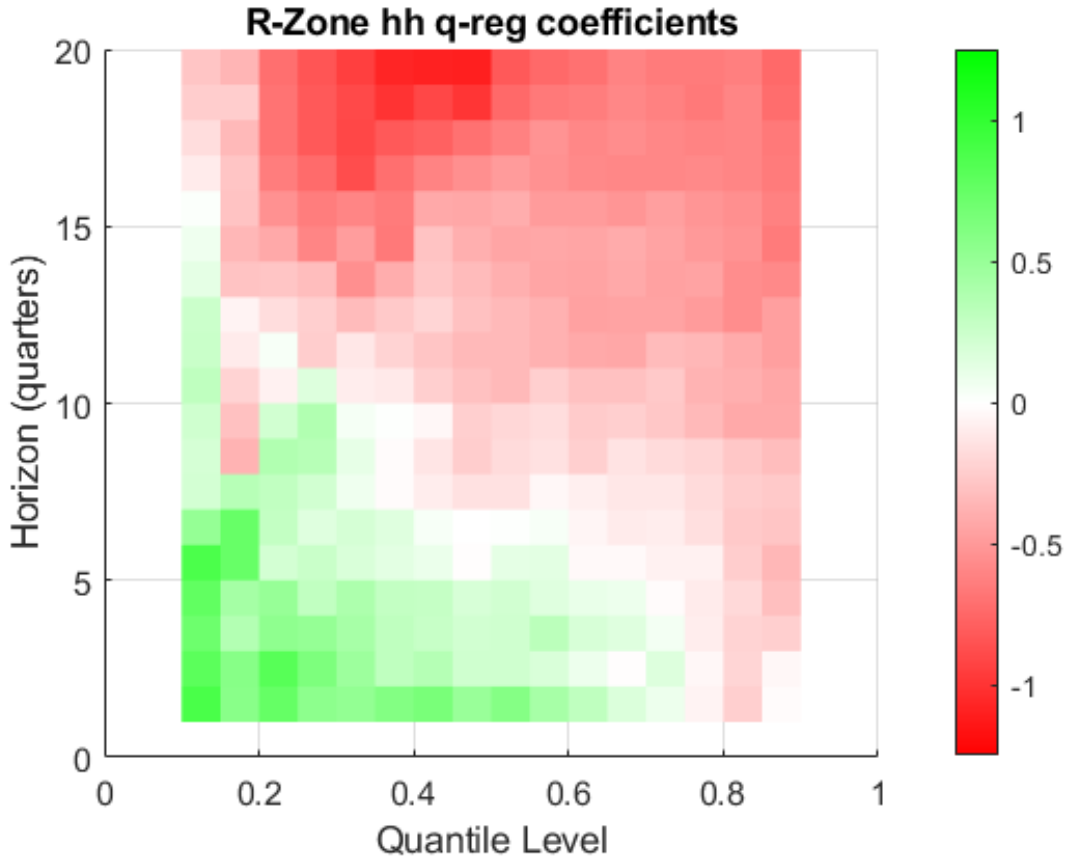
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} R\ zone^{both}{}_{i,t} + \beta_{\tau,2}^{h} R\ zone^{hh}{}_{i,t} + \beta_{\tau,3}^{h} R\ zone^{buss}{}_{i,t} + \beta_{\tau,4}^{h}\ mrk\_vol_{i,t} + \beta_{\tau,5}^{h}\ y_{i,t} + \epsilon_{i,t+h}$
Source: author's own computations.
Notes: Chart on the left exhibits $\beta_{\tau,4}^{h}$; chart in the middle exhibits the sum of $\beta_{\tau,1}^{h}$ and $\beta_{\tau,2}^{h}$; chart on the right exhibits the sum of $\beta_{\tau,1}^{h}$ and $\beta_{\tau,3}^{h}$
Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.

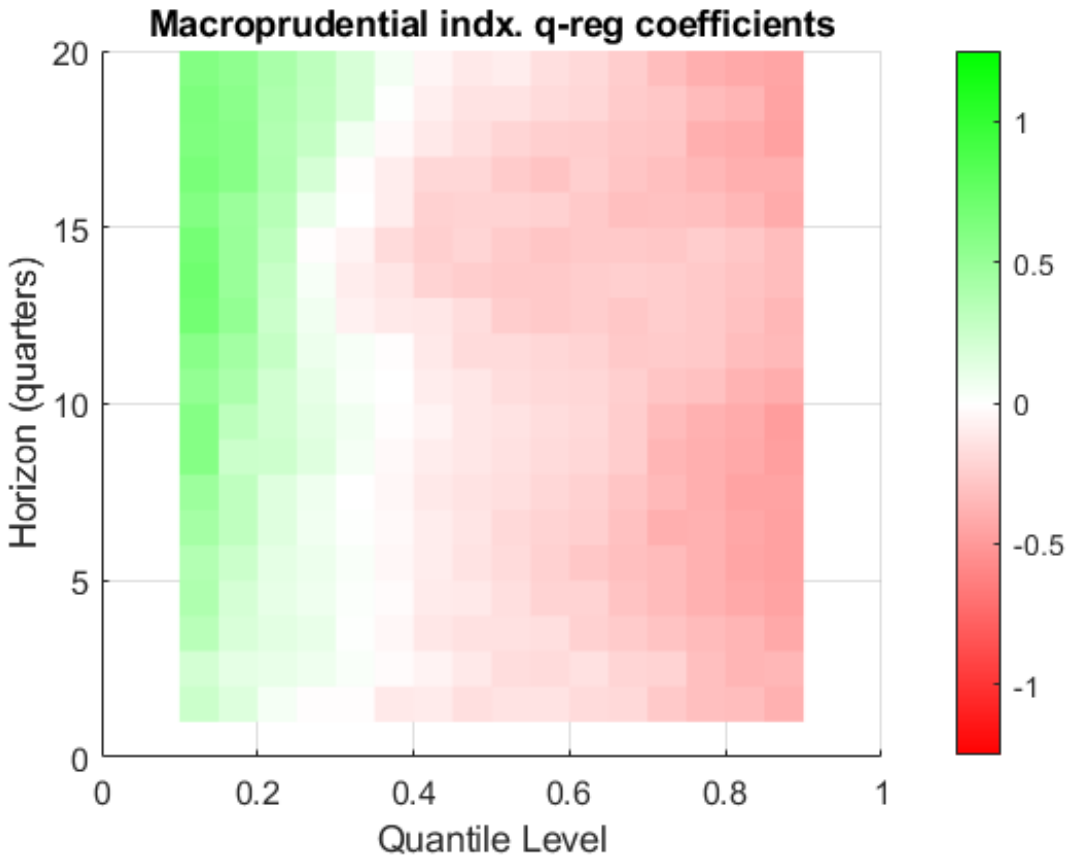
Empirical application – Integrated Macroprudential Policy (iMaPP) (II)



Latest observation: Q4-2019
Notes: The following countries are considered: US, UK, DE, FR, IT, ES, SWE, CA, AUS.
The macroprudential index is the cumulative across all countries and the 12 macroprudential tools described in the previous slide.

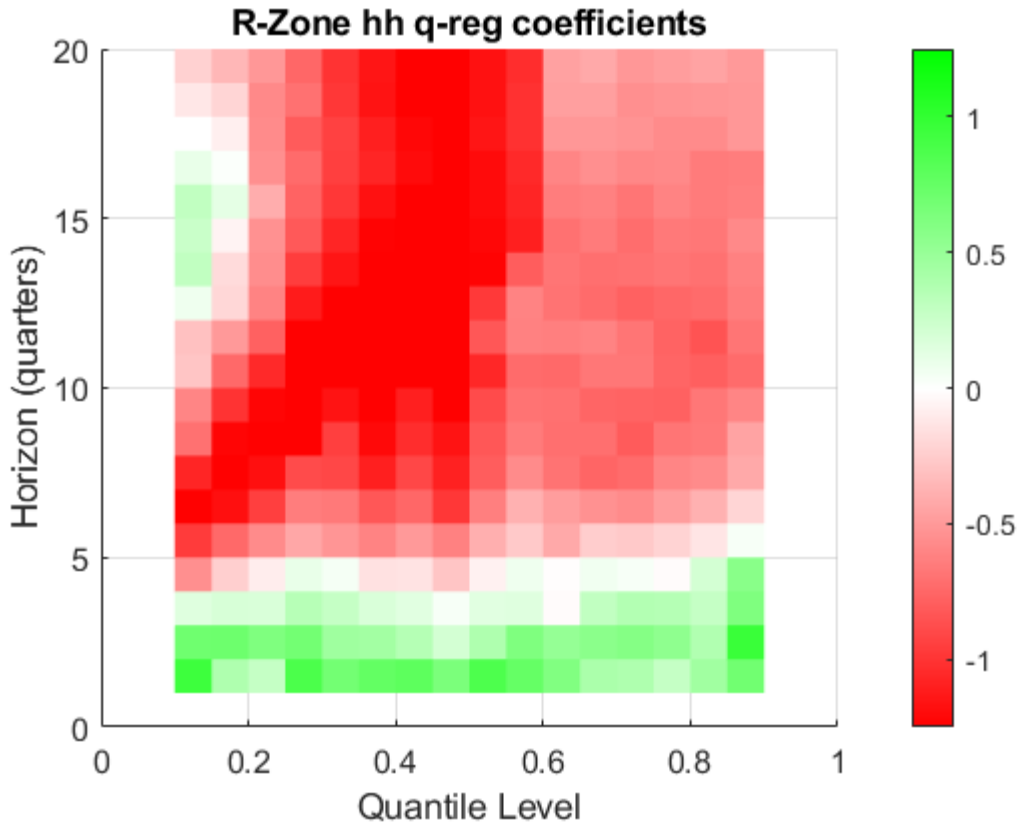
Empirical application – Results
Household R-zone and Macroprudential policy index (all 17 instruments)

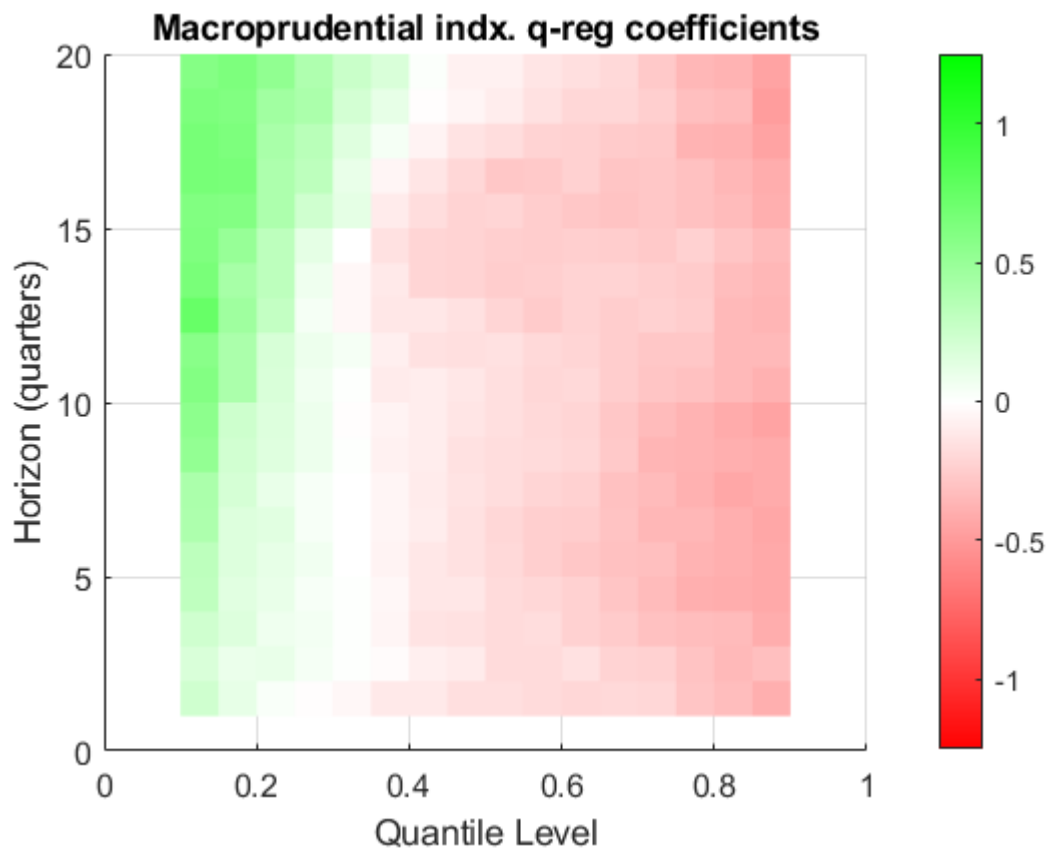




The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h} \, macroprud\_indx_{i,t} + \beta_{\tau,3}^{h} \, y_{i,t} + \epsilon_{i,t+h}$
Source: author's own computations.
Notes: Chart on the lhs exhibits $\beta_{\tau,1}^{h}$; chart on the rhs exhibits $\beta_{\tau,2}^{h}$.
Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Right hand side chart represent the effect of 1 standard deviation shock to the macroprudential policy index on the dependent variable. Macroprudential index has been constructed using all the 17 macroprudential instruments.

Empirical application – Results
Business R-zone and Macroprudential policy index (all 17 instruments)





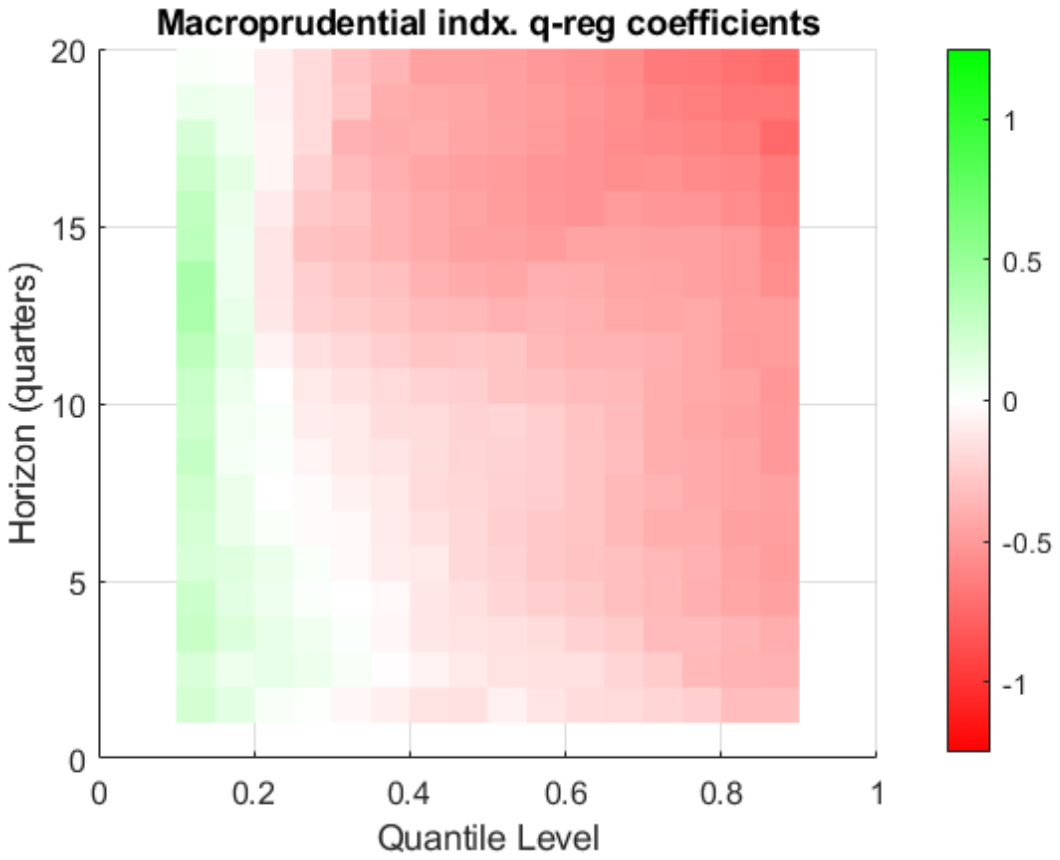
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} \, R\,zone^{buss}{}_{i,t} + \beta_{\tau,2}^{h} \, macroprud\_indx_{i,t} + \beta_{\tau,\mathbf{3}}^{h} \, y_{i,t} + \epsilon_{i,t+h}$

Source: author's own computations.

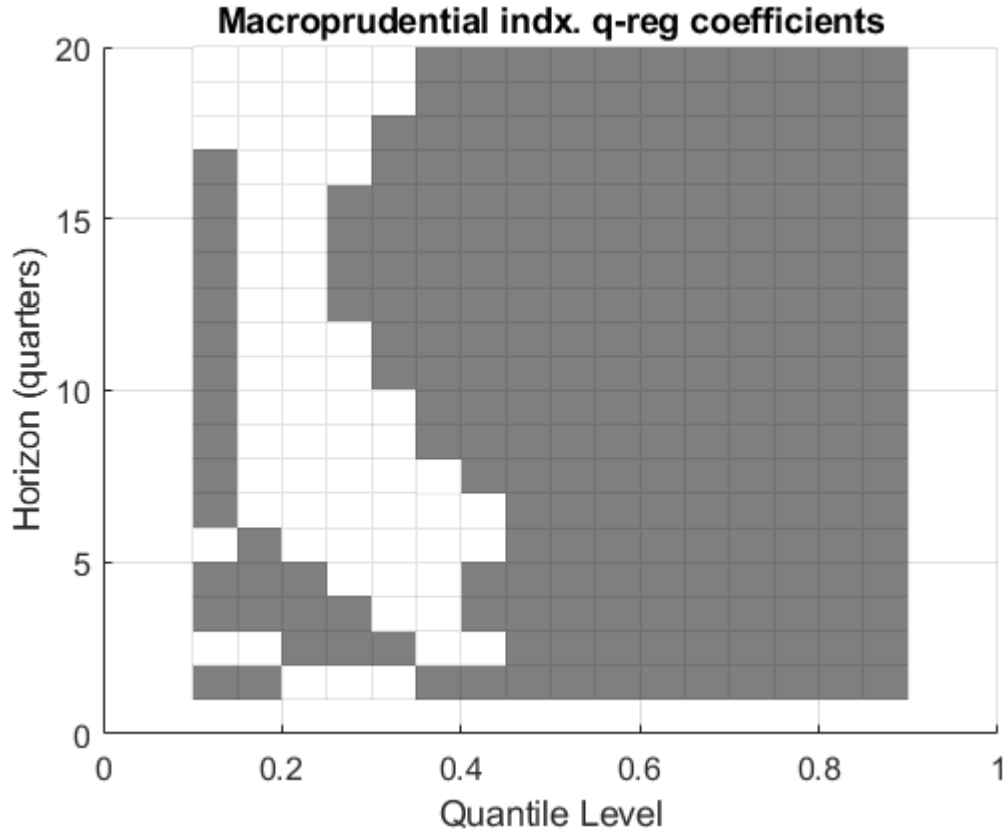
Notes: Chart on the lhs exhibits $\beta_{\tau,1}^{h}$; chart on the rhs exhibits $\beta_{\tau,2}^{h}$.

Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red. Right hand side chart represent the effect of 1 standard deviation shock to the macroprudential policy index on the dependent variable. Macroprudential index has been constructed using all the 17 macroprudential instruments.

Empirical application – Results
Household R-zone & Macroprud. policy index – significance of coefficients



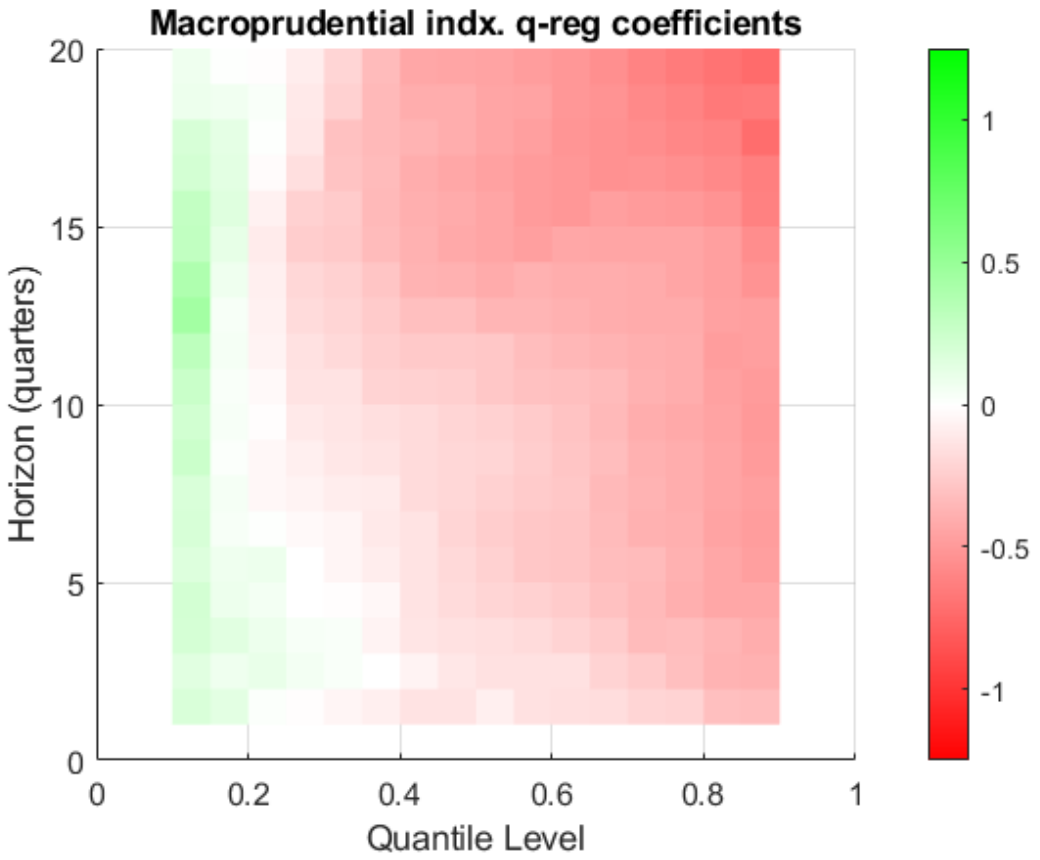
Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h}\ macroprud\_indx_{i,t} + \beta_{\tau,3}^{h}\ y_{i,t} + \epsilon_{i,t+h}$



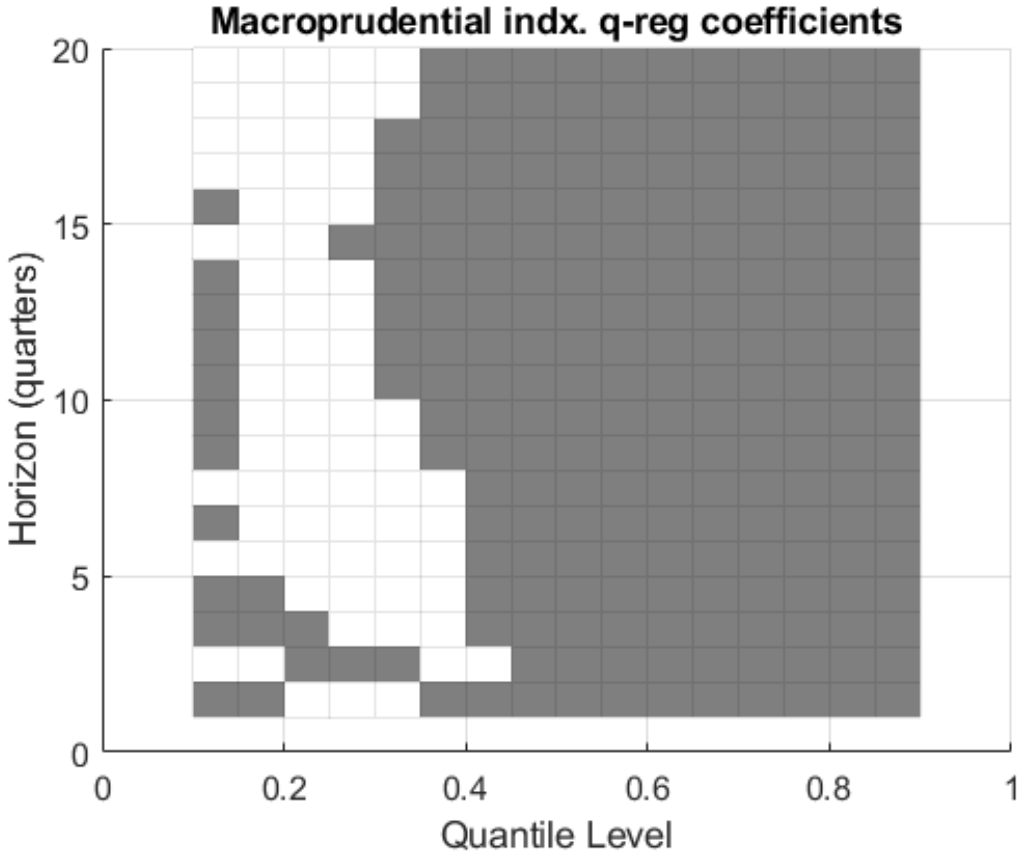
Source: author's own computations.
Notes: Grey cells indicate coefficients that are significant at the 10% level.
The model is: $y_{i,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h} R\,zone^{hh}{}_{i,t} + \beta_{\tau,2}^{h}\ macroprud\_indx_{i,t} + \beta_{\tau,3}^{h}\ y_{i,t} + \epsilon_{i,t+h}$

Empirical application – Results

Business R-zone & Macroprud. policy index – significance of coefficients



Source: author's own computations.
Notes: Colour represent the value of the quantile regression coefficient. Higher positive values are associated with green and lower negative values are associated with red.
The model is: $y_{i,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\, R\, zone^{bus}{}_{i,t} + \beta_{\tau,2}^{h}\ macroprud\_indx_{\,i,\,t} + \beta_{\tau,3}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$



Source: author's own computations.
Notes: Grey cells indicate coefficients that are significant at the 10% level.
The model is: $y_{i,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\, R\, zone^{bus}{}_{i,t} + \beta_{\tau,2}^{h}\ macroprud\_indx_{\,i,\,t} + \beta_{\tau,3}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$

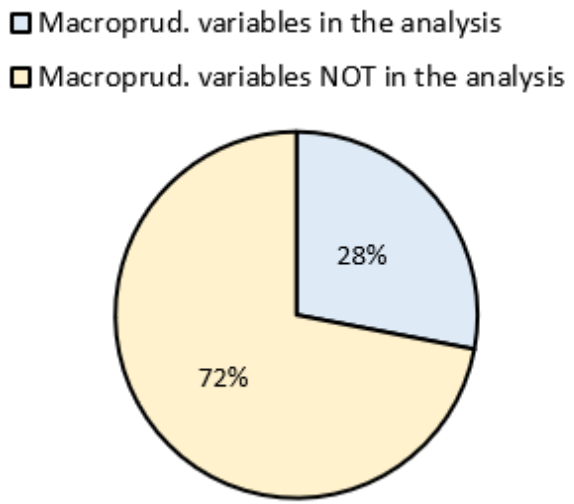
What advancements have been made in modelling GDP-at-risk?

Approaches to fitting the GDP distribution

- Chicana and Nivin (2021) and De Lorenzo et al (2022)?

Advancements in modelling growth at risk (III)
GaR in the context of Macroprudential policy

- Main takeaways:
  - Sanchez and Röhn (2016) and Galan and Rodriguez-Moreno (2020) found that macroprudential policies lower average growth but decreases tail risk
  - On the other hand, Fernandez-Gallardo et al. (2023) discovered that macroprudential measures have near zero effect on the median growth, but they reduce the variance by boosting the left tail and reducing the right one simultaneously
  - Franta and Gambacorta (2020) observed that the behaviour of GDP distribution changes in response to different macroprudential measures, especially in the medium term
  - Lang et al. (2023) observed that both financial stress indicator (spreads and market volatility) and financial vulnerability indicator (credit and asset price imbalances) predict downside risk to GDP growth in the short term. However, only vulnerability indicators provide insights into medium-term risks.



Source: Škrinjarić (2024).
Notes: replication of panel A - figure 1 of the paper (page 7). A total of 46 papers in the period between 2015 and 2023 is considered.

Empirical application – Model (I)

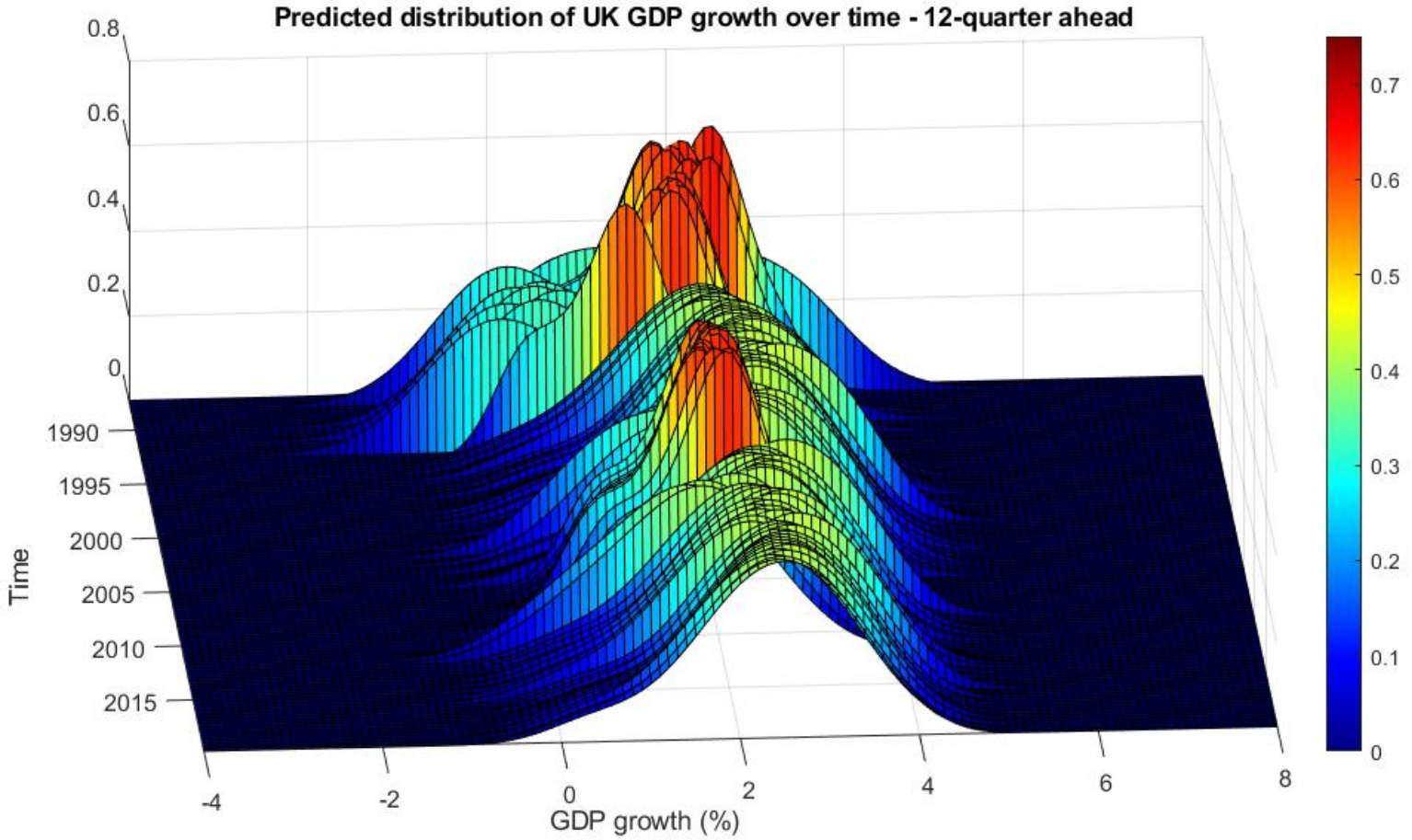
- **Step 1** panel quantile regression:

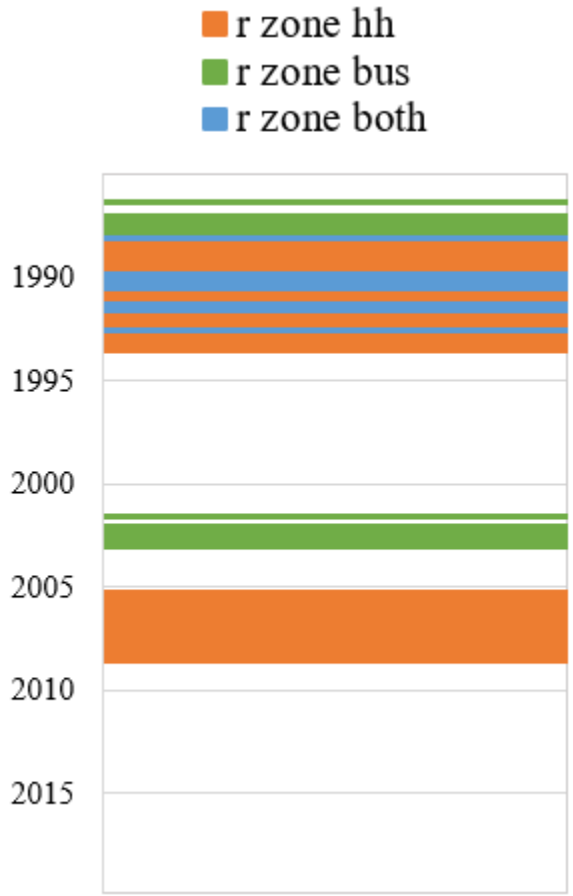
$$y_{i\,,\,t+h} = \alpha_{\tau}^{h} + \beta_{\tau,1}^{h}\ x_{i\,,t} + \beta_{\tau,2}^{h}\ y_{i,\,t} + \epsilon_{i,\,t+h}$$

- Where:
  - τ is the quantile of interest and h is the horizon of interest
  - $y_{i\,,\,t+h}$ is the annualized log-difference between the current level of real GDP and the level of real GDP growth h quarters ahead for country i
  - $x_{i\,,t}$ is a measure of financial conditions or macroprudential risk for country i
  - $y_{i,\,t}$ is the annualized log-difference between the current level of real GDP and the level of real GDP growth from the previous quarter for country i

- **Step 2** estimate the predicted distribution of real GDP growth using a gaussian Kernel density estimation

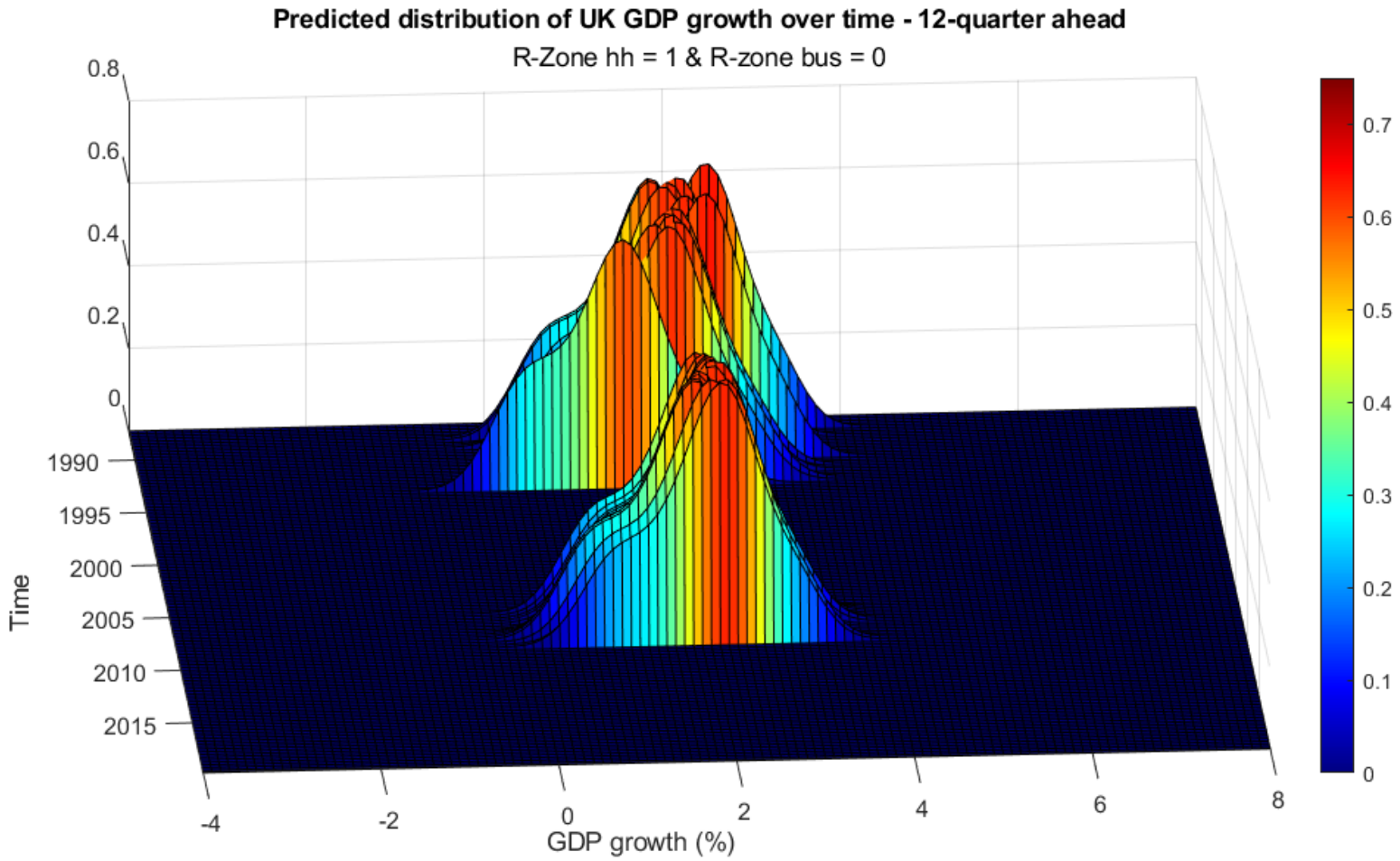
Empirical application – Results
Predicted distribution –Household and business R-zones combined (II)

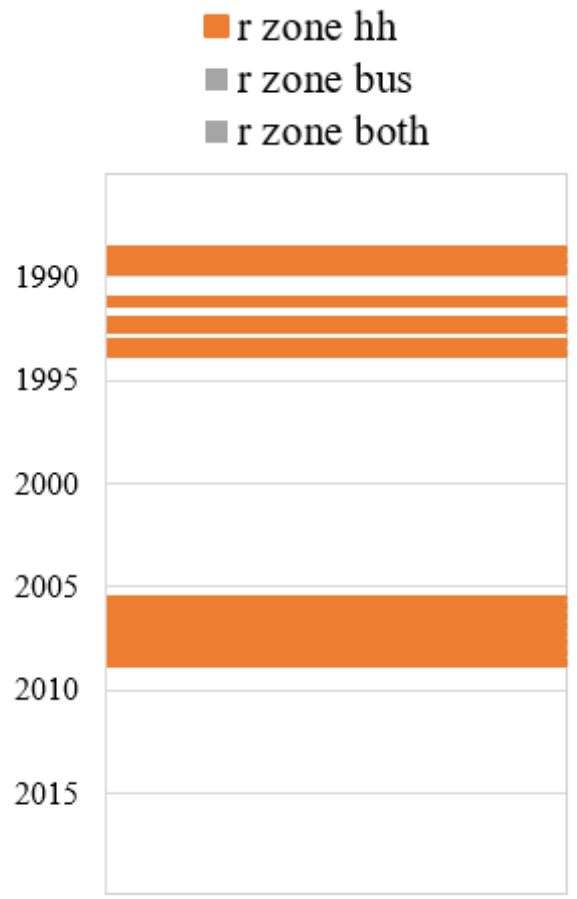




Latest observation: Q4-2019
Notes: Time variable denotes the period for which outcome is forecasted, not the date when the prediction was generated.
(lhs) annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables. (rhs) The assignment of household (business) thresholds are based on the distribution of household (business) credit and house (equity) price growth in our full panel dataset and, thus, are the same for all 9 countries in the sample.

Empirical application – Results
Predicted distribution –Household and business R-zones combined (III)

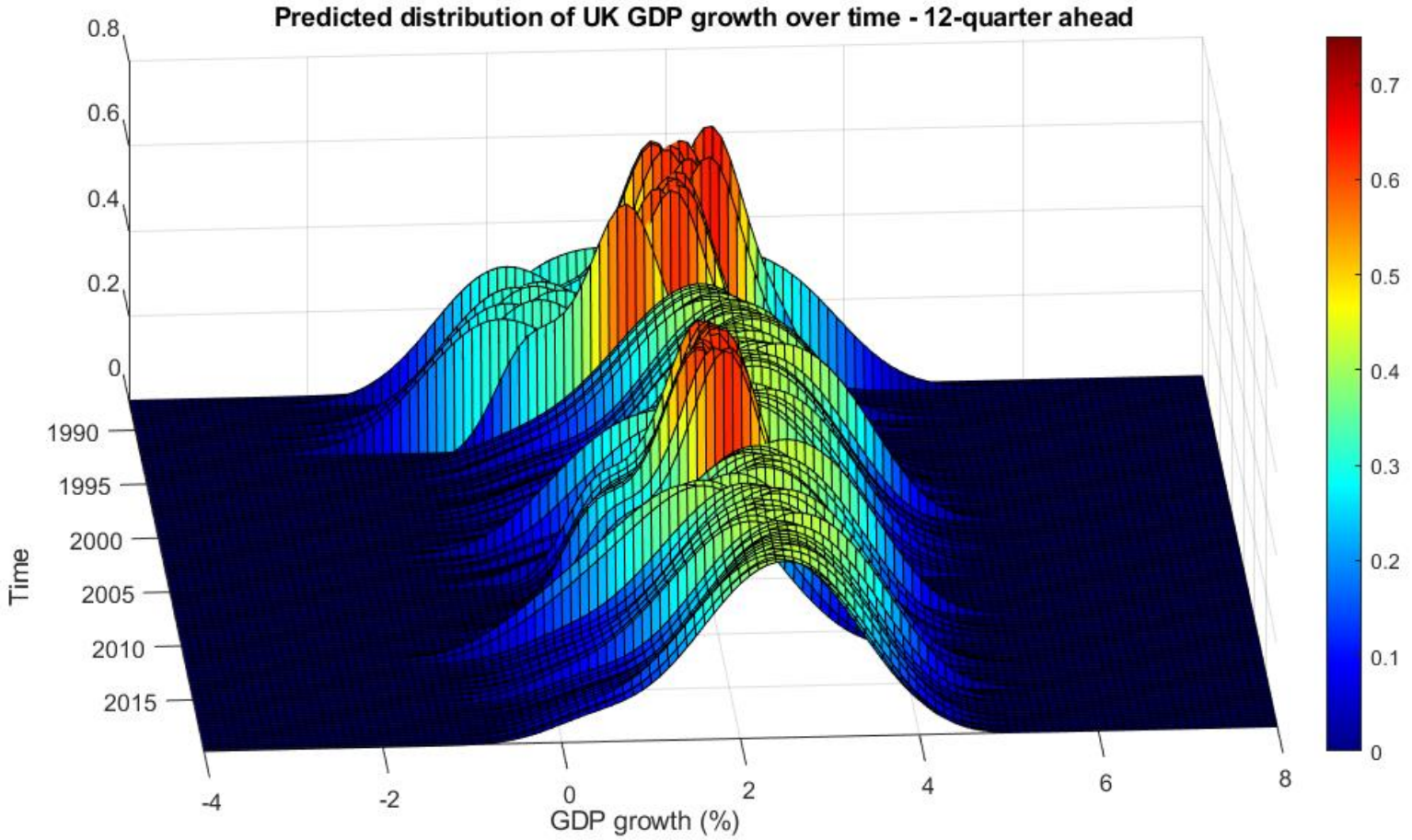


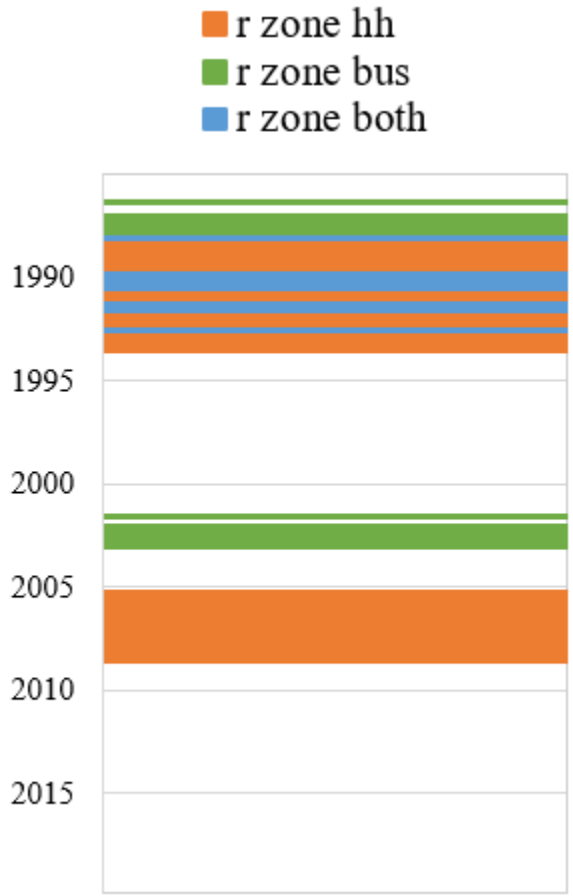


Latest observation: Q4-2019

Notes: Time variable denotes the period for which outcome is forecasted, not the date when the prediction was generated. Only the outcome for which R-zone household is active and R-zone business is not active are plotted. (lhs) annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables. (rhs) The assignment of household (business) thresholds are based on the distribution of household (business) credit and house (equity) price growth in our full panel dataset and, thus, are the same for all 9 countries in the sample.

Empirical application – Results
Predicted distribution –Household and business R-zones combined (II)

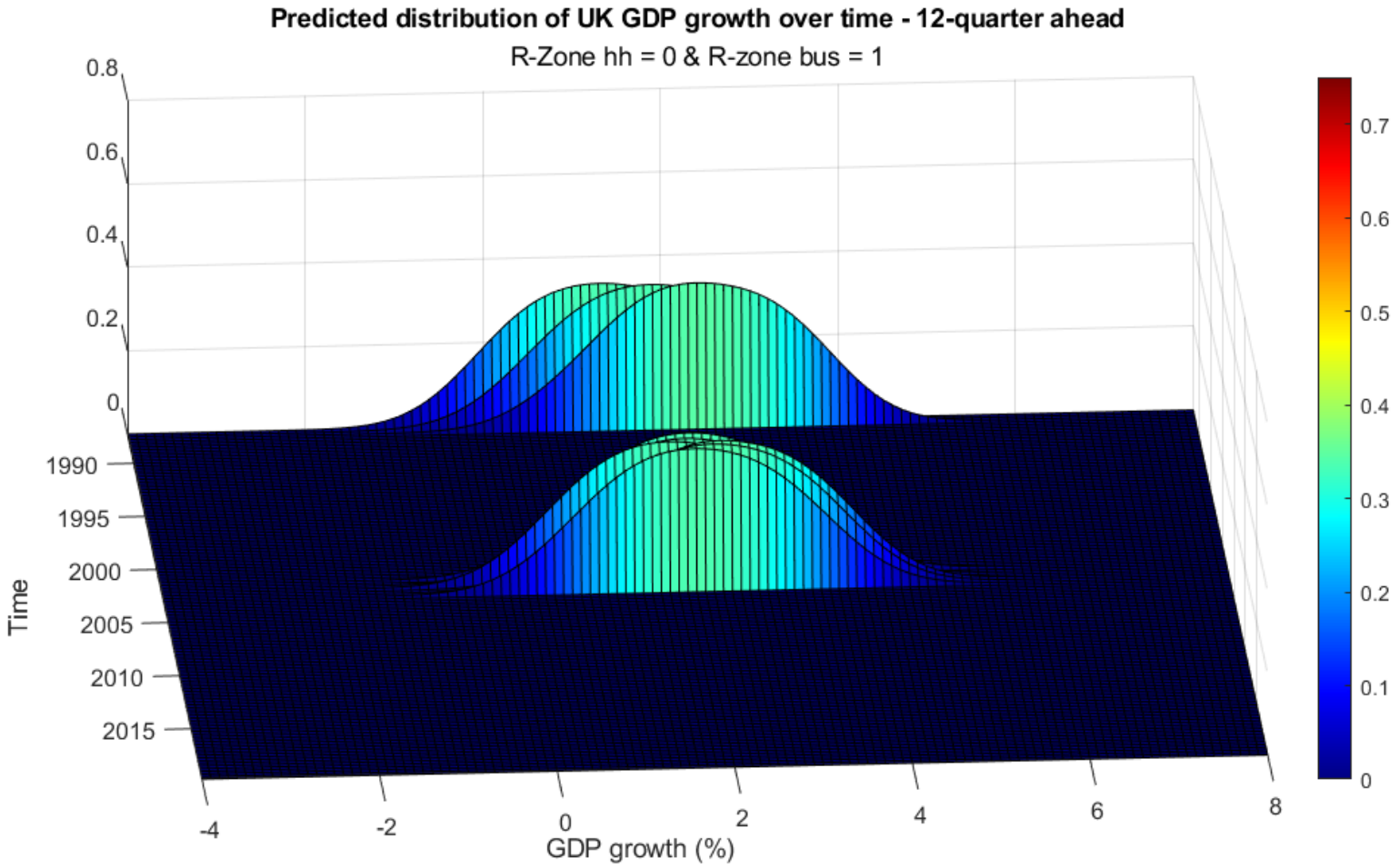


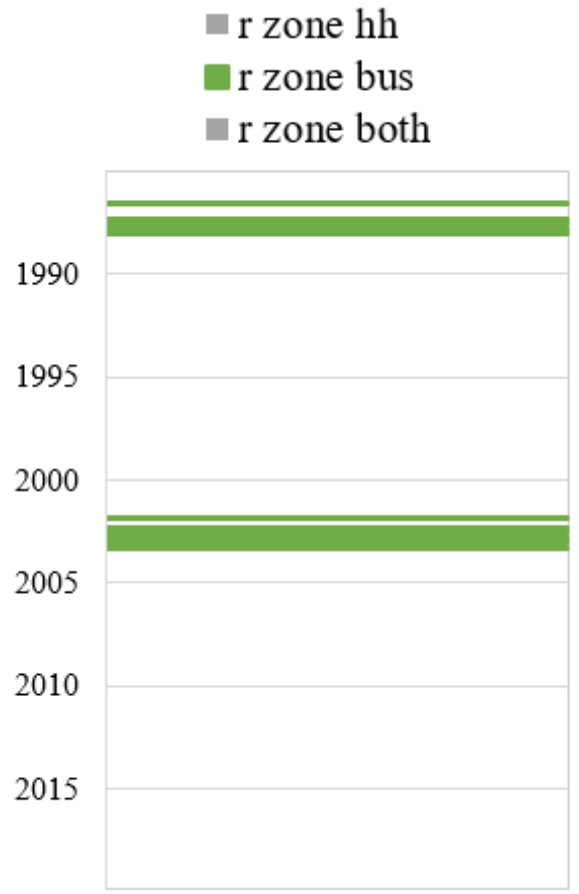


Latest observation: Q4-2019
Notes: Time variable denotes the period for which outcome is forecasted, not the date when the prediction was generated.
(lhs) annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables. (rhs) The assignment of household (business) thresholds are based on the distribution of household (business) credit and house (equity) price growth in our full panel dataset and, thus, are the same for all 9 countries in the sample.

Empirical application – Results

Predicted distribution –Household and business R-zones combined (V)

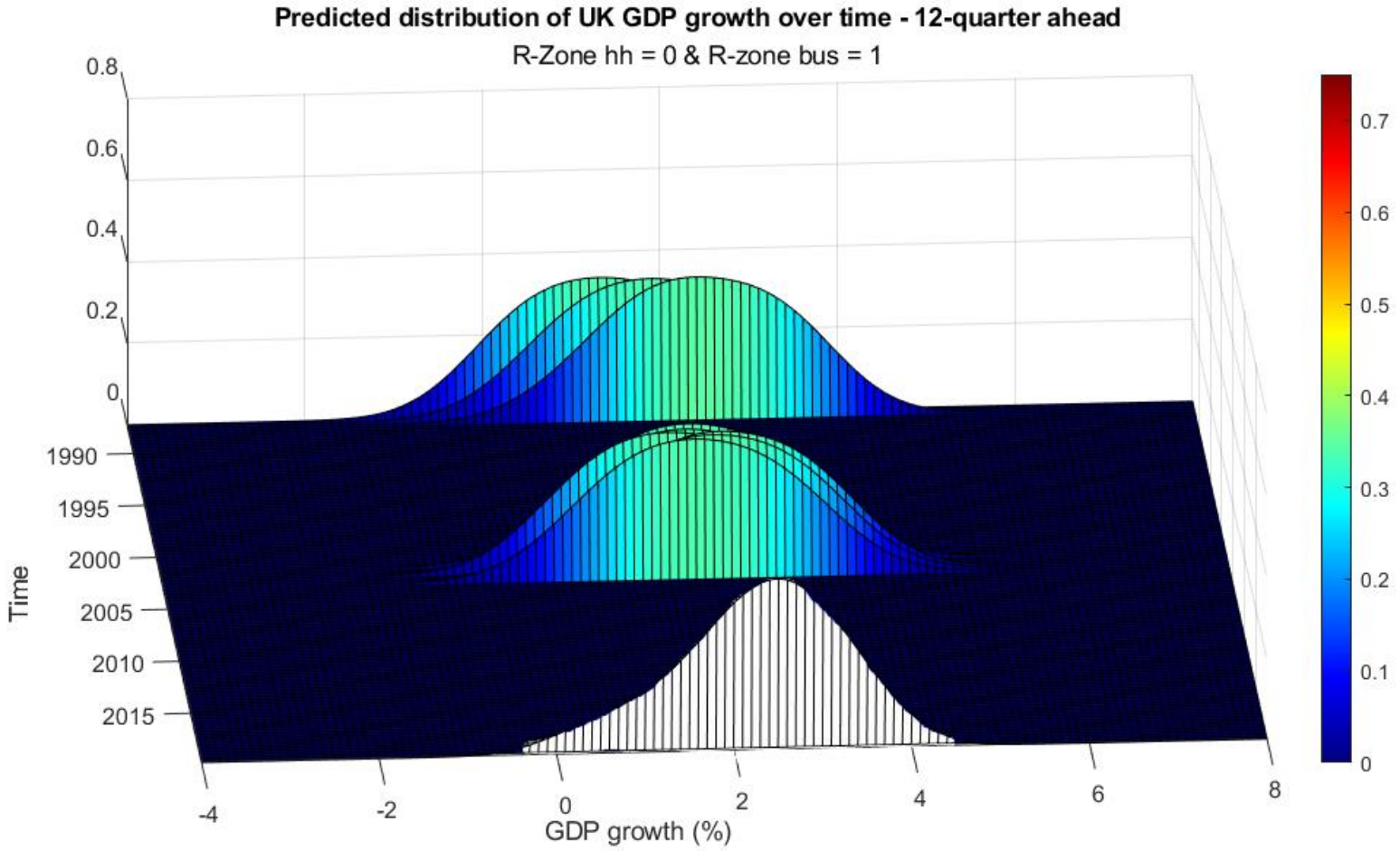


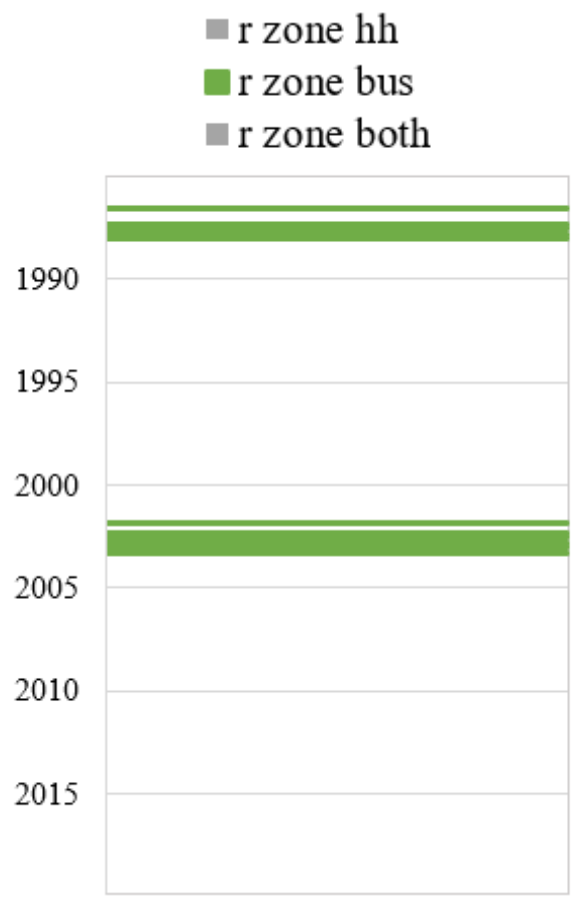


Latest observation: Q4-2019

Notes: Time variable denotes the period for which outcome is forecasted, not the date when the prediction was generated. Only the outcome for which R-zone household is active and R-zone business is not active are plotted. (lhs) annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables. (rhs) The assignment of household (business) thresholds are based on the distribution of household (business) credit and house (equity) price growth in our full panel dataset and, thus, are the same for all 9 countries in the sample.

Empirical application – Results
Predicted distribution –Household and business R-zones combined (VI)

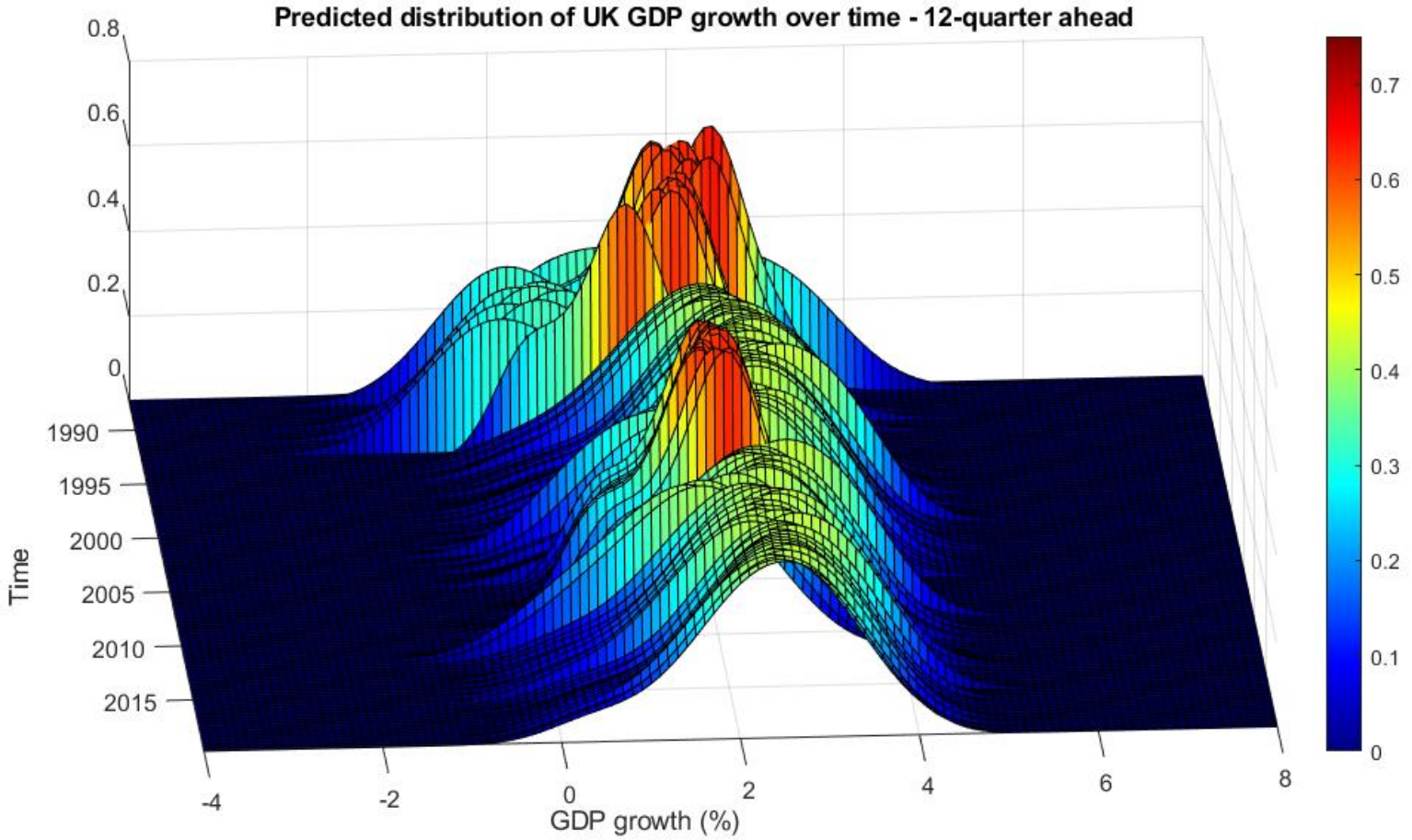


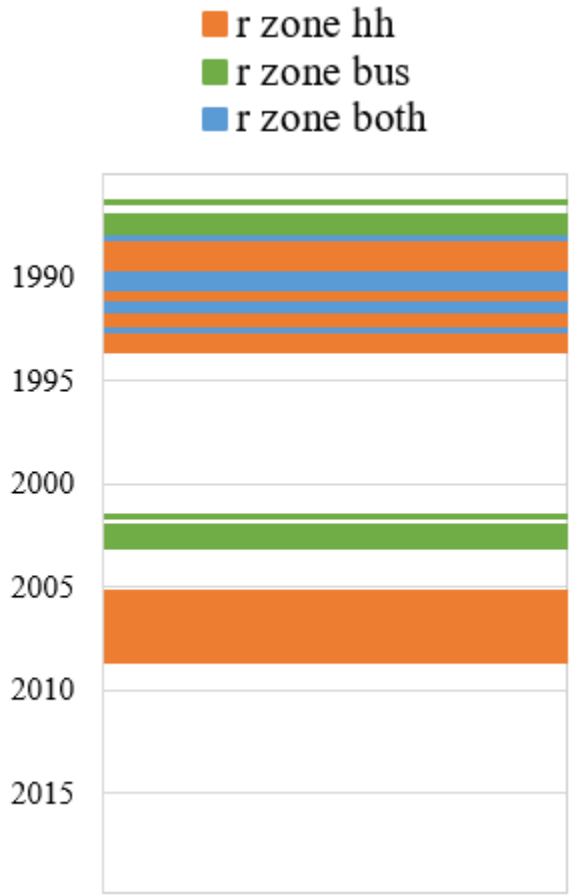


Latest observation: Q4-2019

Notes: Time variable denotes the period for which outcome is forecasted, not the date when the prediction was generated. Only the outcome for which R-zone household is active and R-zone business is not active are plotted. (lhs) annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables. The distribution in light grey represent the unconditional distr. For the uncond. distribution, the avg. value of current GDP growth and R-zone buss = 0 and R-zone hh = 0 and R-zone both = 0 have been used. (rhs) The assignment of household (business) thresholds are based on the distribution of household (business) credit and house (equity) price growth in our full panel dataset and, thus, are the same for all 9 countries in the sample.

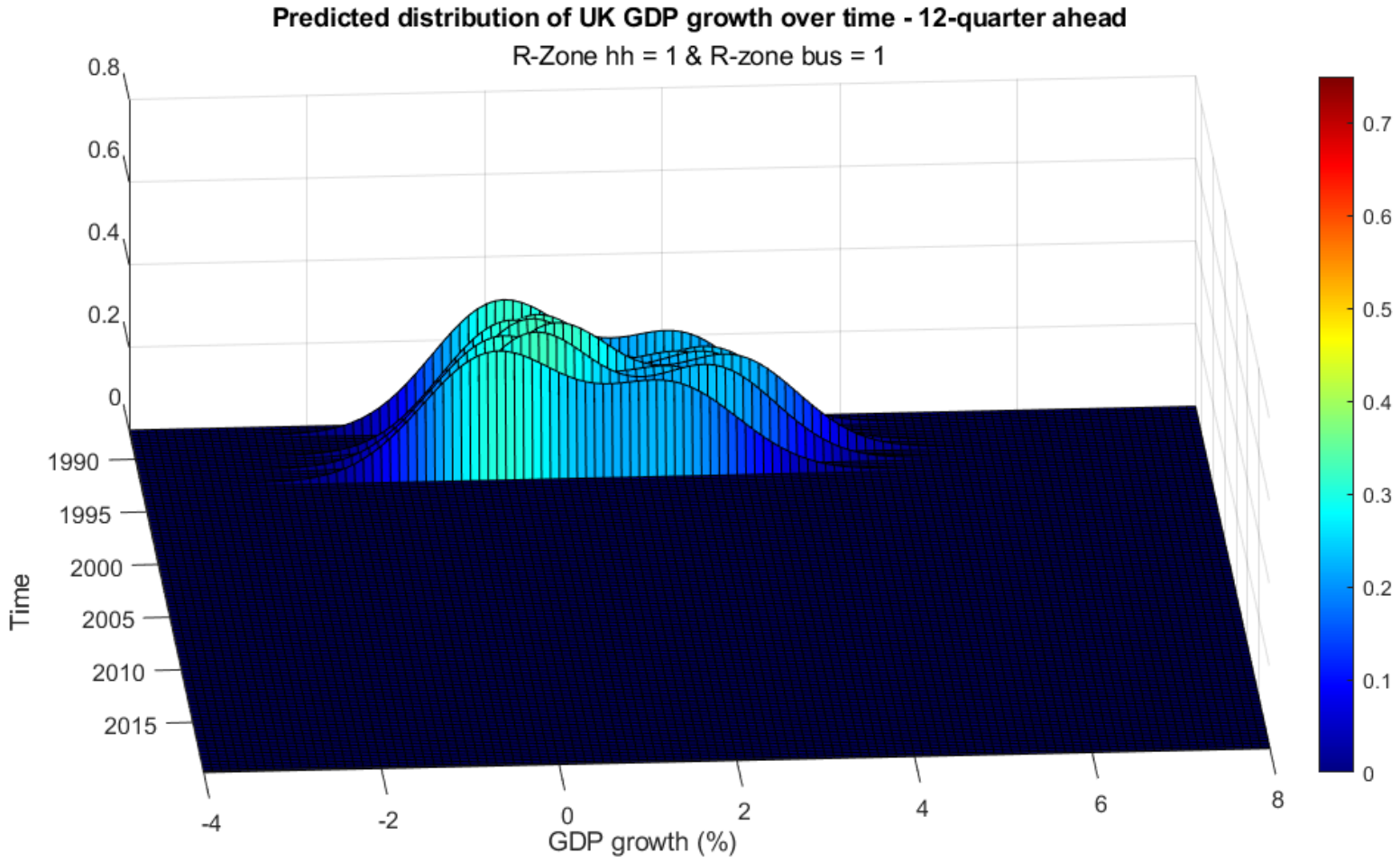
Empirical application – Results
Predicted distribution –Household and business R-zones combined (II)

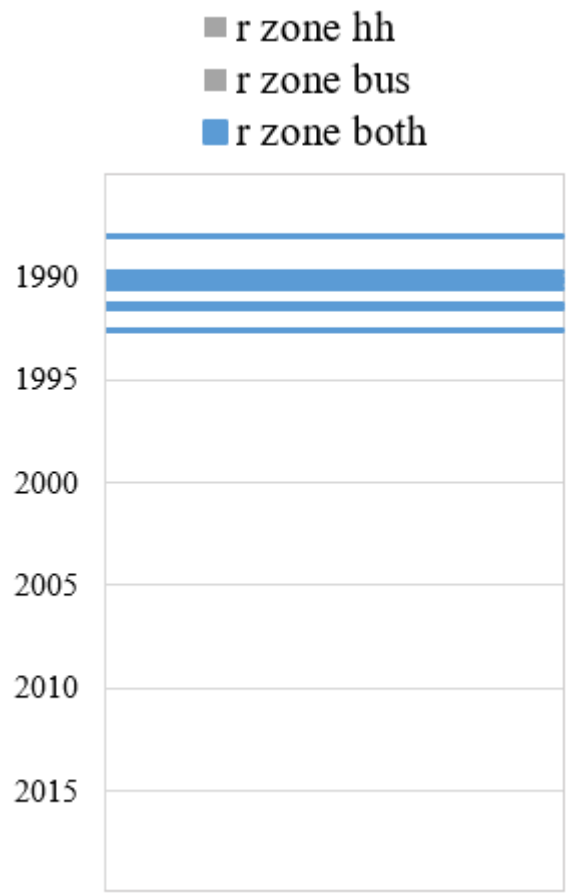




Latest observation: Q4-2019
Notes: Time variable denotes the period for which outcome is forecasted, not the date when the prediction was generated.
(lhs) annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables. (rhs) The assignment of household (business) thresholds are based on the distribution of household (business) credit and house (equity) price growth in our full panel dataset and, thus, are the same for all 9 countries in the sample.

Empirical application – Results
Predicted distribution –Household and business R-zones combined (VIII)



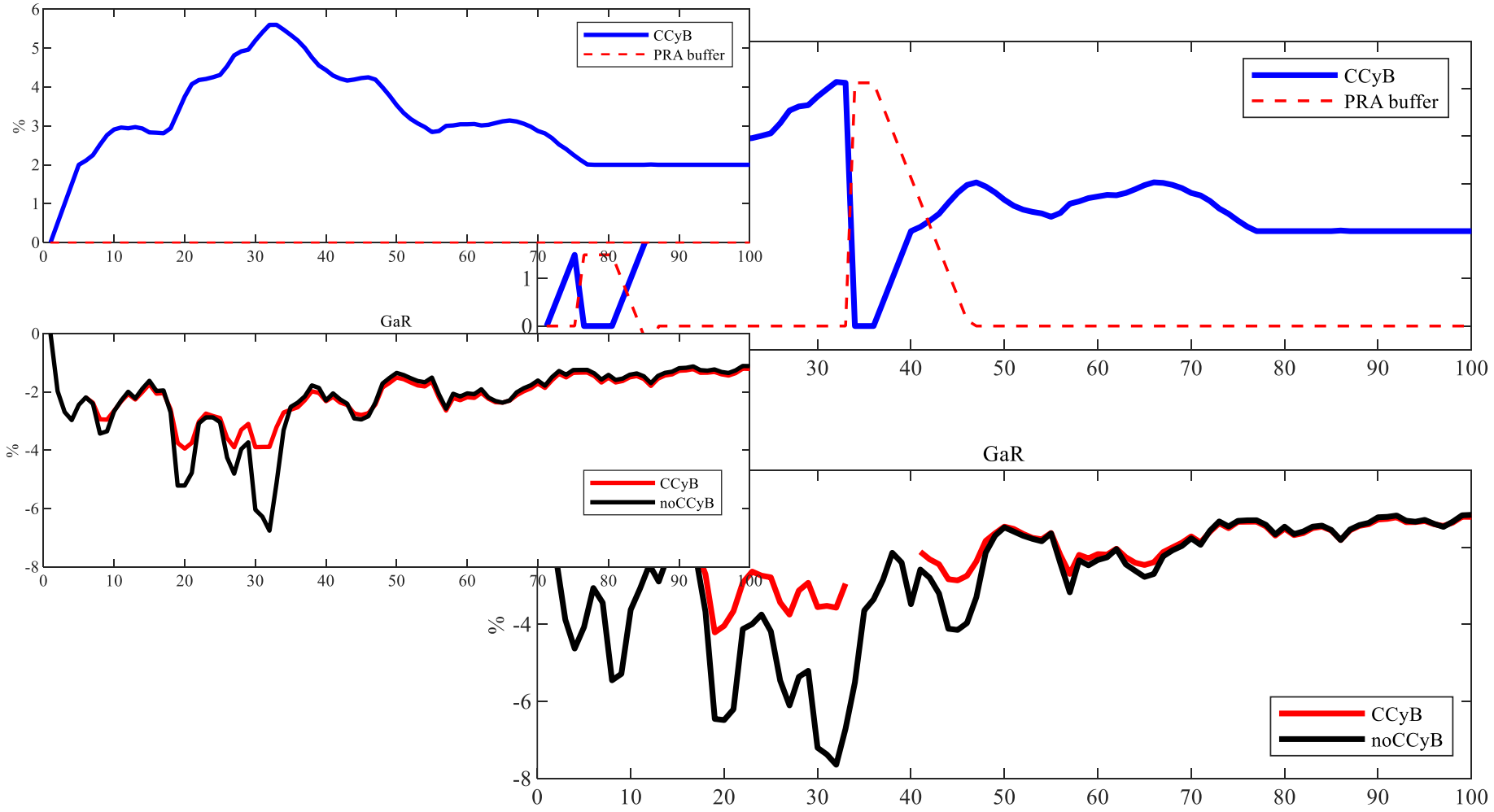


Latest observation: Q4-2019

Notes: Time variable denotes the period for which outcome is forecasted, not the date when the prediction was generated. Only the outcome for which R-zone household is active and R-zone business is not active are plotted. (lhs) annualized twelve-quarter-ahead predictive distribution of GDP growth, based on quantile regression with current GDP growth, household R-zone, business R-zone and min(household R-zone; business R-zone) as conditioning variables. (rhs) The assignment of household (business) thresholds are based on the distribution of household (business) credit and house (equity) price growth in our full panel dataset and, thus, are the same for all 9 countries in the sample.

Can we integrate GDP-at-risk in setting the CCyB?

Simulation type 1: the CCyB reduces risk only



Can we integrate GDP-at-risk in setting the CCyB?

Simulation type 1: the CCyB reduces risk only