Expecting the unexpected: Economic growth under stress

Esther Ruiz

Universidad Carlos III de Madrid

joint with

Gloria Gónzalez-Rivera (UCA-Riverside) and Vladimir Rodríguez-Caballero (ITAM, Mexico, and CREATES, Denmark)

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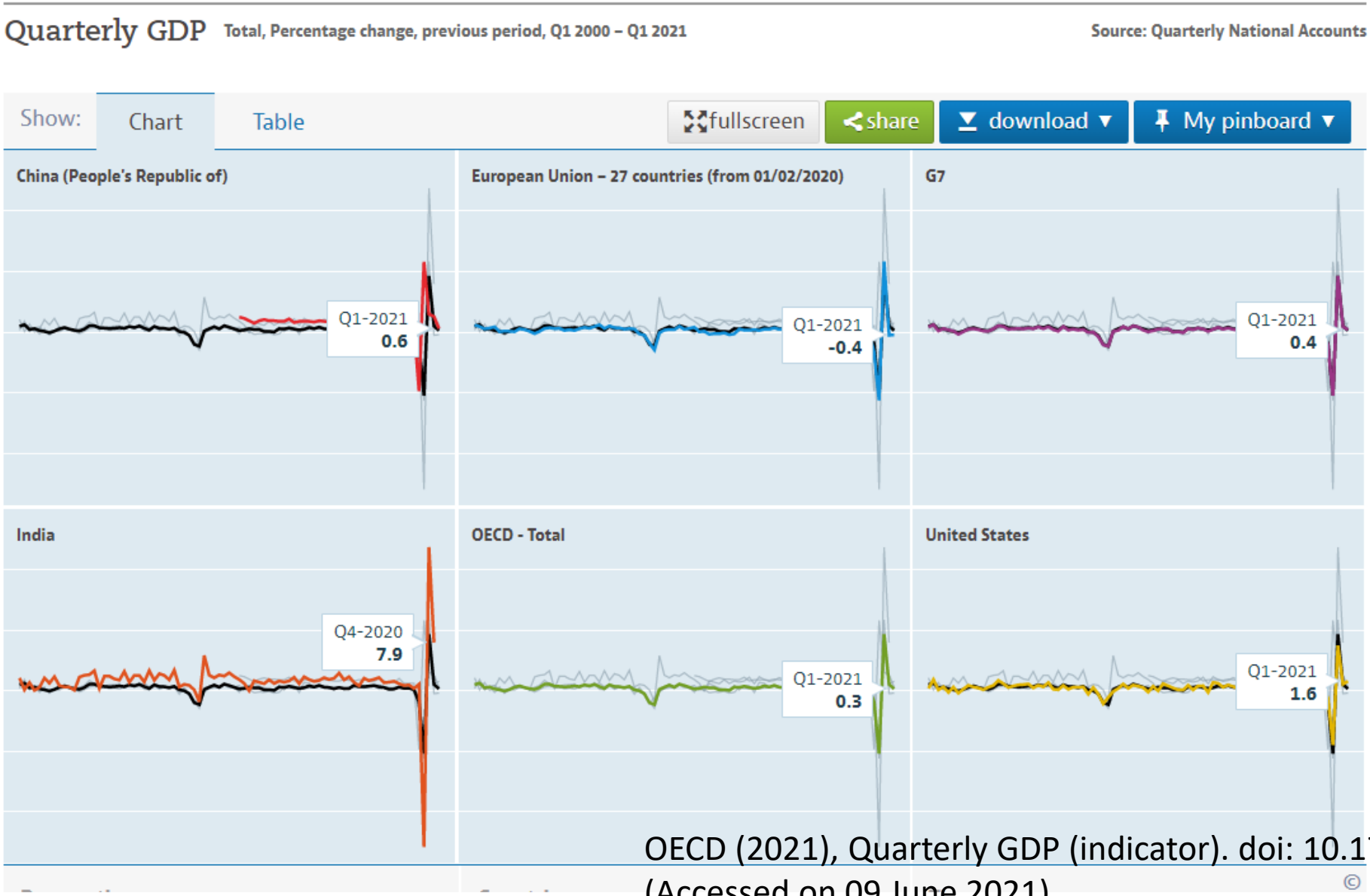
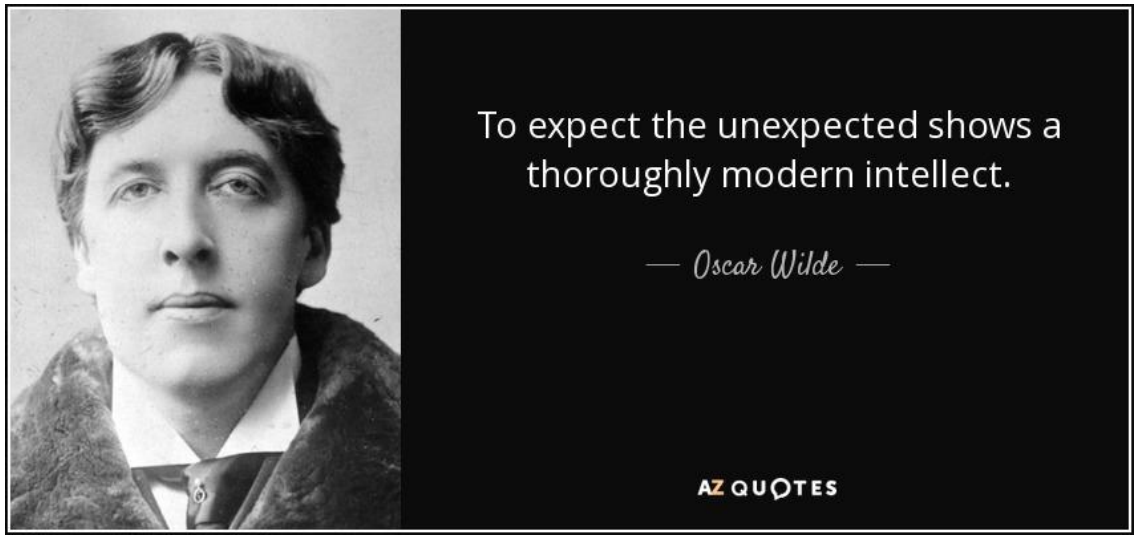
Economic growth under stress



OECD (2021), Quarterly GDP (indicator). doi: 10.1787/b86d1fc8-en
(Accessed on 09 June 2021)

Expecting the unexpected



This is not **forecasting**: Expecting the expected

Vulnerability refers to whether and how strongly (unexpected and extreme) shocks hit the economy. It depends on the structure of the economy (global and local sectors, financial and real sectors) and various policy settings, among other.

Measuring vulnerability is important for the construction of resilience policies. Policy makers should be prepared for **extreme shocks** so that corrective measures can be implemented; see Kilian and Manganelli (2008, *J. of Money, Credit and Banking*) and Alessi et al. (2014, *JBES*) for the importance of having appropriate measures of risk for policy makers and central Banks, respectively.

Contributions

1. Measure of growth vulnerability in stressed situations: **Growth in Stress (GiS)**. Different scenarios for the underlying factors can be considered. Stress can be defined as very unlikely scenarios or “unexpected shocks”.

2. Methodology to determine the **relevant factors** underlying growth densities.

Roadmap

- Forecasting growth vulnerability: GaR
- Stressed factors: GiS
- Growth in Stress: Underlying relevant factors in US
- Conclusions

1. Forecasting growth vulnerability: GaR

The most popular measure of growth vulnerability is **Growth at Risk (GaR);** Adrian, Boyarchenko and Giannone (2019, *AER*).

The GaR is defined as a quantile of the growth density.

Growth quantiles are modelled as functions of **underlying unobserved common** factors using **factor-augmented-quantile regressions**

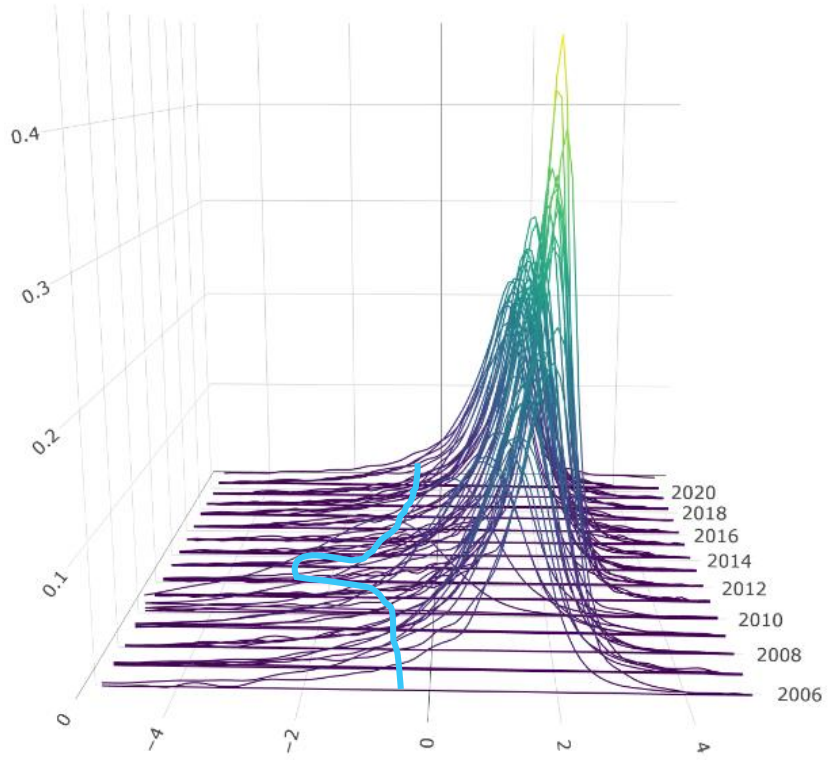
$$q_\tau(y_{t+h|t}) = \mu_\tau^{(h)} + \phi_\tau^{(h)} y_t + \sum_{i=1}^{r} \beta_{\tau,i}^{(h)} F_{it} + v_{\tau,t+h}$$

ABG (2019) propose the 5% quantile

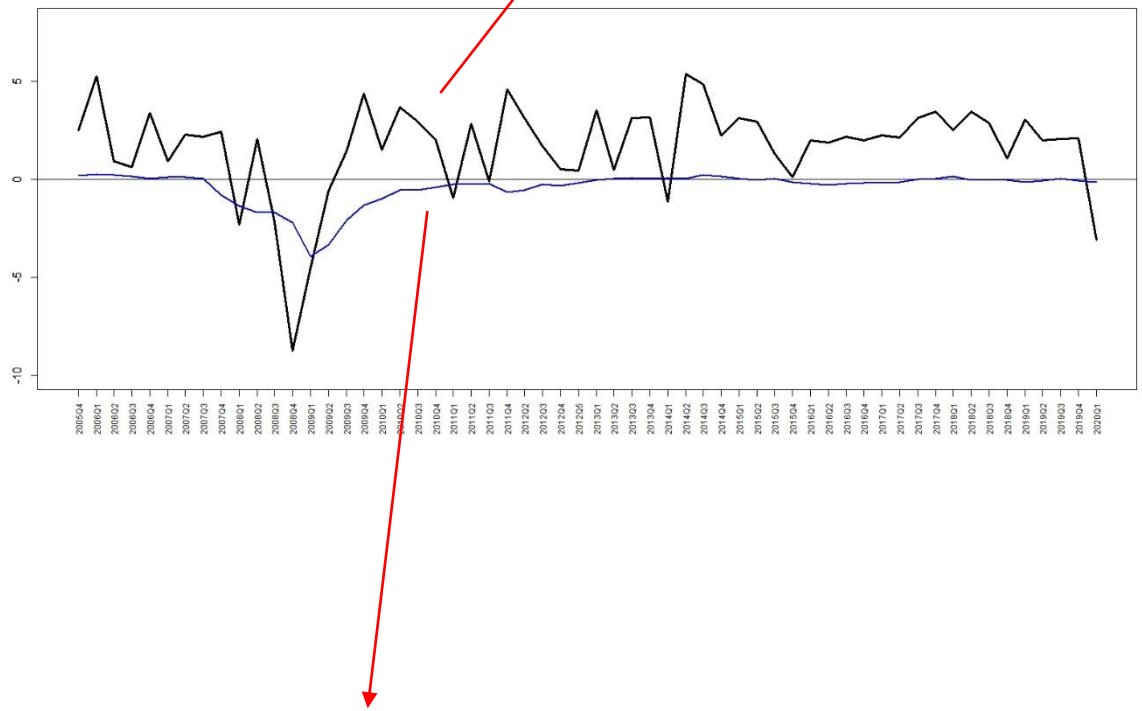
Unoberved latent factors extracted from a set of N variables, X_t.

For the US, ABG (2019) propose extracting one local financial factor (r=1): NFCI

Matching the estimated quantiles with those of an asymmetric Student density, it is posible to obtain h-step-ahead forecasts of the density of growth



GDP growth in US



5% GaR based on NFCI

The GaR is closely related with Value at Risk (VaR), proposed as a measure of financial risk.

However, VaR is not designed to measure financial risk under stressed conditions.

Stress testing refers to the analysis and forecasting of the left tail behaviour of the probability distribution financial returns, when hit by extreme shocks, which are abnormal and rare relative to those expected during tranquil times; Borio, Drehmann and Tsatsaronis (2014, *J. of Financ. Stability*) and Flood and Korenko (2015, *Quantitative Finance*).

2. Stressed factors: GiS

Based on the literature about measuring financial risk in stressed conditions (González-Rivera, 2003, *Journal of Fixed Income*), the vulnerability of growth can be defined using the stressed VaR: **Growth in Stress**.

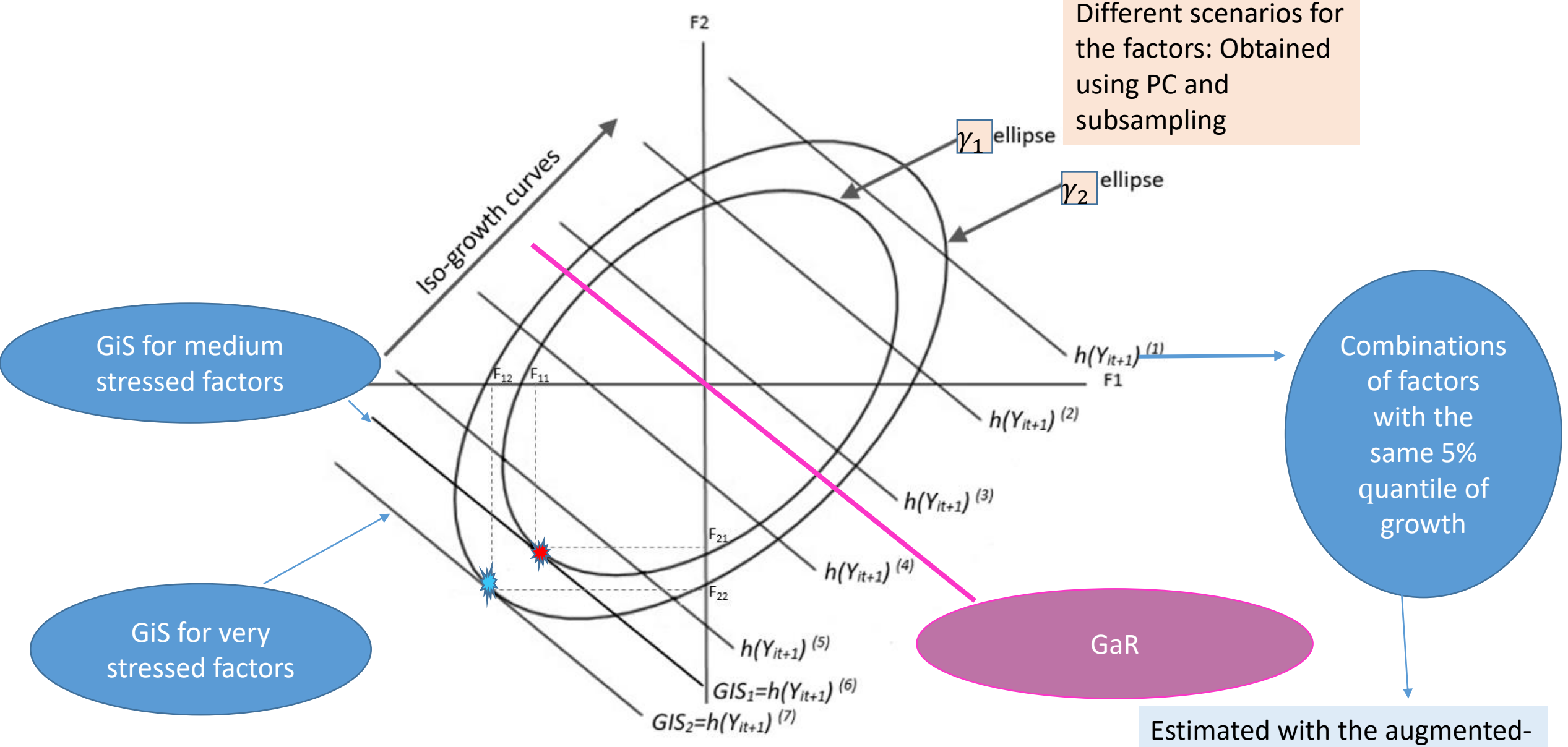
$$q_\tau(y_{t+h|t}) = \mu_\tau^{(h)} + \phi_\tau^{(h)} y_t + \sum_{i=1}^{r} \beta_{\tau,i}^{(h)} F_{it} + v_{\tau,t+h}$$

As in ABG, $\tau = 5\%$ quantile

Once the factor-augmented regressions are estimated, the factors are "stressed" to compute the quantile: González-Rivera, Maldonado and Ruiz (2019, IJF)

We investigate not only local financial factors but also global and/or macroeconomic factors (for the US)

Different scenarios for the factors: Obtained using PC and subsampling



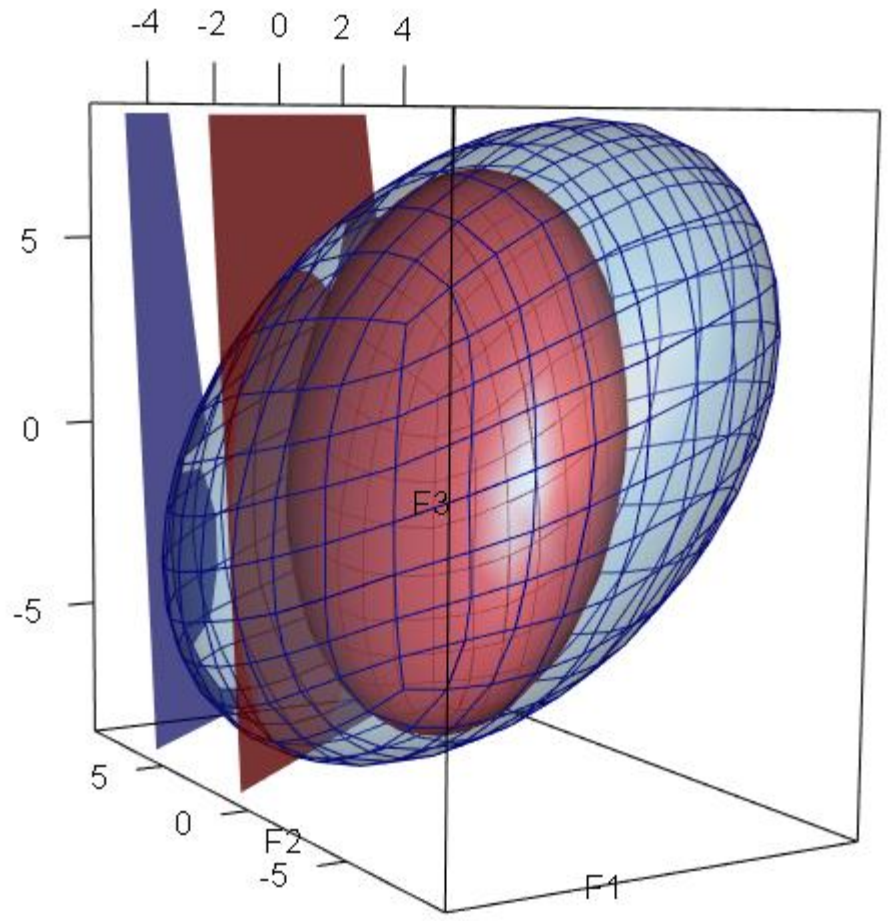
GiS for medium stressed factors

GiS for very stressed factors

GaR

Combinations of factors with the same 5% quantile of growth

Estimated with the augmented-quantile regression



For more than three factors, we use the simple binary mesh algorithm proposed by Flood and Korenko (2015, *Quantitative Finance*)

- $GiS_{t+h} = \min q_{\alpha}(y_{t+h|t})$
- s.t. $g(F_t, \gamma) = 0$

where $g(F_t, \gamma)$ is an ellipsoid that contains the true factor vector with probability γ.

Which factors should be used? Global/Local Macroeconomic/Financial

- Local Financial factors: Adrian, Boyarchenko and Giannone (2019, *AER*), Adrian, Grinberg, Liang, Malik and Yu (forthcoming, *AEJ: Macroeconomics*), Ferrara, Mogliani and Sahuc (2020, *WP*)
- Local macroeconomic factors: Cook and Doh (2020, *WP*)
- Global financial factors: Cerutti, Claessens and Rose (2019, *IMF Economic Review*)
- Global macroeconomic factors: González-Rivera, Maldonado and Ruiz (2019, *IJF*)

Our proposal is to extract factors from an extended set of variables including local and global macroeconomic and financial variables based on **Multi-level Dynamic factor models.**

- The factor structure is decomposed into different levels, allowing for some factors to be associated with the **full cross-section** of variables (pervasive factors), some other factors impacting only a **specific subset of variables** (non-pervasive factors), and other factors impacting **several subsets of variables** (semi-pervasive factors); see Hallin and Liska (2011, *JE*) for the determination of the factor structure and Breitung and Eickmeier (2015, *Advances in Econometrics*) and Rodríguez-Caballero and Caporin (2019, *J. Intern. Financ. Markets, Instit. and Money*) for the factor extraction.

3. Growth in Stress: underlying factors in US

Factors are extracted from the following set of variables observed quarterly from 2005Q1 to 2020Q2:

1. Local financial, X_1: same as those used to construct the NFCI, $N_1 = 105$: The local financial factor is not relevant once all other variables are considered.
2. Global financial, X_2: Arregui et al. (2018, *WP*), $N_2 = 208$
3. Local macroeconomic, X_3: McCracken and Ng (2016, *JBES*), $N_3 = 248$
4. Global macroeconomic, X_4: González-Rivera, Maldonado and Ruiz (2019, *IJF*), $N_4 = 63$

The following multi-level DFM with 5 factors is selected:

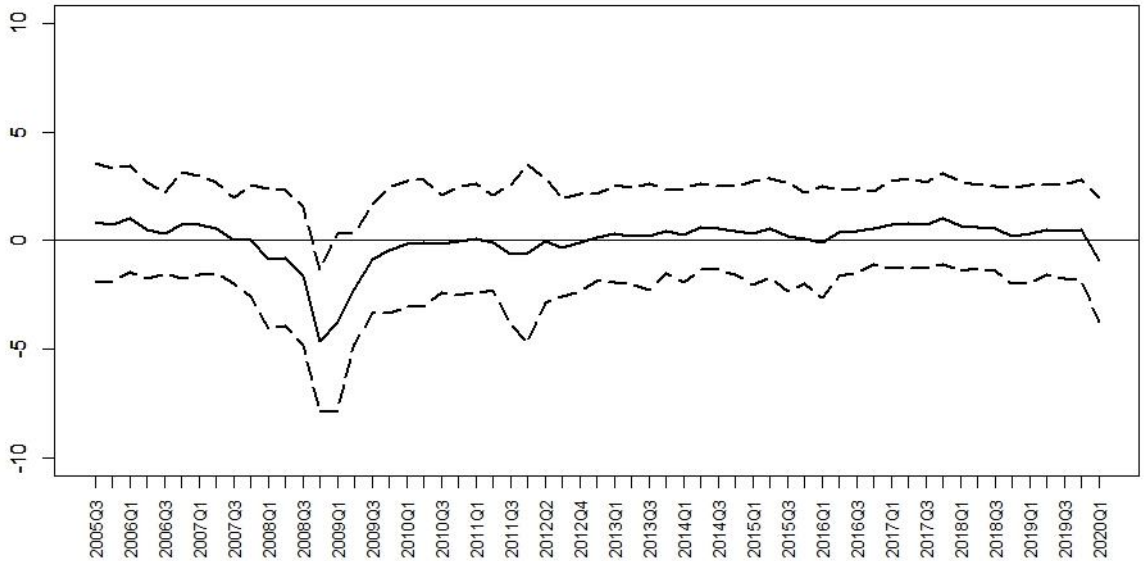
$$\begin{bmatrix} X_{2t} \\ X_{3t} \\ X_{4t} \end{bmatrix} = \begin{bmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} & 0 & 0 \\ \lambda_{21} & 0 & 0 & \lambda_{24} & 0 \\ \lambda_{31} & \lambda_{32} & 0 & 0 & \lambda_{35} \end{bmatrix} \begin{bmatrix} F_{1t} \\ F_{2t} \\ F_{3t} \\ F_{4t} \\ F_{5t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix}$$

F_{1t} is a pervasive factor that loads on all variables in the system

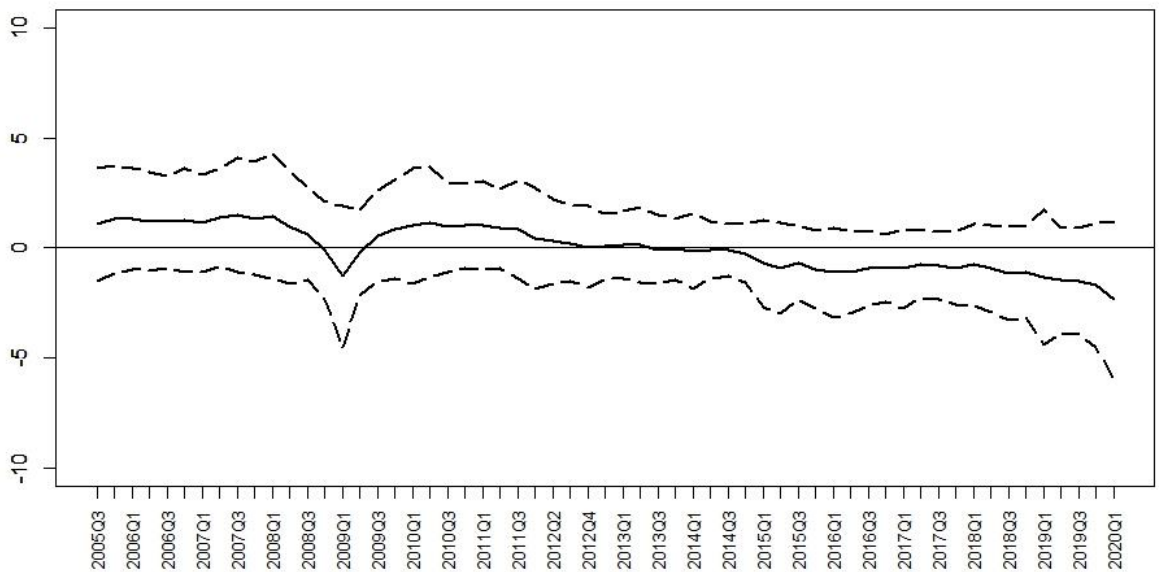
F_{2t} is a semi-pervasive factor that loads on world (financial and macro) variables

F_{3t} (global financial), F_{4t} (local macro) and F_{5t} (global macro) are non-pervasive factors.

Other countries may require different factor structures



Pervasive factor and 95% confidence bounds



Local (financial and macro) factor and 95% confidence bounds

Factor augmented quantile regression (one-step-ahead)

$$q_\tau(y_{t+1|t}) = \mu_\tau + \phi_\tau\, y_t + \sum_{i=1}^{7} \beta_{\tau,i} F_{it} + v_{\tau,t+1}$$

Lagged growth: If growth increases, the interquantile range decreases.

The global factor is positive for extreme quantiles of the growth distribution: Stronger in upper quantiles

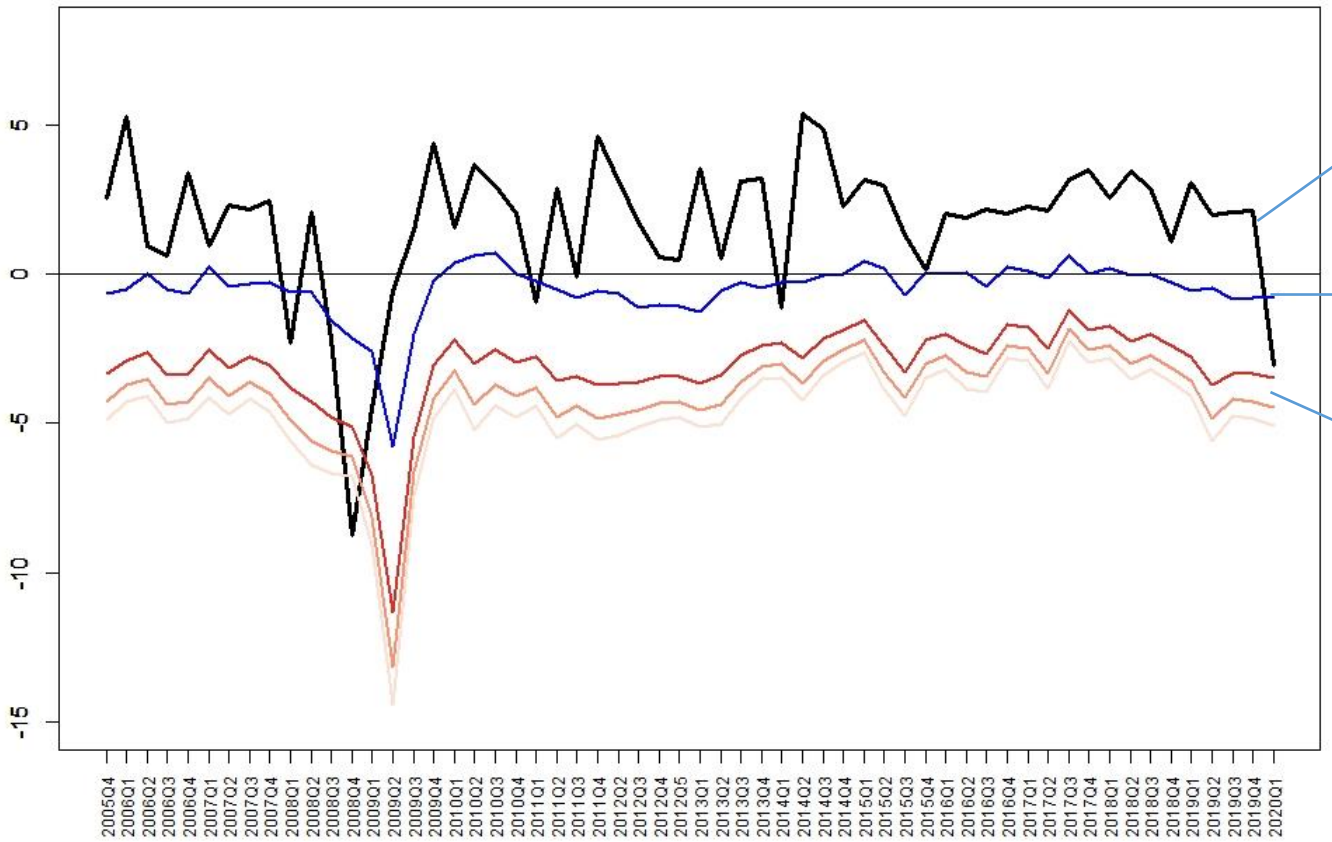
The world factor is positive for extreme quantiles of the growth distribution: Stronger in lower quantiles

The world financial factor is negative for the growth distribution

The local macro factor is negative for left quantiles of the growth distribution

The world macro factor is positive (negative) for the left (right) tail of the growth distribution: decreases the interquantile range

	$\tau = 0.05$	$\tau = 0.5$	$\tau = 0.95$
μ	**−2.62** (0.00)	**2.04** (0.00)	**4.33** (0.00)
ϕ	**0.15** (0.00)	−0.19 (0.37)	**−0.24** (0.01)
β_1	**0.68** (0.00)	0.45 (0.38)	**1.30** (0.00)
β_2	**2.19** (0.01)	−0.01 (0.99)	**0.62** (0.00)
β_3	**−1.20** (0.01)	**−0.87** (0.03)	**−1.06** (0.00)
β_4	**−1.21** (0.03)	0.48 (0.29)	0.23 (0.21)
β_5	**3.44** (0.00)	0.58 (0.19)	**−0.59** (0.00)
R^1	**0.49**	0.16	0.36



Observed growth

GaR

Gis with factors stressed at 70%, 95% and 99%

One-step-ahead GaR and GiS for 2020Q2 (-9.53%, according to IMF)	
GaR	-5.34
GiS 70%	-10.01
GiS 95%	-11.80
GiS 99%	-12.84

4. Conclusions

- Propose a **tool for measuring growth vulnerability under stress**. We can identify vulnerabilities during seemingly tranquil times so that triggering remedial action is posible. Resilience measures can be taken in advance for potential negative shocks to growth.

  By choosing different levels of stress, GiS helps policy makers to deal with the tradeoff between building greater resilience in normal times and reducing downside risk in highly stressed periods.

- The multilevel-DFM helps to **identify relevant factors** for growth that can be world/local and financial/macro factors.

  The structure of local/global macro/financial factors can be different for different countries.

Thanks a lot

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