



MONETARY AND CAPITAL MARKETS

Growth at Risk: Concept and Application in Surveillance

CEMLA: IX Meeting on Financial Stability

Selim Elekdag
Deputy Unit Chief
Strategy and Planning Unit



MONETARY AND CAPITAL MARKETS

Growth at Risk: Concept and Application in Surveillance

CEMLA: IX Meeting on Financial Stability

The views expressed in the presentation are those of the author and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.



Outline

I: Growth at Risk (GaR)

- A. Definition, Key Features and Policy Insights
- B. Empirical Framework Overview

II: GaR Tool for Macroeconomic Surveillance

- A. GaR Tool: Overview
- B. Main Elements



What Did We Learn From the GFC?

Financial conditions...

Asset price returns and their volatilities, spreads (corporate, interbank, term)...

Macrofinancial vulnerabilities...

Leverage (household, corporate, financial sector, sovereign); liquidity, maturity, and FX mismatches

Have implications for growth prospects

Shocks can be amplified and transmitted across multiple channels



Financial conditions and risks to growth

Macrofinancial vulnerabilities increase in good times...

Vulnerabilities (leverage; mismatches) tend to increase when financial conditions are accommodative.

Financial conditions and macrofinancial vulnerabilities signal risks...

Tighter financial conditions, amid elevated vulnerabilities, pose downside risks to economic activity.

Monitoring these conditions and vulnerabilities can inform policy

Tracking financial conditions and vulnerabilities can provide valuable information for policymakers



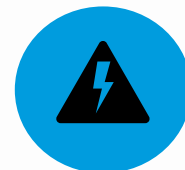
Growth at Risk: Definition



Quantifies macrofinancial risks to future GDP growth



Financial and economic indicators used to identify macrofinancial linkages and gauge financial vulnerabilities



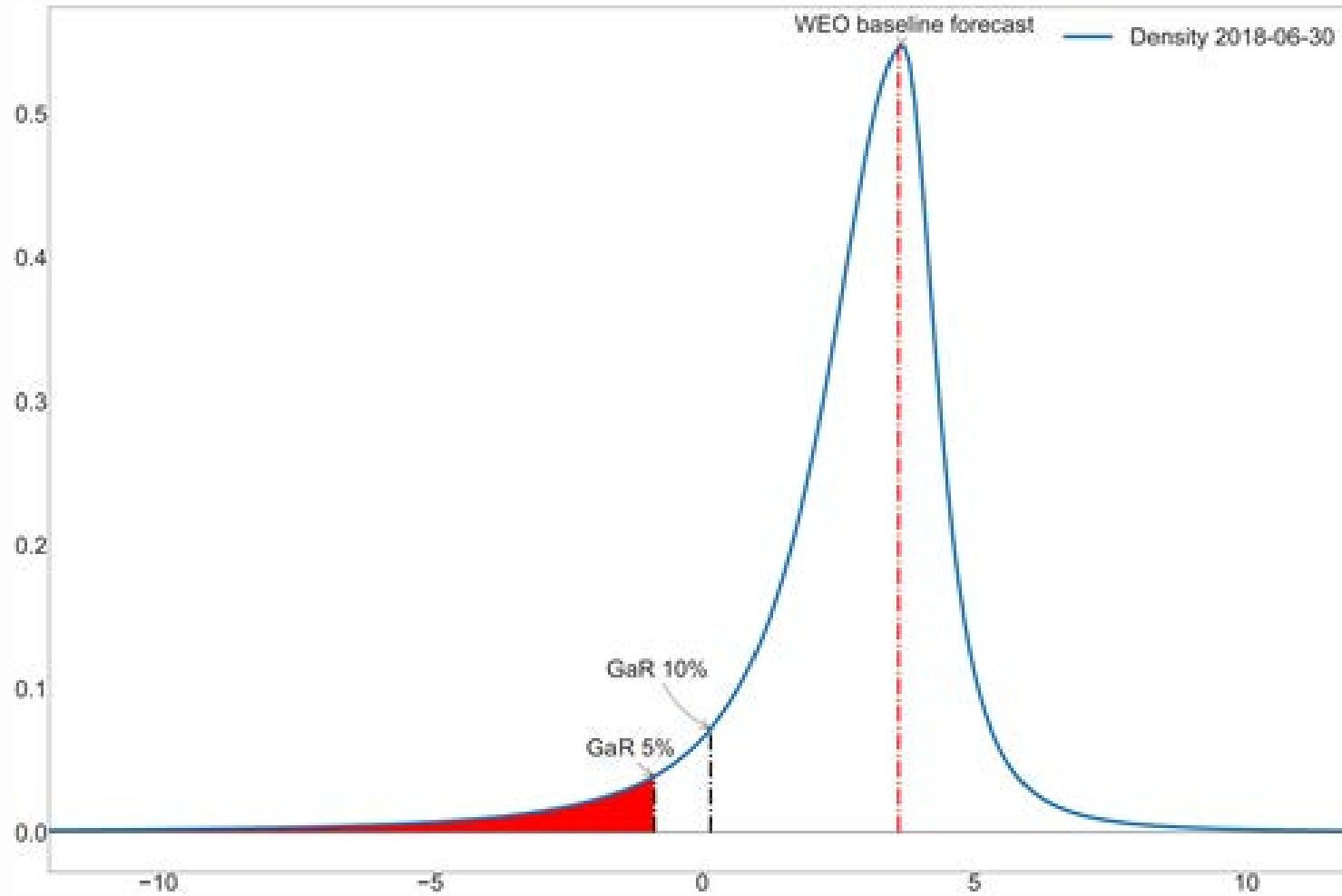
Flexible, parsimonious, forecasting framework, that can, inter alia, estimate the severity and the likelihood of a future recession



**Idea: Adrian, Boyarchenko, Giannone (2019) AER
Tool and operationalization for IMF surveillance: IMF WP/19/36**



Growth at Risk: Teaser





I: Growth at Risk (GaR): Concept



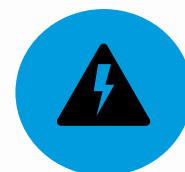
Growth at Risk: Definition



Quantifies macrofinancial risks to future GDP growth



Financial and economic indicators used to identify macrofinancial linkages and gauge financial vulnerabilities



Flexible, parsimonious, forecasting framework, that can, inter alia, estimate the severity and the likelihood of a future recession



Growth at Risk: Key Features and Policy Insights

Differences with existing approaches:

Enables discussion on the *entire* growth distribution at different horizons

Estimates relative importance of key drivers of future growth

Distribution of future growth depends on current state of financial and macroeconomic conditions

Policy insights:

Helps generate scenarios based on statistical analysis

Facilitates quantification of alternative scenarios linked to key risks

Allows policymakers to better monitor and deploy policies to mitigate downside risks

Identifies risk-return and intertemporal policy tradeoffs

Tailored to individual country risks and vulnerabilities



Growth at Risk: Empirical Framework Overview

GaR comprises three steps:

1. Macrofinancial variable selection

2. Quantile regression analysis

3. Fitting conditional growth distributions





Step 1: Macrofinancial Variables Selection

Goal:

- Select variables that are likely to influence growth prospects,...
- ...choose appropriate (groups of) variables for the following equation:

$$growth_{t+h} = \beta_1 * X_{1,t} + \beta_2 * X_{2,t} + \beta_3 * X_{3,t} + \gamma * growth_t + e_t$$



Step 1: Macroeconomic Variables Selection

Goal:

- Select variables that are likely to influence growth prospects,...
- ...guided by theory,...
- ...country-specific circumstances, and...
- ...expert judgement.



Step 1: Macroeconomic Variables Selection

Financial Conditions:

- Large body of empirical work showing have financial conditions can improve growth *point* forecasts
- Asset price growth
- Stock return volatility
- Spreads (corporate, term, interbank)



Step 1: Macroeconomic Variables Selection

Macroeconomic Vulnerabilities:

- Leverage (financial accelerator models)
- Maturity, liquidity, and FX mismatches
- Fragile balance sheets (elevated NPLs)
- Asset price misalignments



Step 1: Macrofinancial Variables Selection

Other Factors:

- Commodity prices
- Market sentiment
- Behavioral finance: neglect of downside risk



Step 1: Macrofinancial Variables Selection

Too many variables?

- Important to organize variables into groups or “partitions”
- Facilitates estimation and intuition
- Importantly, these partitions should be guided by theory



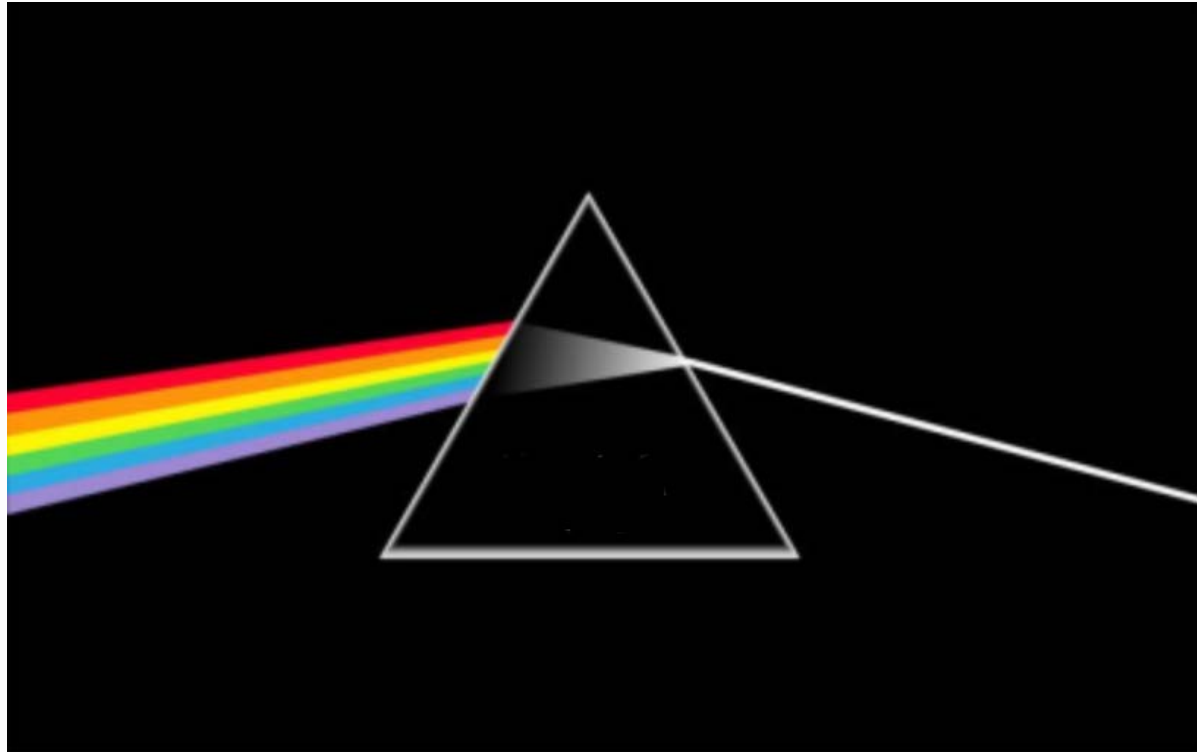
Step 1: Macrofinancial Variables Selection

How to construct a “partition”?

- Choose a set of variables such as spreads, asset prices and volatilities
- These price-based indicators could be a natural grouping
- Principal component analysis (PCA) extracts underlying “trends”



Step 1: Macrofinancial Variables Selection



PCA intuition...

- Instead of 10 variables, can now include a single variable capturing the common information



Step 1: Macroeconomic Variables Selection

Macroeconomic variables can be grouped along the following partitions:

Financial conditions (“price of risk”):

- Credit and term spreads, valuation ratios, volatility measures...

Macroeconomic vulnerabilities:

- Credit growth, leverage metrics, FX and maturity mismatches...

Other relevant factors:

- Commodity prices, global risk appetite, and external demand...



Step 2: Quantile Regressions

Recall standard the forecasting equation (OLS)

$$growth_{t+h} = \beta * X_t + \gamma * growth_t + e_t$$

Forecast of growth h quarters ahead, conditional on current growth and a macrofinancial variable (X_t) of interest—e.g., financial conditions index (FCI)

Can be generalized:

$$growth_{t+h} = \beta_1 * X_{1,t} + \beta_2 * X_{2,t} + \beta_3 * X_{3,t} + \gamma * growth_t + e_t$$

where $X_{1,t}$, $X_{2,t}$, $X_{3,t}$ could be the three partitions discussed above...



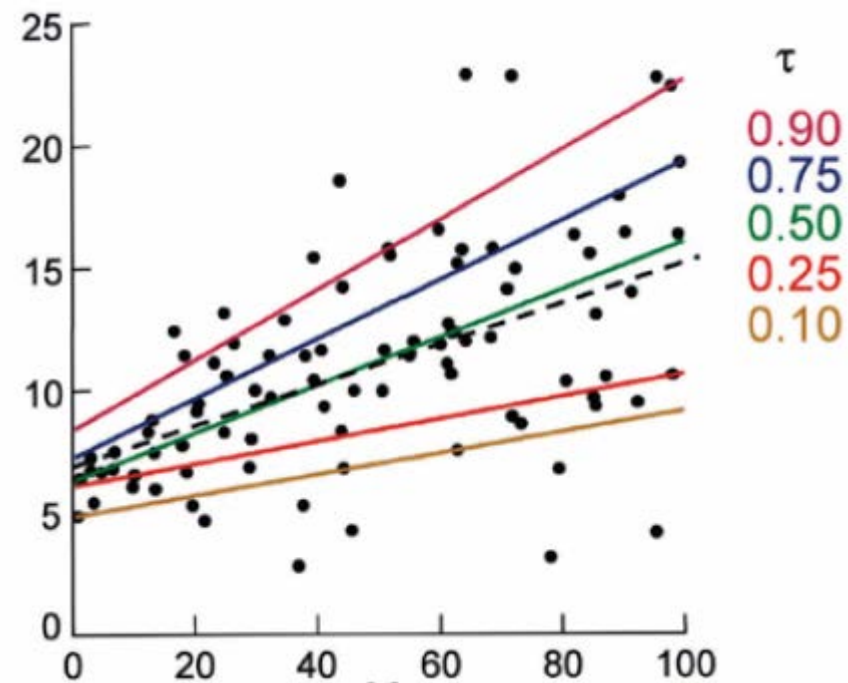
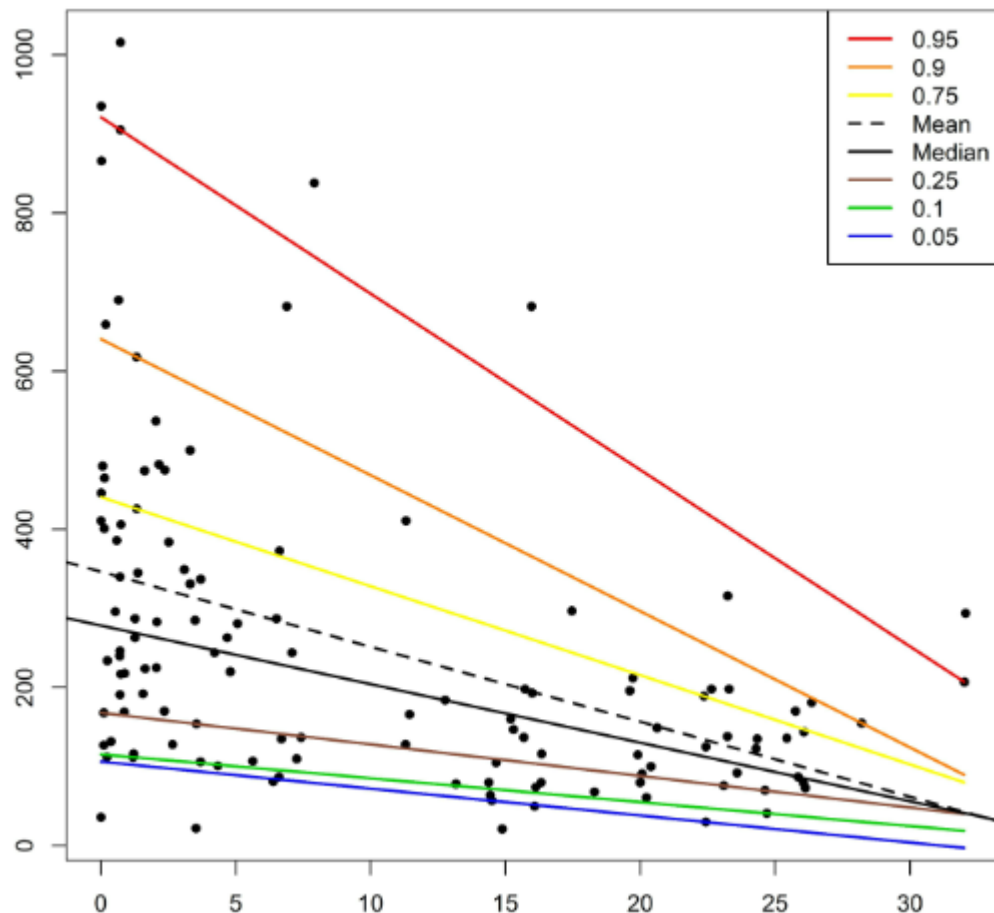
Step 2: Quantile Regressions

$$growth_{t+h}^q = \beta_1^q * X_{1,t} + \beta_2^q * X_{2,t} + \beta_3^q * X_{3,t} + \gamma^q * growth_t + e_{t+h}^q$$

- Mapping between the current macrofinancial variables ($X_{1,t}$, $X_{2,t}$, $X_{3,t}$) and future growth ($growth_{t+h}^q$) across quantiles (superscript “ q ”).
- Typical application:
 - $h = 1 \dots 12$ (quarters),
 - $q = 0.1 \dots 0.9$ (quantiles)
 - $X_{1,t}$, $X_{2,t}$, $X_{3,t}$: indices of financial conditions, vulnerabilities, and other macroeconomic factors, respectively.



Step 2: Quantile Regressions





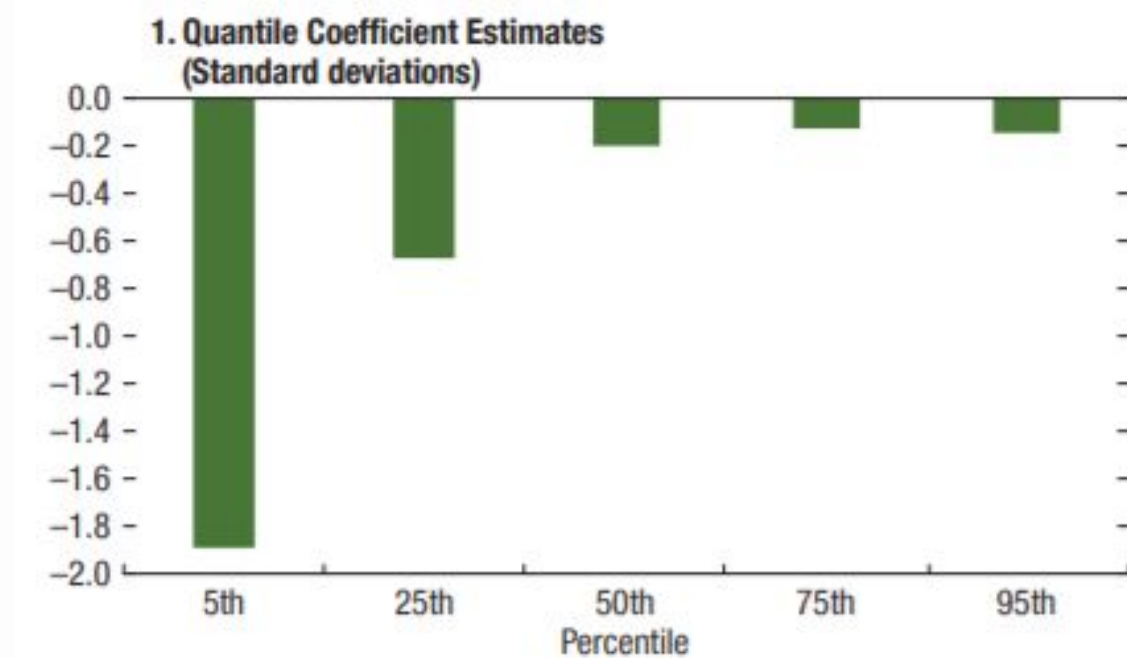
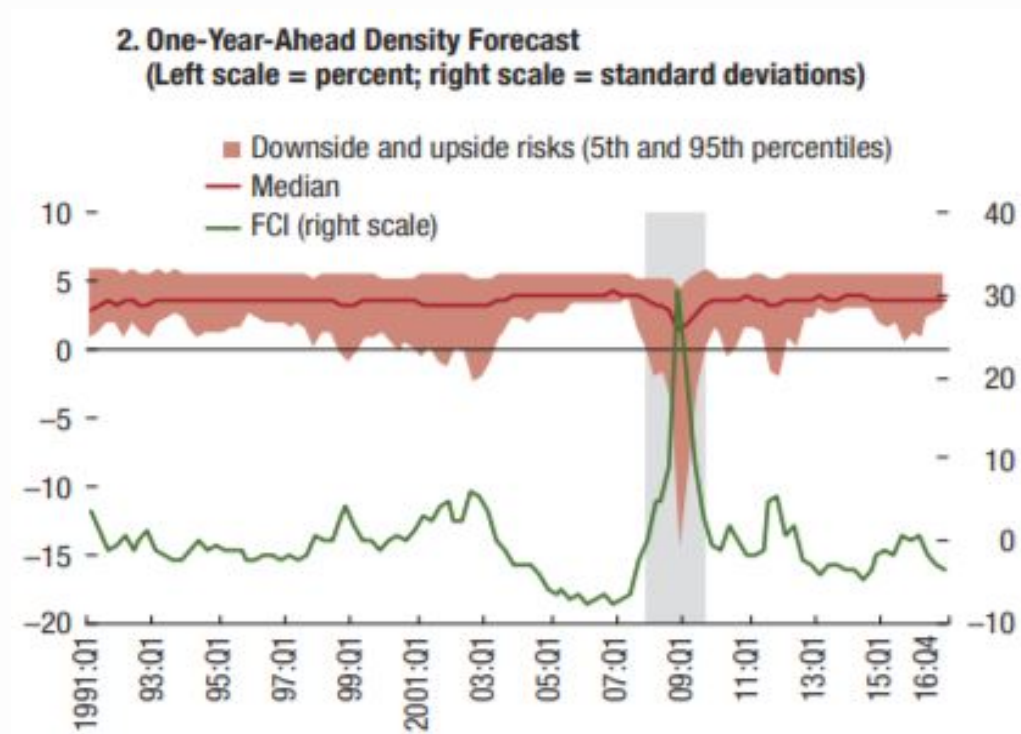
Step 2: Quantile Regressions

$$growth_{t+h}^q = \beta_1^q * X_{1,t} + \beta_2^q * X_{2,t} + \beta_3^q * X_{3,t} + \gamma^q * growth_t + e_{t+h}^q$$

- Mapping between the current macrofinancial variables ($X_{1,t}$, $X_{2,t}$, $X_{3,t}$) and future growth ($growth_{t+h}^q$) across quantiles (superscript “ q ”).
- Typical application:
 - $h = 1 \dots 12$ (quarters),
 - $q = 0.1 \dots 0.9$ (quantiles)
 - $X_{1,t}$, $X_{2,t}$, $X_{3,t}$: indices of financial conditions, vulnerabilities, and other macroeconomic factors, respectively.



Step 2: Quantile Regressions



The inverse relationship between FCIs and future growth

- ...is stronger for economic contractions (5th percentile) than for expansions.



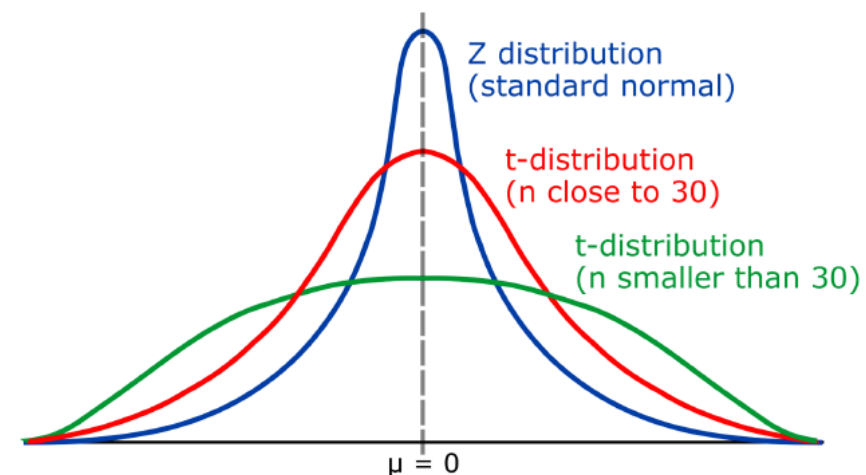
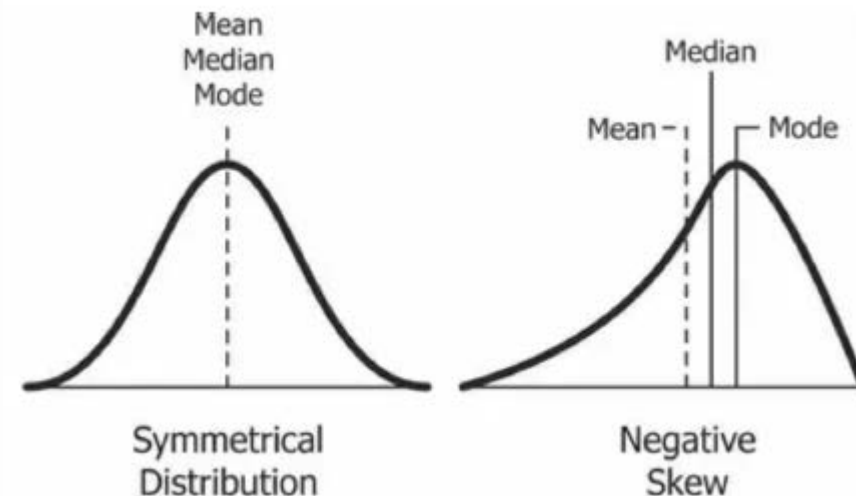
Step 3: Fitting Conditional Growth Distributions

Use the predicted values across quantiles to fit a flexible distribution function

T-skew nests the Normal distribution

Allows for (1) skewness and (2) fatter tails

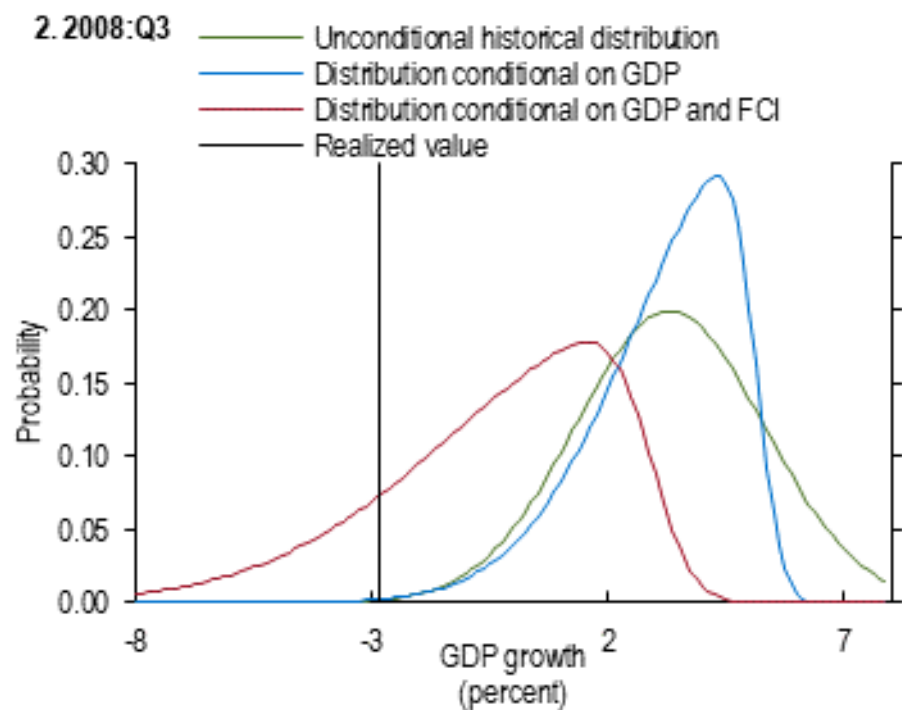
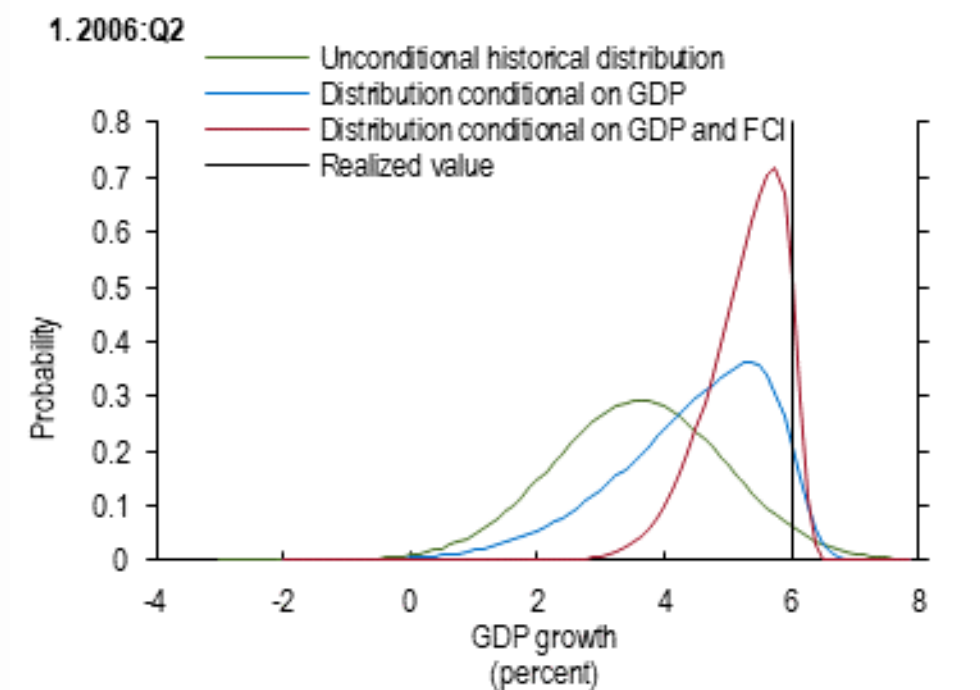
Based on Adrian, Boyarchenko, and Giannone (2019)





Step 3: Fitting Conditional Growth Distributions

Financial conditions improve the ability to predict future economic downturns.





II: GaR: Applications in IMF Surveillance



GaR Tool for Macroeconomic Surveillance: Overview

Excel-based GaR tool developed (Python with Excel interface)

To support macroeconomic surveillance

Usage to date includes:

- **Article IVs:** Singapore, Panama, Portugal, Albania, Korea, Romania
- **FSAPs:** Peru, Canada, Singapore, France, Italy



GaR Tool for Macroeconomic Surveillance: Main Elements

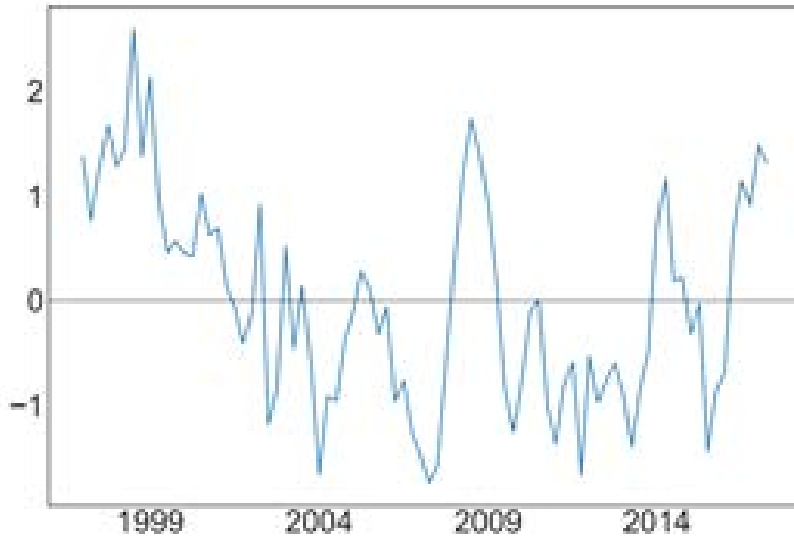
Flexibly Customizable

- Computes country-specific FCIs
- Allows for partitions of macrofinancial variables
- Ranks variables according to their informational content for future growth
- Estimates quantile regression coefficients
- Generates future growth distributions
- Growth distributions can be centered on WEO forecasts
- Facilitates scenario analysis

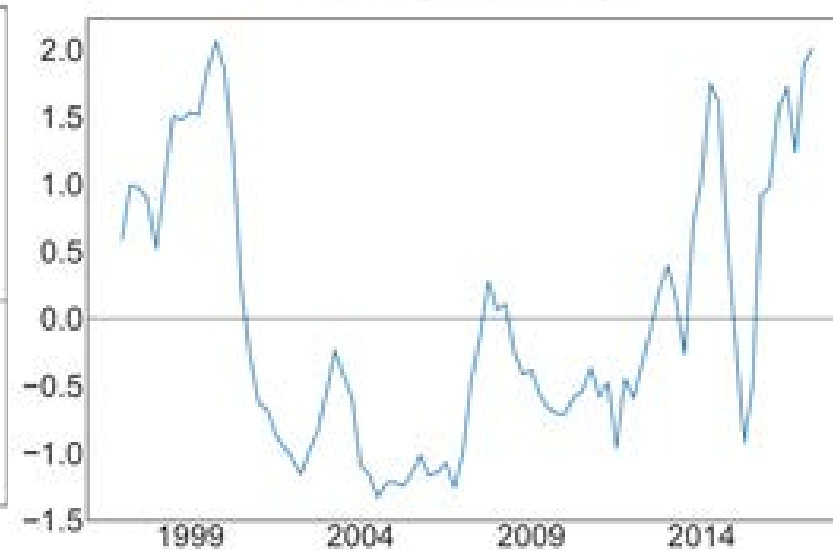


Step 1: Partitions

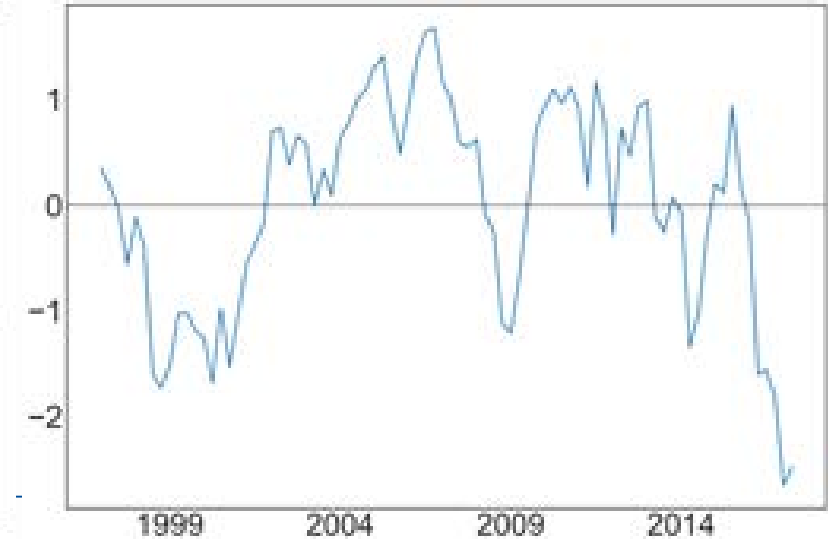
Price of Risk over time



Leverage over time



External over time

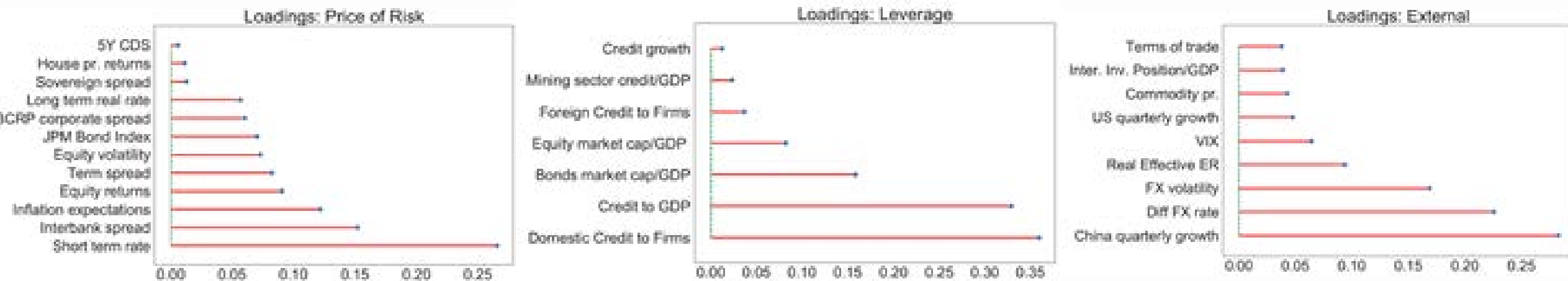


Three partitions were considered:

- **Price of Risk:** domestic and external asset prices (returns, spreads, volatility metrics)
- **Leverage:** selected measures of household- and corporate-sector leverage
- **External:** other relevant factors, e.g., main trading partner growth, commodity prices



Step 1: Loadings



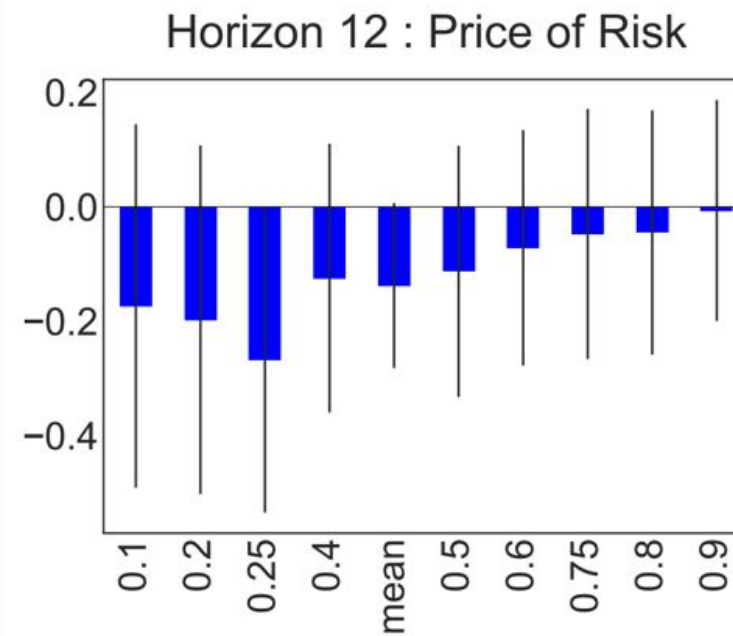
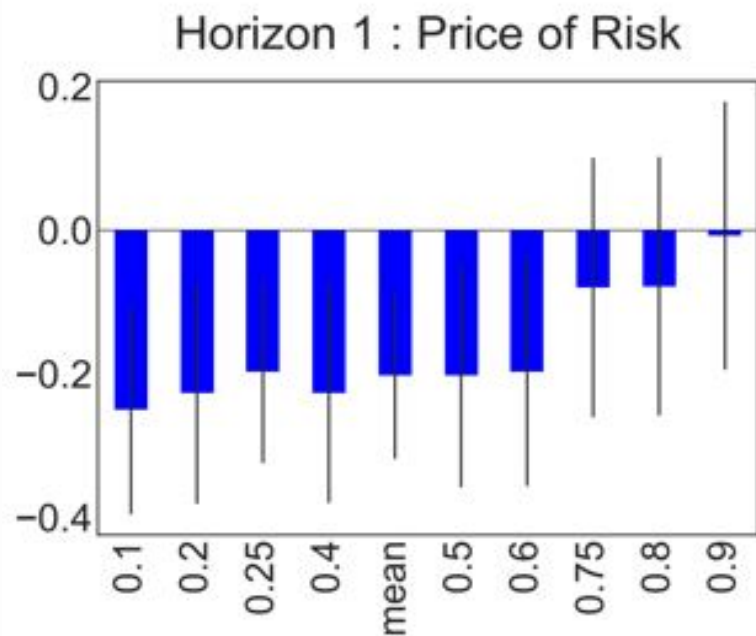
Partition “loadings” quantify the relative importance of variables:

The most influential macrofinancial variables include:

- **Price of Risk:** short-term rates, interbank spreads
- **Leverage:** domestic credit measures
- **External:** Chinese growth, FX-related variables



Step 2: Quantile Regression Coefficients

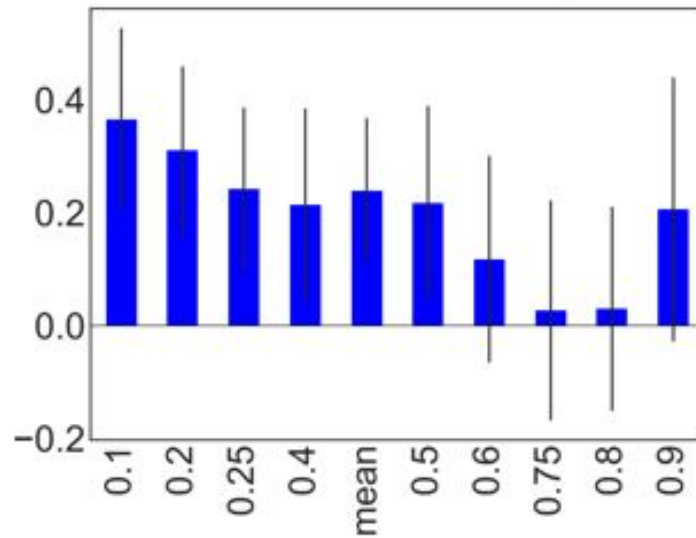


Price of risk is negatively correlated with near-term future growth, especially for lower tail...

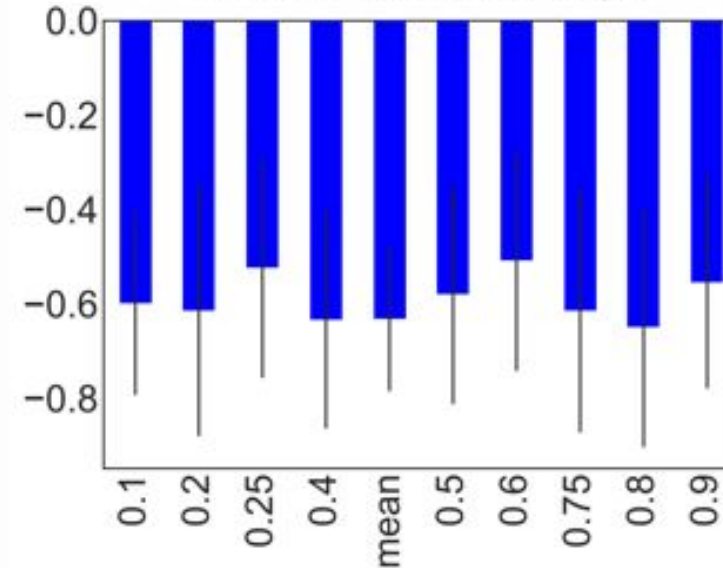


Step 2: Quantile regression Coefficients

Horizon 1 : Leverage



Horizon 12 : Leverage

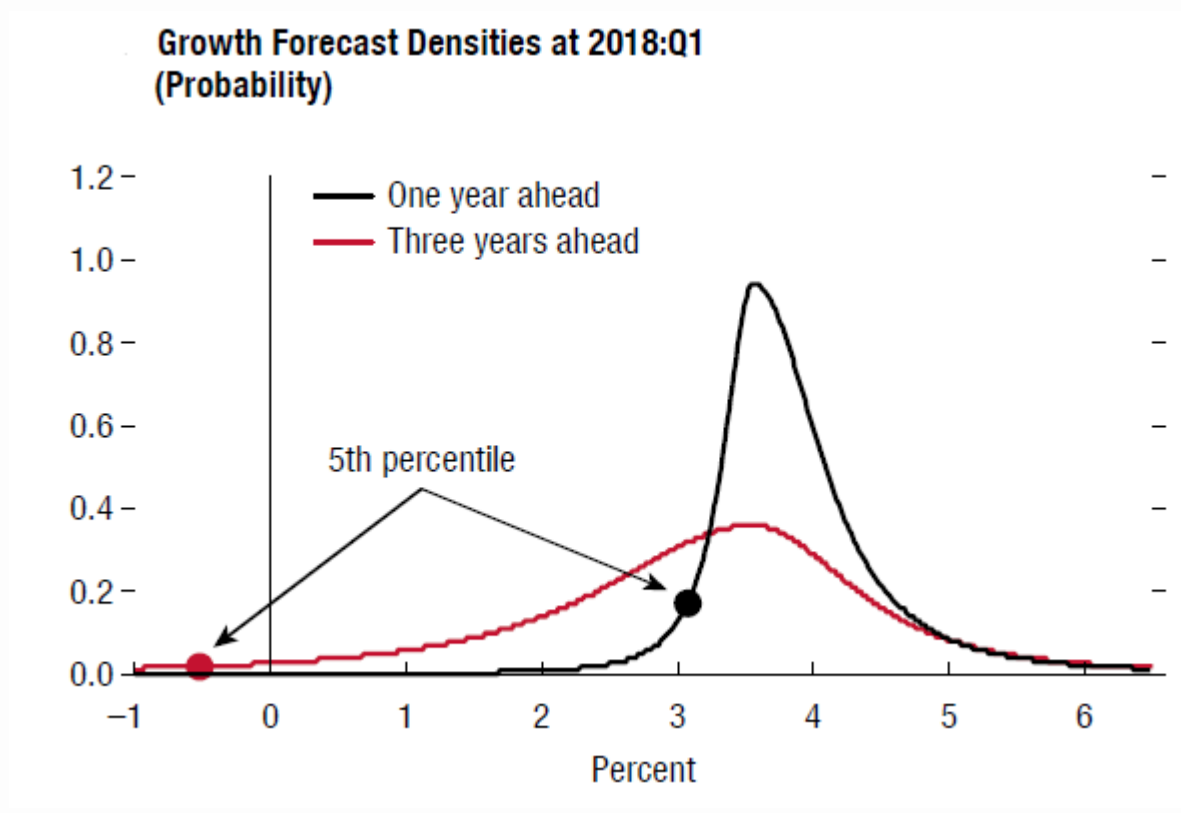


In contrast, **leverage** is positively associated with growth 1 quarter ahead...

- ...but it is strongly negatively correlated 12 quarters out.
- A clear example of how loose financial conditions can stimulate growth in the near term...
- ...but increase the likelihood of medium-term downside risks.



Step 3: Conditional Distributions



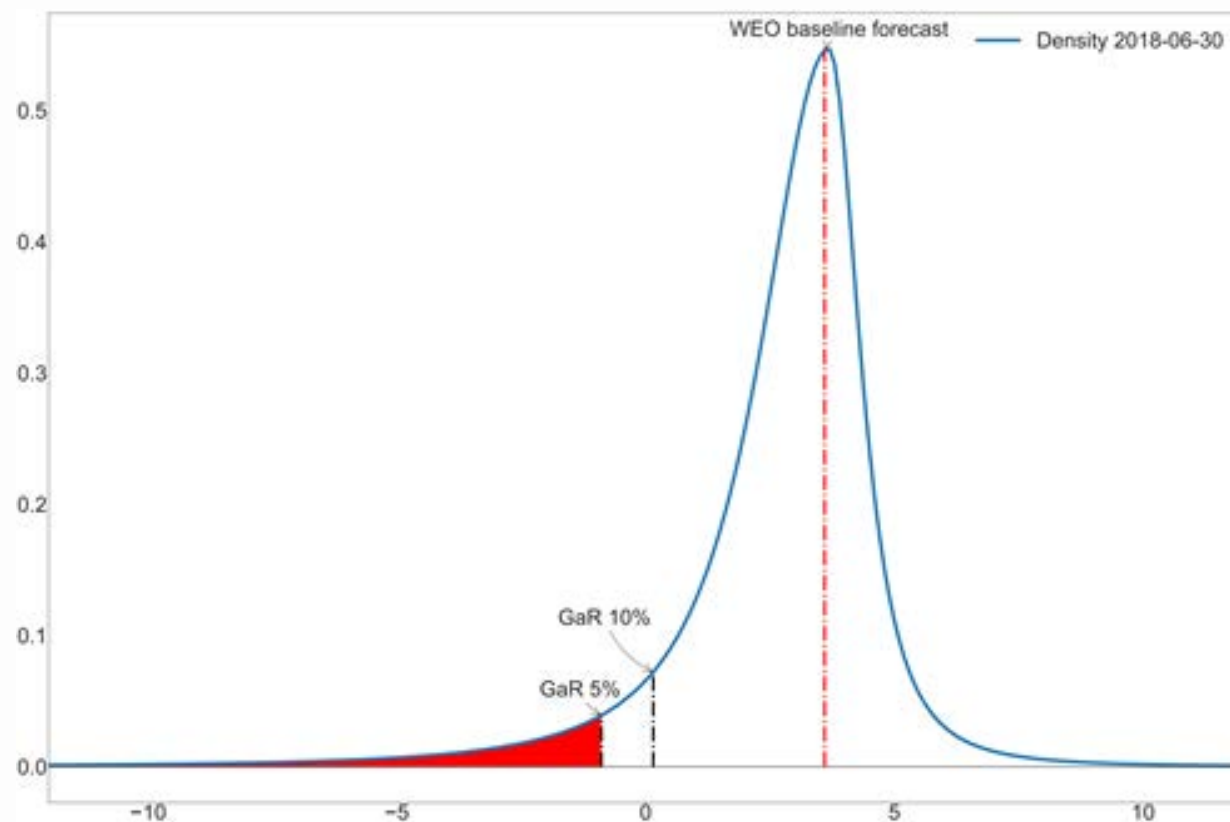
Accommodative financial conditions tend to dampen near-term risks...

...but also raise the odds of adverse medium-term growth outcomes.

Notice the relatively fatter left tail of the three-year-ahead growth distribution.



Step 3: Conditional Distributions



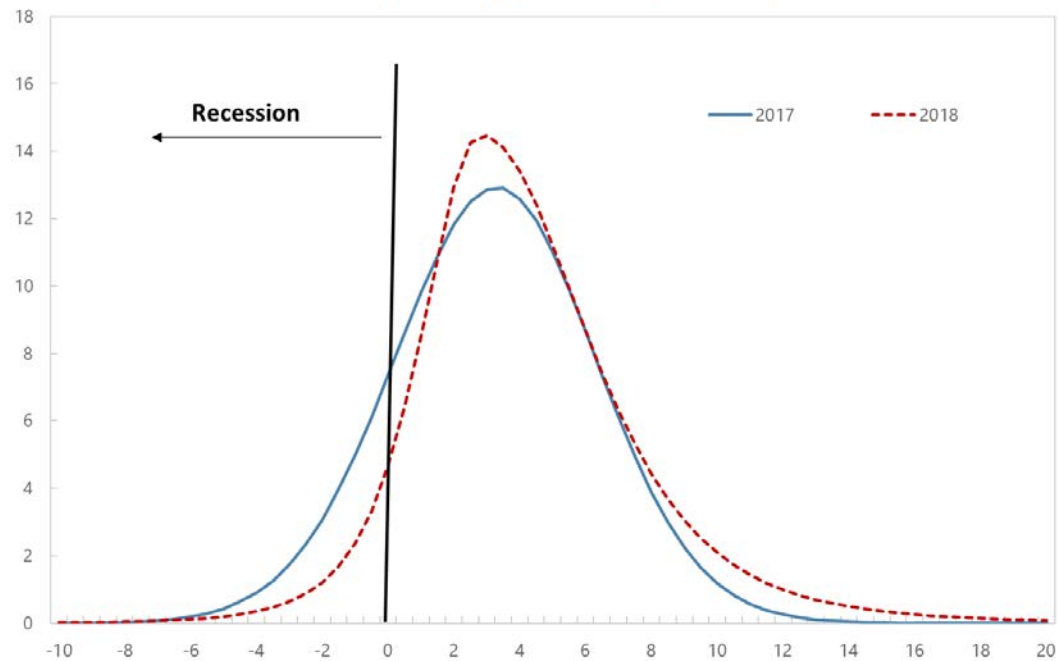
Distributions can be centered around the WEO baseline forecast...

- Notice the negative skew



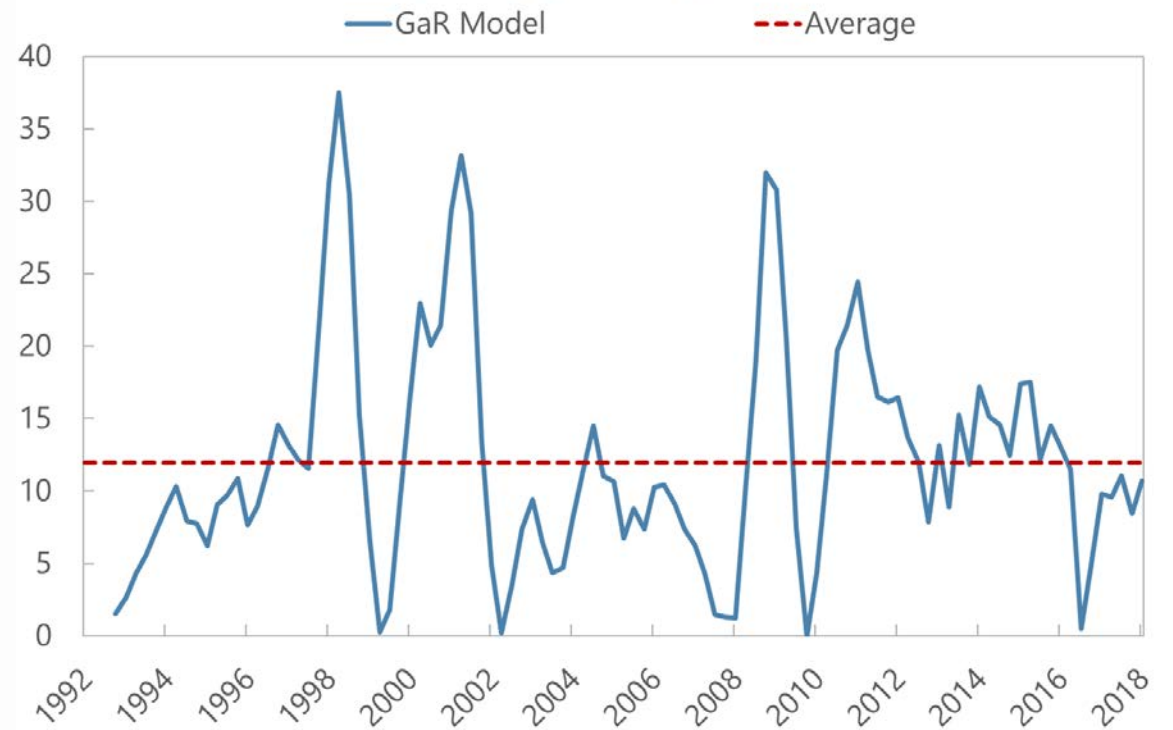
Step 3: Conditional Distributions

Growth Distribution
(percentage points; one-year ahead)



Probability of Recession

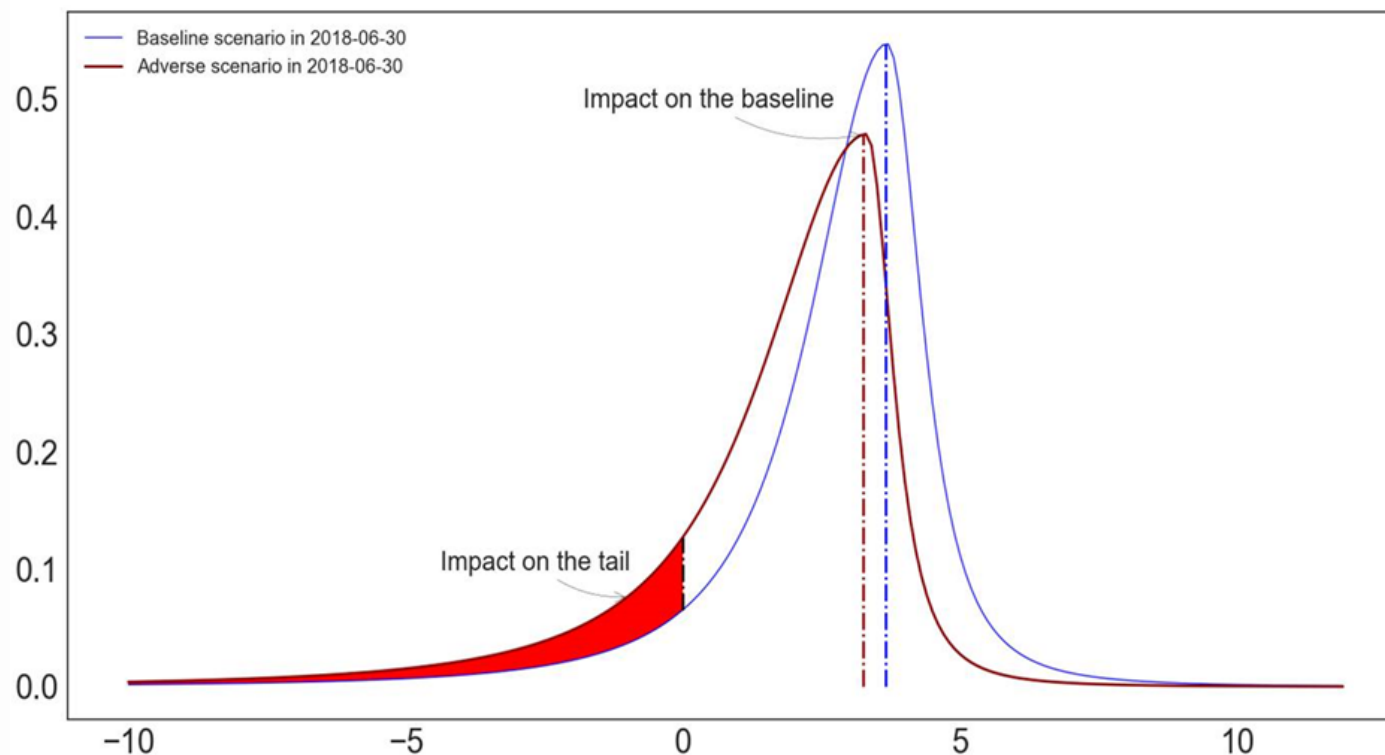
(percentage points; one-year ahead)



Can track the probability of a recession over time...



Step 3: Scenario Analysis: Tighter Financial Conditions



Tool can be used to shock macrofinancial conditions to assess how tail risks change

- Can quantify the impact of a realization of a risk.
- Illustration of how tighter global financial conditions would increase the likelihood of a recession.
- Entire distribution is affected: changes in the average, degree of skewness, and shape of the tails.



Step 3: Scenario Analysis: Risk Quantification

Source of Risk	Relative Likelihood compared with the no-shock scenario	Simulated Shock (<i>in standard deviations</i>)	Estimated Impact on the Median vs. 10 th percentile (<i>in p.p. real growth</i>)	No-shock and counterfactual probability of growth <2%
Weaker than expected growth in main trading partners	Medium	- 2 <u>std</u> in macroeconomic conditions of main trading partners	-1.6 p.p. ; -1.7 p.p.	3% ; 43%
Sharp tightening of financial conditions in the Euro Area	High	+ 2 <u>std</u> in EA FCI composite	-0.9 p.p. ; -1 p.p.	3% ; 20%
Financial turmoil in key partners country	Medium	+ 2 <u>std</u> in key partners bond rates	-1.1 p.p. ; -1.8 p.p.	3% ; 25%
Increase in leverage	Low	+ 2 <u>std</u> in leverage index	-0.4 p.p. ; -2 p.p.	3% ; 16%



GaR Tool Screenshots



GaR Tool: Screenshots

Excel Tool for Estimating Growth at Risk Model
This version: v1.4 - February 2019

Work distributed under the license [Creative Commons Attribution-NonCommercial-ShareAlike 3.0 IGO](https://creativecommons.org/licenses/by-nc-sa/3.0/igo/) (CC BY-NC-SA 3.0 IGO) <https://creativecommons.org/licenses/by-nc-sa/3.0/igo/>. When using the tool, please cite: Prasad et al. (2019), "Growth at Risk: Concept and Application in IMF Country Surveillance", IMF working paper, as well as Lafarguette, R. (2019) "Growth at Risk Tool: Technical Appendix." mimeo, International Monetary Fund

This file fits the Growth at Risk model (cf Adrian et al., Vulnerable Growth (American Economic Review, forthcoming)), with data partitioning, constrained optimization, distribution fitting, counterfactual scenario design and multiple horizons projections.

Python has to be installed on the computer through the software center to be able to execute the Excel file. Please refer to the documentation attached in the folder for a step-by-step explanation.

For questions about the methodology, please contact Romain Lafarguette (rlafarguette@imf.org). For questions related with the Excel tool, please contact Wang Changchun (ITD, cwang2@imf.org). Reuse of this tool and IMF data does not imply any endorsement of the research and/or product. Any research presented should not be reported as representing the views of the IMF, its Executive Board, or member governments.

NB: The data set used in this tool has only an illustrative purpose and comes from public sources, aggregated through © Haver. Data should be replaced by the user's own data when running the tool.

Legend:
 Yellow worksheets are user inputs
 Blue worksheets are outputs
 Pink worksheets are log files

Instructions

There are 6 main functions, Running Partition, Quantile Regression, Tskew Fit, Historical Distributions, Scenario Design and Multiple Horizons Projections. Compulsory inputs are highlighted in orange, optional inputs are in green. Fill numerical data data in Data spreadsheet (for missing values, please leave blank), with the first column for questions, contact Romain Lafarguette (rlafarguette@imf.org) and Wang Changchun (cwang2@imf.org). When using the tool, please cite: Prasad et al. (2019), "Growth at Risk: Concept and Application in IMF Country Surveillance", IMF working paper, as well as Lafarguette, R. (2019) "Risk Tool: Technical Appendix." mimeo, IMF

Common Parameters

The parameters below are common to all 6 steps. If these are changed then all 6 steps should be run again in order.

Forecast variable in level	real_gdp_moving_sum
Forecasting horizon in periods	4

Partition Parameters

Frequency	Quarterly
Start Date	3/31/2002
End Date	6/30/2018
Partition Method	PCA
Benchmark Percentile Cutoff (in case of LDA)	20%
Growth Calculation Method (compound, year on year or level)	qpd
Retropolated Partitions	Yes

Partition sheet name (default: Output_partitions)
Loadings sheet name (default: Output_loadings)

Output sheets will be overwritten for pre-existing sheets
Results are Z-scored

1st of 6
Run the partitions

Quantile Regression Specification and Parameters

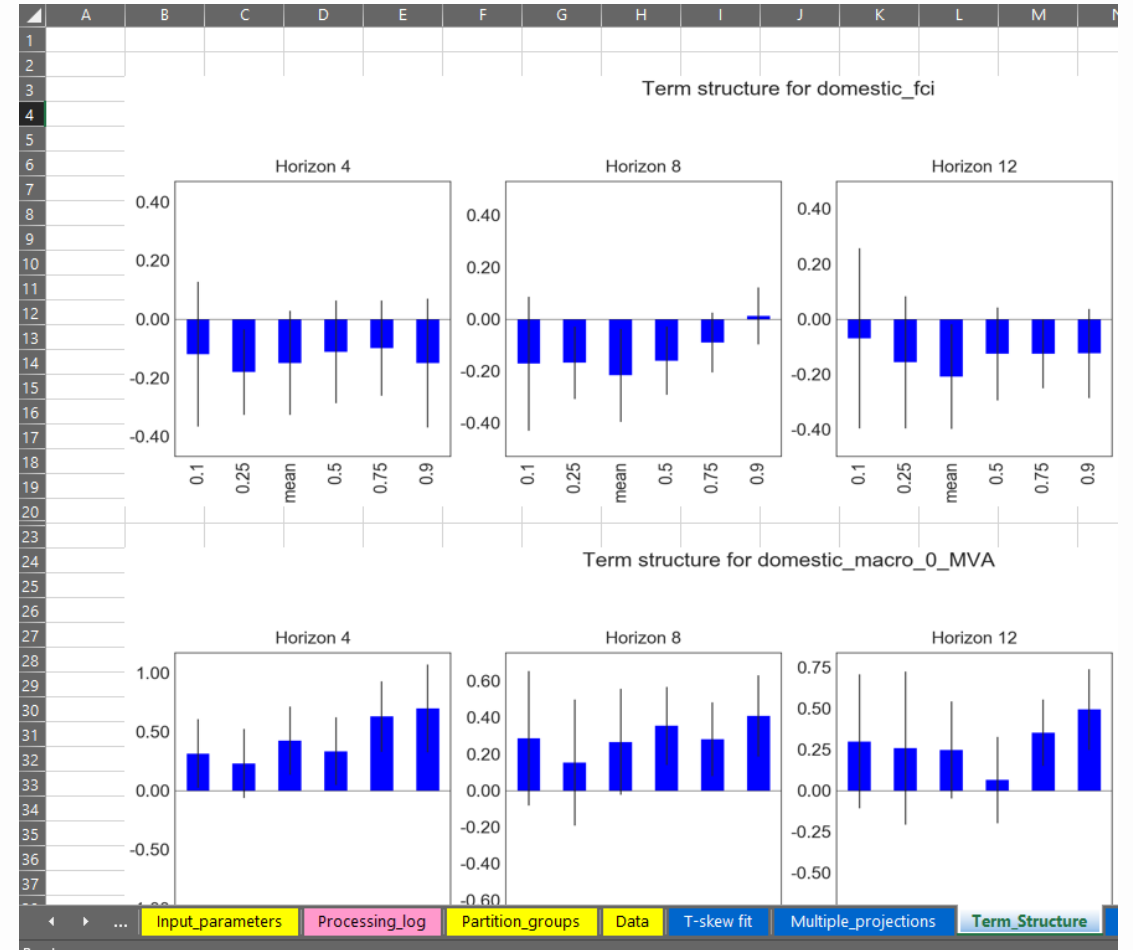
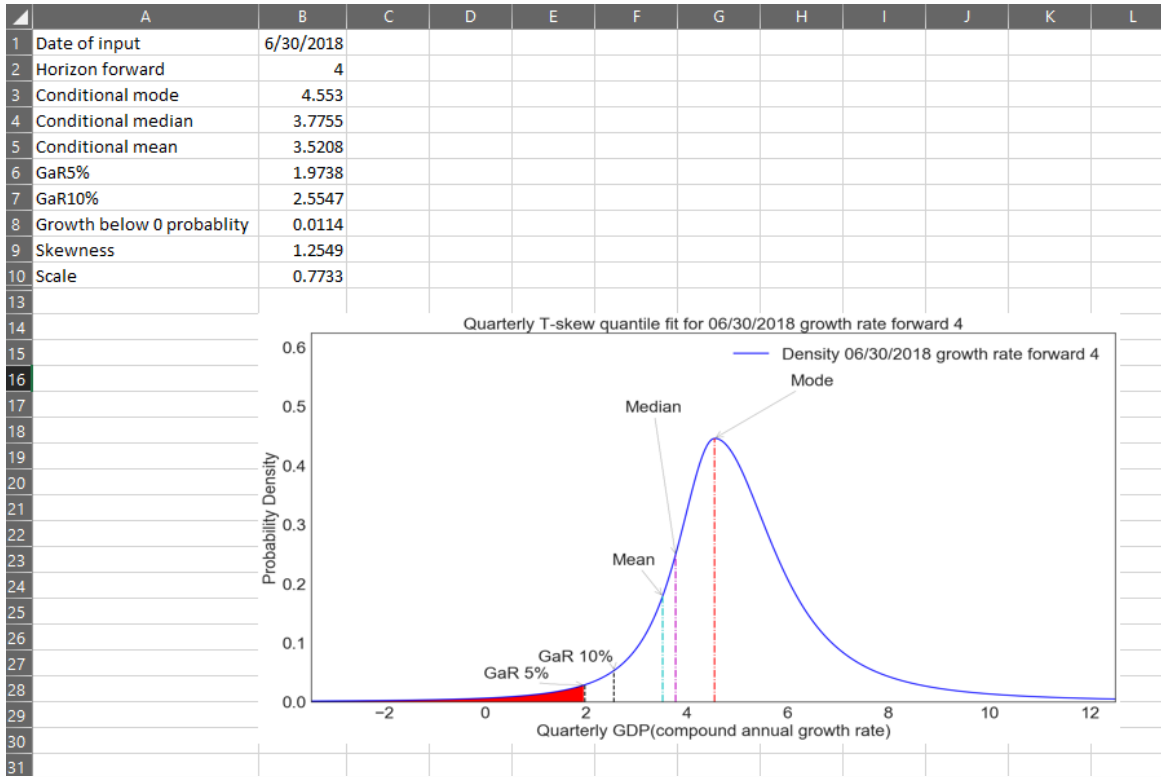
Fill as many as necessary, but the regressors should be in the partition groups columns

Regressors	Transformation	Parameter (Click for info)	Quantiles list (between 0 and 1)
domestic_macro	MVA	2	0.10
domestic_fc	None		0.25
			0.50

These values are fixed and required

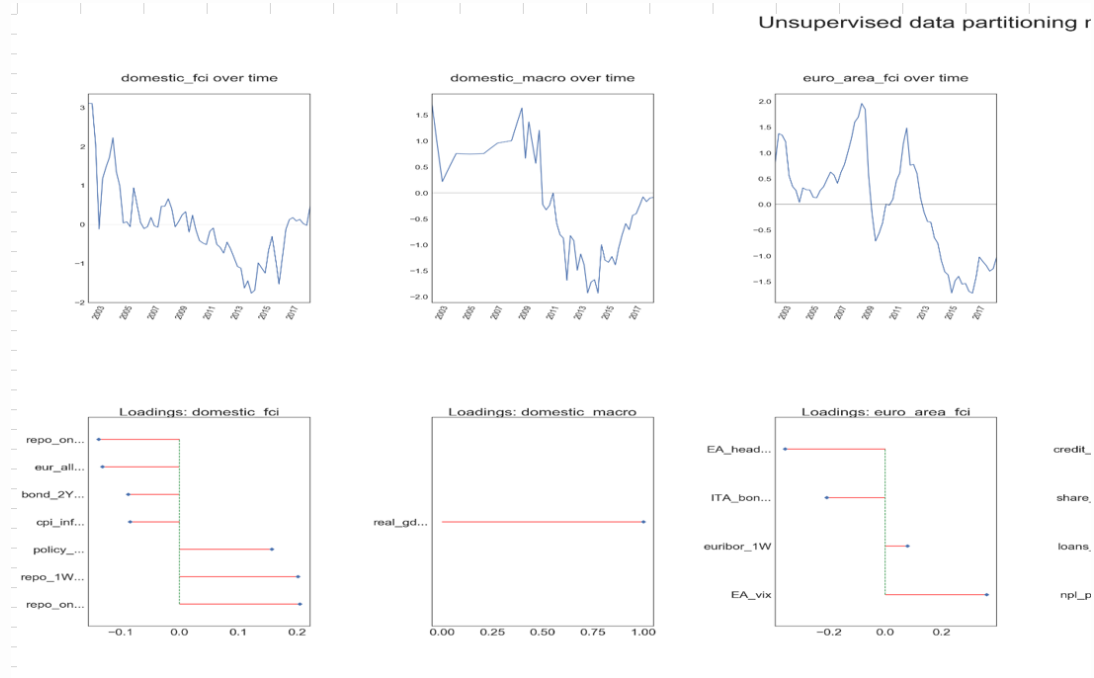


GaR Tool: Screenshots

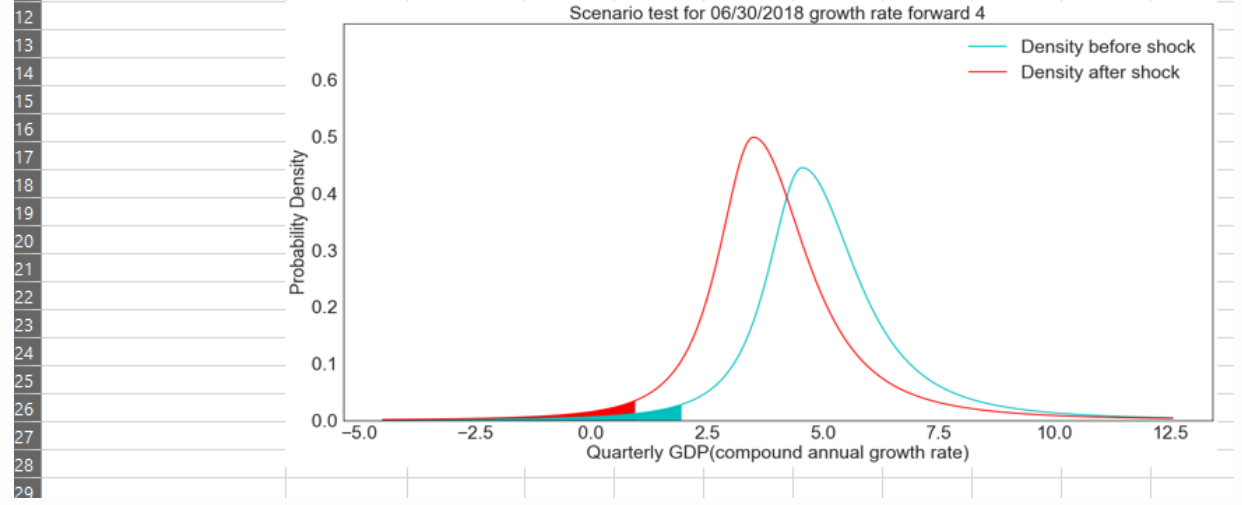




GaR Tool: Screenshots



	A	B	C	D	E	F	G	H	I	J	K
1		Before shock	After shock								
2	Date of input	6/30/2018	6/30/2018								
3	Horizon forward	4	4								
4	Conditional mode	4.552954869	3.500576868								
5	GaR5%	1.950576868	0.950576868								
6	GaR10%	2.550576868	1.500576868								
7	Growth below 0 probability	0.0114	0.02								
8	Skewness	1.2549	1.2282								
9	Scale	0.7733	0.6934								



 Looking forward:

Paper:

- Growth at Risk: Concept and Application in IMF Country Surveillance—IMF WP/19/36 (A. Prasad, S. Elekdag, P. Jeasakul, R. Lafarguette, A. Alter, A.X. Feng, C. Wang)

Tool:

- Available at **GitHub**: <https://github.com/IMFGAR/GaR>

Related and forthcoming work:

- The Term Structure of Growth-at-Risk—IMF WP/18/180 (T. Adrian, F. Grinberg, N. Liang, S. Malik)
- Downside Risks to House Prices—GFSR (April 2019)
- A Financial Stability Monitoring Framework for the GFSR—IMF SDN (forthcoming) (T. Adrian, D. He, N. Liang, F. Natalucci)

Thank you!

The views expressed in the presentation are those of the author and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.