

# Density Forecasting: Growth at Risk

## Part II. Applications

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



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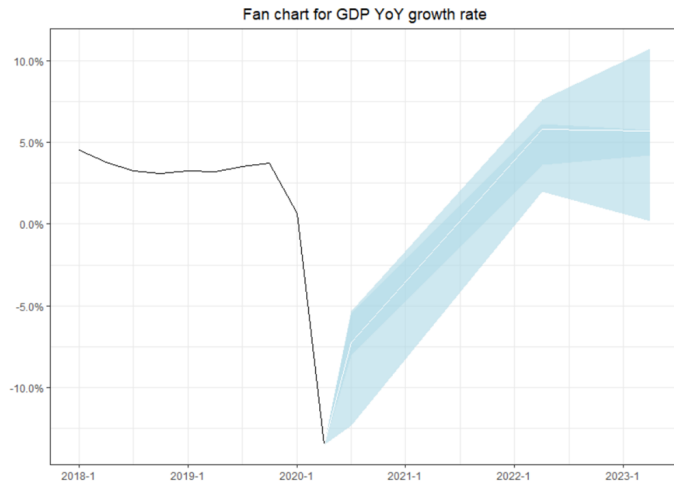
2

## Excel Tool

# Fan Charts

- Fan charts are popular to present the balance of risks going forward
- Density forecasting is a natural framework to build fan charts
- Fundamentally different from the fan charts inherited from VAR (or SVAR)
  - ▶ In a VAR-fan chart, the distribution comes from the residual (the “ $\epsilon$ ”): uncertainty here is about our ignorance of the deterministic DGP centered around the mean
  - ▶ In a density framework however, the DGP is fundamentally uncertain: there are no residuals, the object of interest is the distribution itself

# Fan chart: Israel 2020

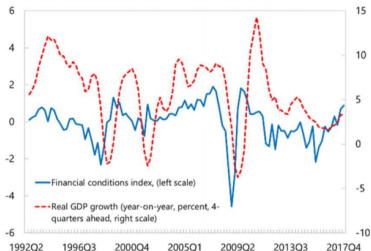


*Source: Bol Financial Stability Report, June 2020*

# Singapore: Probability of Recessions

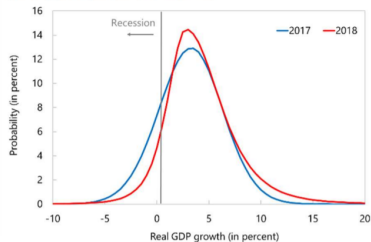
- Probability of recession (growth below zero) in Singapore
- Identify key macrofinancial variables: External factors, financial conditions, housing, China

Financial Conditions and Real GDP Growth



Conditional Distribution of Real GDP Growth

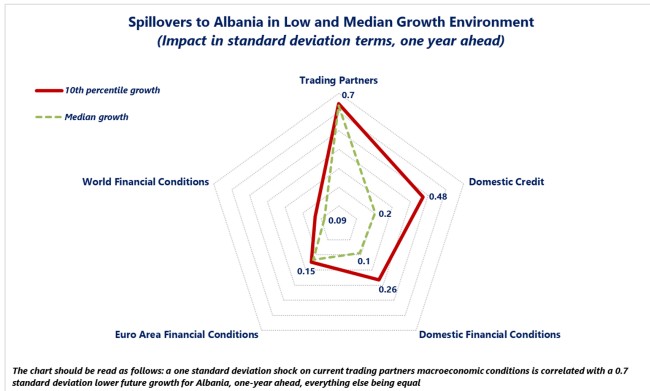
(Probability, year-on-year growth, 4-quarters ahead)



*Source: IMF Article IV (2018)*

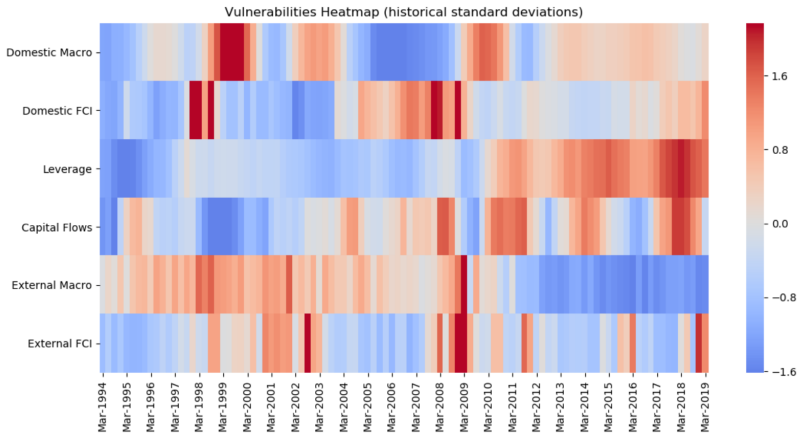
# Spillover analysis

## Spillovers Amplification in Crisis Time



Source: IMF Albania Article IV 2019

# Vulnerabilities Heatmap



Source: IMF Staff

# Assessing the Likelihood of a Scenario (I)

- A simple use of GaR is to estimate the likelihood of a scenario, provided via other methods (2 standard deviations, structural models, etc.)
- Because GaR provides the full conditional distribution, the probability of any given scenario can be estimated
- Useful approach to put the "severity" of stress-testers assumptions into perspective



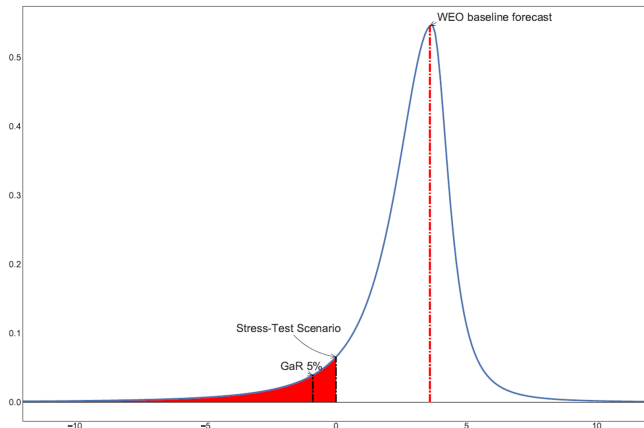
# Assessing the Likelihood of a Scenario (II)

## Results:

Probability of  
recession (stress-  
test scenario): 8.9%

GaR at 5%: -0.9%

GaR at 10%: 0.2%



*Source: IMF FSAP (2018)*

# Modeling Tail-Risks Around a Baseline Scenario

- Using the constrained approach, possibility to make the density forecast consistent with the authorities **baseline scenario**
- **Consistency**: if the authorities scenario is very optimistic, the left tail will inflate accordingly
- Useful to discuss the drivers of the model (partitions and the quantile regressions coefficients)

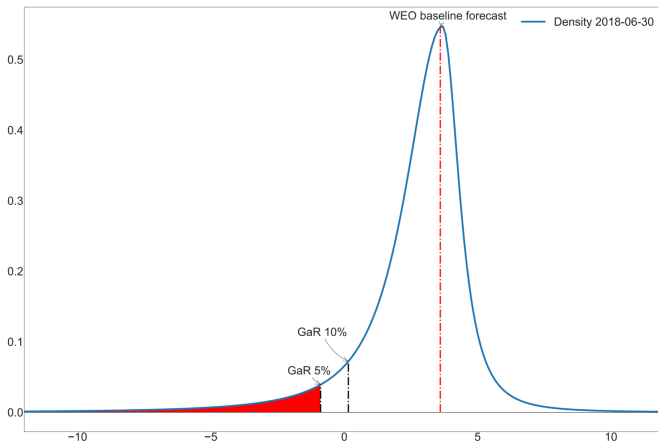
# Modeling Tail-Risks Around a Baseline Scenario (II)

## Results:

WEO baseline: 3.6%

Growth at Risk at  
5%: -0.9%

Growth at Risk at  
10%: 0.2%



*Source: IMF FSAP (2018)*

# Shocks Simulation

- Simulate scenario via **counterfactual regressors**
- E.g. impact of 2-std fci shock on future growth ?
- The tool estimates counterfactual scenarios:
  - 1 On a new  $\tilde{X}_t$  ad-hoc generated by the user
  - 2 Using the same  $\hat{\beta}^\tau$  as estimated over past data
- Interesting point: a **shock can be amplified at certain points of the distribution** (non-linearities)

## Comparative Static Approach

- The shock on  $X_t$  is "*ceteris paribus*": NOT a structural shock in a VAR-sense
- Should be used to inform about potential spillovers, not for rigorous policy analysis: transmission channels are **not clearly identified**

# Comparative Static Example (I)

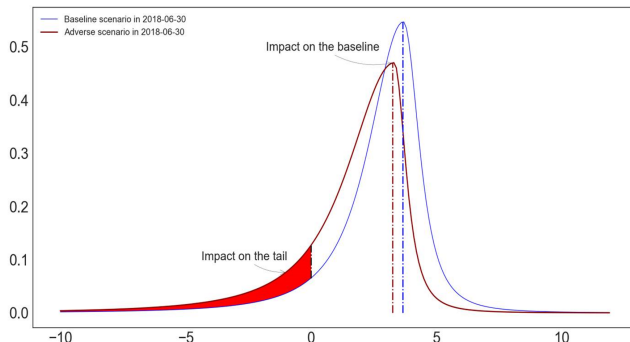
## Impact of Tightened Financial Conditions on Growth

Adverse scenario assumes a 1 sd shock on price of risk

### Results:

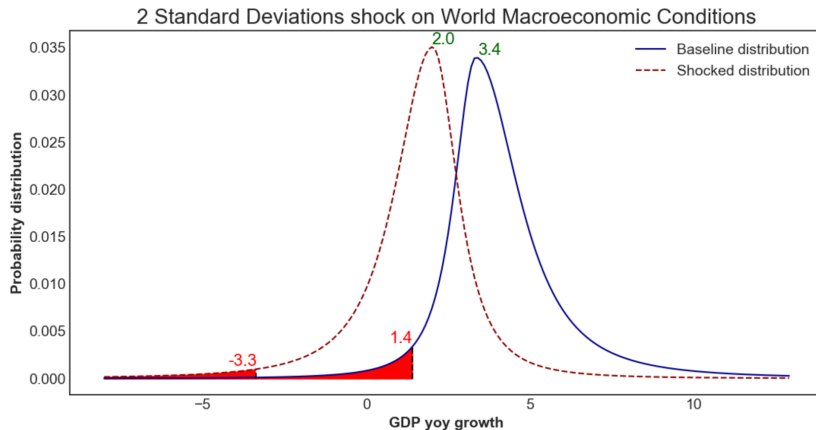
Impact on the average growth:  
from 3.6% to 3.25%

Impact on the cumulative probability of a recession: from 8% to 18%



*Source: IMF Staff*

# Comparative Static Example (II)



*Source: IMF Staff*

# Quantifying the Risk Assessment Matrix (RAM)

- Because GaR is a density, it provides not only the pdf, but also the cdf and quantile functions
- Using the scenario analysis above, it is straightforward to quantify the RAM in terms of:
  - 1 Risks to the **baseline**
  - 2 **Tail**-risks
- Again, this is a comparative statics analysis without clean identification

# Quantifying the RAM: Albania

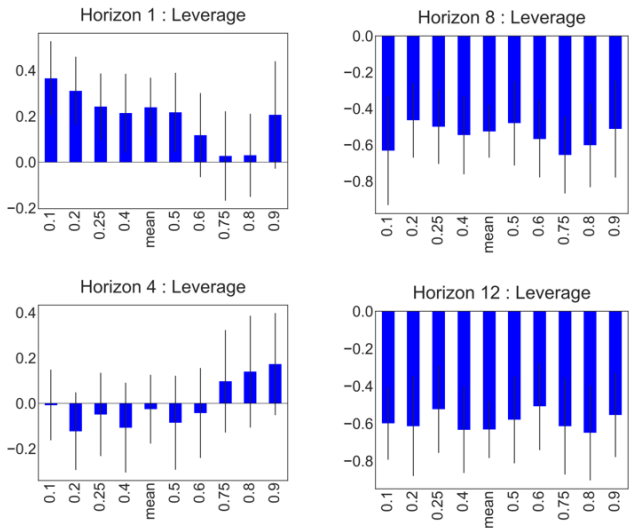
## Quantitative Risk Assessment, One-Year Horizon

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 <sup>th</sup> 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 std 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 std in EA FCI composite	-0.9 p.p ; -1 p.p	3% ; 20%
Financial turmoil in key partners country	Medium	+ 2 std in key partners bond rates	-1.1 p.p. ; -1.8 p.p.	3% ; 25%
Increase in leverage	Low	+ 2 std in leverage index	-0.4 p.p. ; -2 p.p.	3% ; 16%

*Source: IMF Albania Article IV (2018)*



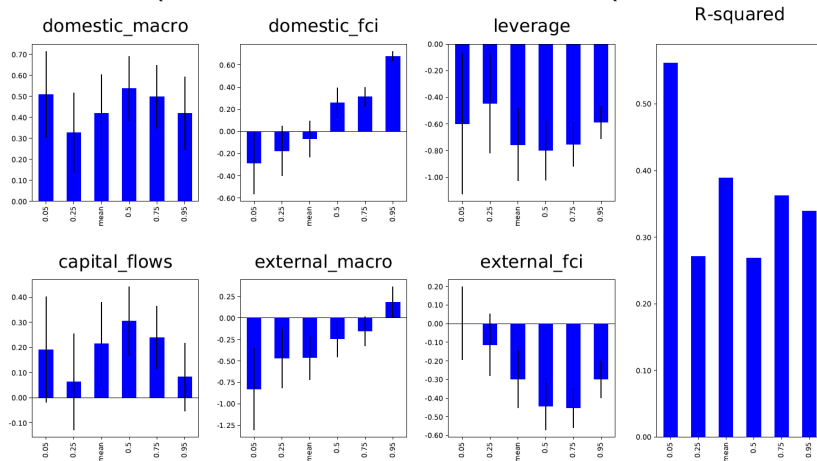
# Term Structure of Growth at Risk (Local Projections)



Source: IMF Staff

# Quantile Regressions Output 1 year Ahead

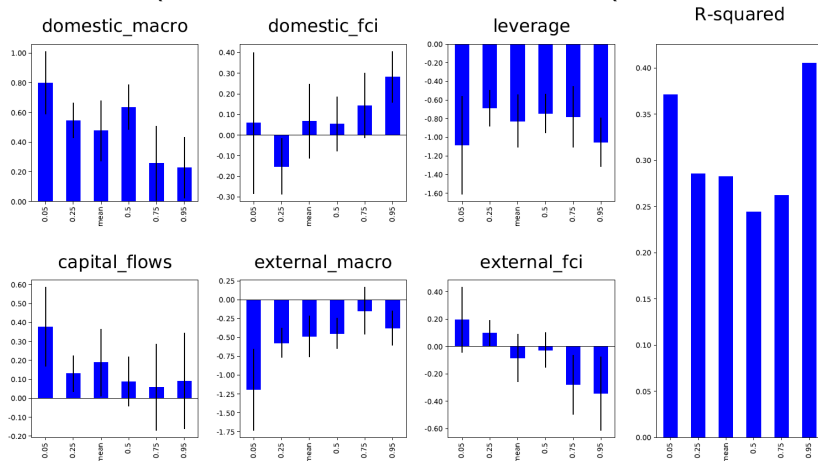
## Quantile Coefficients for Growth at Horizon 4-Quarter



Source: IMF Article IV (2018)

# Quantile Regressions Output 2 years Ahead

## Quantile Coefficients for Growth at Horizon 8-Quarter



Source: IMF Article IV (2018)

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- Quantile Regressions
- Distribution Fit
- Advanced topics: Term Structure and Scenario Design
- Support

# Making Sense of GaR

- We developed a user-friendly Excel tool
- The Excel tool makes it easier for economists to estimate multi-layers density forecasting model
- However, it can not be applied automatically to forecast risk to growth for a country
  - The tool is just a set of Python macros with an Excel interface
  - The tool has limitations, but is useful to quickly dig into the model and see if "it worths it" to invest in GaR

# Applied Work with GaR

- Identify key macro-financial factors and vulnerabilities guided by economic intuition, experience, theory
- Understand what variables shift the mean and what variables change the volatility and downside risk
- Aggregate data and construct meaningful regressors (cf partitioning). Evaluate whether the data partitions make economic sense
- Design appropriate GaR model by specifying quantiles, forecasting horizon, independent/control variables
- Be mindful of limitations and caveats, correlation/causation, data quality, sample size, types of financial regressors, etc.

# Install Free and Open-Source Python Anaconda distribution

## Anaconda Installers

### Windows

#### Python 3.7

64-Bit Graphical Installer (466 MB)

32-Bit Graphical Installer (423 MB)

#### Python 2.7

64-Bit Graphical Installer (413 MB)

32-Bit Graphical Installer (356 MB)

### MacOS

#### Python 3.7

64-Bit Graphical Installer (442 MB)

64-Bit Command Line Installer (430 MB)

#### Python 2.7

64-Bit Graphical Installer (637 MB)

64-Bit Command Line Installer (409 MB)

### Linux

#### Python 3.7

64-Bit (x86) Installer (522 MB)

64-Bit (Power8 and Power9) Installer (276 MB)

#### Python 2.7

64-Bit (x86) Installer (477 MB)

64-Bit (Power8 and Power9) Installer (295 MB)

*Source: <https://www.anaconda.com/products/individual>*

# Download GaR from Github (Official IMF Repo)

IMFGAR / GaR

Unwatch 7 Unstar 29 Fork 17

Code Issues Pull requests Actions Projects Wiki Security Insights

master 1 branch 0 tags

Go to file Add file Code

IMFGAR fixed a bug for possible error when force negative mode


File	Description	Updated
Documentation	Add files via upload	
GAR	fixed a bug for possible error when for	
EN-logo_large_blue.png	Add log of IMF	
GaR_license.txt	Add files via upload	
IMF disclaimer.txt	Add files via upload	17 months ago
README.md	Update to new version 10/28/2019.	8 months ago
gar.xism	Update to new version 10/28/2019.	8 months ago
readme.txt	Update to new version 10/28/2019.	8 months ago
run_GaR.py	Update to new version 10/28/2019.	8 months ago

Clone with HTTPS Use Git or checkout with SVN using the web URL. <https://github.com/IMFGAR/GaR.git>

Open with GitHub Desktop

Download ZIP

README.md



## Growth at Risk

### Disclaimer

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.

About

No description, website, or topics provided.

Readme

Releases

No releases published. [Create a new release](#)

Packages

No packages published. [Publish your first package](#)










Languages

- Python 100.0%






Source: <https://github.com/IMFGAR/GaR>



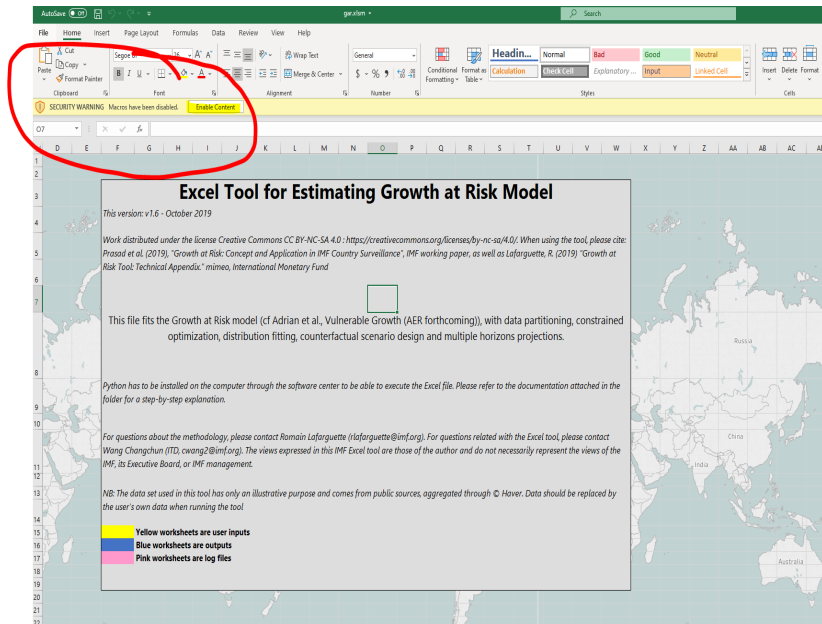
# Unzip the folder: Documentation and Main Excel File

Name	Date modified	Type	Size
 Documentation	4/29/2020 3:07 PM	File folder	
 GAR	4/29/2020 3:07 PM	File folder	
 EN-logo_large_blue.png	4/29/2020 3:07 PM	PNG File	268 KB
 GaR license.txt	4/29/2020 3:07 PM	Text Document	19 KB
 gar.xlsm	4/29/2020 3:07 PM	Microsoft Excel M...	3,020 KB
 IMF disclaimer.txt	4/29/2020 3:07 PM	Text Document	1 KB
 README.md	4/29/2020 3:07 PM	MD File	2 KB
 readme.txt	4/29/2020 3:07 PM	Text Document	2 KB
 run_GAR.py	4/29/2020 3:07 PM	PY File	2 KB

# Documentation

 GaR - IMF Working Paper 19-36.pdf	4/29/2020 3:07 PM	Adobe Acrobat D...	2,307 KB
 GaR - Technical Appendix.docx	4/29/2020 3:07 PM	Microsoft Word D...	933 KB
 GaR license.txt	4/29/2020 3:07 PM	Text Document	19 KB
 HowToUseGaR.docx	4/29/2020 3:07 PM	Microsoft Word D...	396 KB
 Some examples of IMF GaR applications....	4/29/2020 3:07 PM	Microsoft Word D...	21 KB

# Open the Excel tool and enable content



The screenshot shows the Microsoft Excel interface. The ribbon is set to 'Home'. A red circle highlights the 'Enable Content' button in the 'Clipboard' group on the 'Home' ribbon. Below the ribbon, a yellow warning bar states: 'SECURITY WARNING: Macros have been disabled. [Enable Content]'. The background of the spreadsheet is a world map. A text box is overlaid on the map, containing the following text:

**Excel Tool for Estimating Growth at Risk Model**

This version: v1.6 - October 2019

Work distributed under the license Creative Commons CC BY-NC-SA 4.0 : <https://creativecommons.org/licenses/by-nc-sa/4.0/>. 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 (AER 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](mailto:rlafarguette@imf.org)). For questions related with the Excel tool, please contact Wang Changchun (ITD, [cwang2@imf.org](mailto:cwang2@imf.org)). The views expressed in this IMF Excel tool are those of the author and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

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

- Yellow worksheets are user inputs
- Blue worksheets are outputs
- Pink worksheets are log files

# Input data on the "Data" yellow sheet

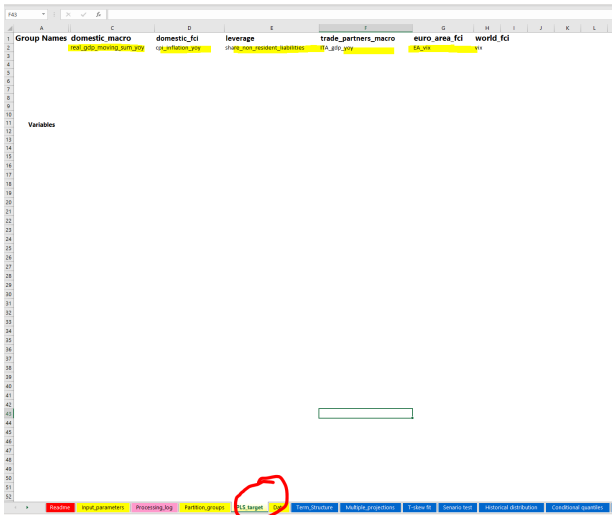
	A	B	C	D
1	date	real_gdp_moving_sum	real_gdp_moving_sum_yoy	repo_1w_rate
2	3/31/2001	720666.53		
3	6/30/2001	735802.47		
4	9/30/2001	75038.41		
5	12/31/2001	765474.35		
6	3/31/2002	780410.29		0.0829007
7	6/30/2002	789267.87		0.07295435
8	9/30/2002	798125.45		0.06340187
9	12/31/2002	800983.03		0.054228089
10	3/31/2003	815840.61		0.045399606
11	6/30/2003	827119.71		0.047958167
12	9/30/2003	838398.81		0.050459937
13	12/31/2003	849677.91		0.052906788
14	3/31/2004	860357.01		0.053100208
15	6/30/2004	872816.49		0.05348327
16	9/30/2004	884876.37		0.05519755
17	12/31/2004	896536.05		0.055148121
18	3/31/2005	908395.73		0.055099987
19	6/30/2005	920954.1075		0.055151807
20	9/30/2005	933512.485		0.05502237
21	12/31/2005	946070.8625		0.055251334
22	3/31/2006	958629.24		0.055299148
23	6/30/2006	972769.2225		0.056262429
24	9/30/2006	986909.205		0.057199792
25	12/31/2006	1001049.188		0.05811227
26	3/31/2007	1015189.17		0.05900084
27	6/30/2007	1030366.203		0.05920295
28	9/30/2007	1045543.235		0.059417777
29	12/31/2007	1060720.268		0.059608539
30	3/31/2008	1075897.3		0.05979982
31	6/30/2008	1096070.293		0.063767707
32	9/30/2008	1116243.285		0.067620398
33	12/31/2008	1136416.278		0.071362839
34	3/31/2009	1133955.953		0.053628402
35	6/30/2009	1188924.635		0.066468677
36	9/30/2009	1182059.318		0.058962086
37	12/31/2009	1195134		0.051845194
38	3/31/2010	1205576		0.063497093
39	6/30/2010	12125268		0.037936338
40	9/30/2010	1223979		0.035461265
41	12/31/2010	1239645		0.037069974
42	3/31/2011	1255487		0.041400127
43	6/30/2011	1250088		0.030942595
44	9/30/2011	1256685		0.026721047
45	12/31/2011	1271200		0.025454868
46	3/31/2012	1268806		0.010608632
47	6/30/2012	1283037		0.026357344
48	9/30/2012	1287593		0.024594867
49	12/31/2012	1289218		0.014174009
50	3/31/2013	1294077		0.01991715
51	6/30/2013	1303063		0.01599798
52	9/30/2013	1295356		0.006184408
53	12/31/2013	1302136		0.010020028
54	3/31/2014	1308102		0.010818784
55	6/30/2014	1311504		0.006091765
56	9/30/2014	1325606		0.023194675

# Group variables into partitions in the "Partition" excel sheet

	A	C	D	
1	Group Names	domestic_macro	domestic_fci	I
2		real_gdp_moving_sum	repo_1w_rate	C
3			policy_target_deviation	L
4			repo_on_rate_diff	N
5			cpi_inflation_yoy	N
6			eur_all_vol	N
7			repo_on_vol	
8			bond_2y_vol	
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Processing Job Partition\_group PLS\_target Data

# In case of PLS: determine supervising variables in "PLS target" sheet



The screenshot shows a spreadsheet application with a taskbar at the bottom. The taskbar contains several tabs: 'Realtime', 'Input parameters', 'Processing\_log', 'Partition\_group', 'PLS target', 'Data', 'Term structure', 'Multiple projections', 'T-test fit', 'Sensit test', 'Historical distribution', and 'Conditional quantiles'. The 'PLS target' tab is highlighted with a red circle. The spreadsheet area shows a list of variables in column A, with corresponding values in columns B through L. The variables are: 'domestic\_macro', 'domestic\_fci', 'leverage', 'trade\_partners\_macro', 'euro\_area\_fci', and 'world\_fci'. The values are: 'real\_gdp\_growing\_sum\_yoy', 'car\_refaction\_yoy', 'share\_non\_resident\_habitations', 'H4\_gdp\_yoy', 'H4\_ine', and 'H4'.

Group Names	domestic_macro	domestic_fci	leverage	trade_partners_macro	euro_area_fci	world_fci
	real_gdp_growing_sum_yoy	car_refaction_yoy	share_non_resident_habitations	H4_gdp_yoy	H4_ine	H4

# Estimate the partitions: choose horizon, partitioning methods, etc.

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 in Data spreadsheet (for missing values, please leave blank), with the first column as "date". For questions, contact Romain Lafarguette (lafarguette@imf.org) and Wang Chengchun (cswang2@imf.org). When using the tool, please cite: Prosser 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" [version 4.0](#).

Common Parameters

The parameters below are common to all 5 steps. If these are changed then all 5 steps should be run again in order:

Forecast variable to level: real\_gdp\_moving\_sum

Forecasting horizon in periods: 4

Partition Parameters

Frequency: Quarterly

Start Date: 3/31/2002

End Date: 12/31/2019

Partition Method: PCA

Benchmark Percentile Cutoff (in case of LDA): 25%

Output Calculation Method (temporal; year on year or level): out

Interpolated Partitions: Yes

Output sheets will be overwritten for pre-existing sheets

Output sheets will be overwritten for pre-existing sheets

Results are 2 second

Quantile Regression Specification and Parameters

Fill as many of variables as you requires should be in the partition groups columns

Regressors

1 domestic\_macro

2 domestic\_fo

3 leverage

4 trade\_partners\_macro

5 mun\_area\_fo

6 world\_fo

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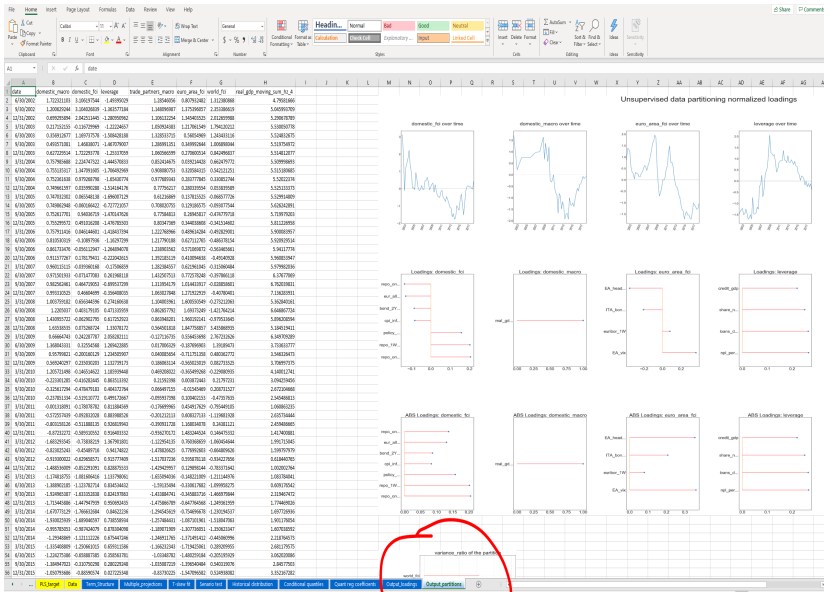
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# Estimated partitions are in "Output partitions"





Estimated loadings are in "Output loadings"

[illegible]

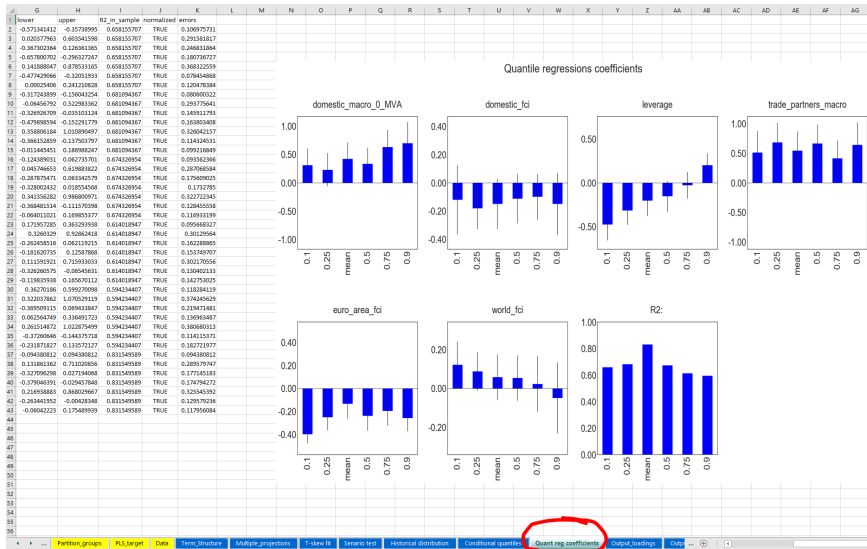
## Parameters for the quantile regressions

### Quantile Regression Specification and Parameters

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

Regressors	Transformation	Parameter (Click for info)	Quantiles list (between 0 and 1)	
domestic_macre	MVA	2	0.10	These values are fixed and required
domestic_fo	None		0.25	
leverage	None		0.50	
inside_porter_macro	None		0.75	
max_asset_size	None		0.90	
world_fo	None			Add quantile additional values - if necessary - in the green area  <div style="border: 1px solid black; padding: 5px; text-align: center;">                         2nd of 6: Run quantile reg                     </div> Partition must be run before quantile regression
	None			
	None			
	None			
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	None			
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	None			
	None			
	None			
Quantile regression sheet name (default: Quant reg coefficients) Conditional quantiles sheet name (default: Conditional quantiles)				Output sheets will be overwritten for pre-existing sheets Output sheets will be overwritten for pre-existing sheets

# Results of the quantile regressions in "Quant Reg Coefficients"

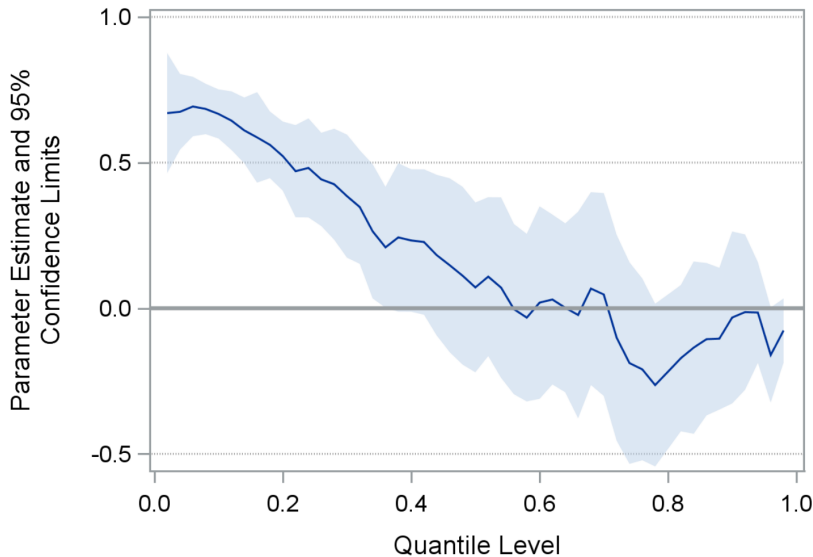


# In-sample Conditional Quantiles in "Conditional Quantiles"

A1	B	C	D	E	F	G	H	I	J	
	date	horizon	tau	realized_value	conditional_quantile_mean	conditional_quantile_mean_se	conditional_quantile_mean_o_lower	conditional_quantile_mean_o_upper	conditional_quantile_obs_o_lower	conditional_quantile_obs_o_upper
1	2/20/2017	4	0.1	5.8459379	5.845434	0.530544	5.305444	5.845434	5.8459379	5.8459379
2	3/1/2017	4	0.1	5.290678789	4.841361771	0.52144931	3.755451707	5.887241855	2.579091451	11.01041401
3	3/3/2017	4	0.1	5.530505778	5.067016166	0.374917042	4.255627811	5.799504452	2.865538924	7.149650477
5	6/30/2017	4	0.1	5.5248132675	5.470406508	0.484787031	4.577506167	6.380583049	3.288002534	7.670808662
6	9/30/2017	4	0.1	5.5175754072	5.519750512	0.445658468	4.617695132	6.330589618	3.130589618	7.719484642
7	12/1/2017	4	0.1	5.5148112077	5.517188352	0.445455034	4.703085192	6.370138352	2.972059696	7.370911938
8	3/3/2018	4	0.1	5.50996693	5.236044637	0.412260075	6.330821318	6.330821318	2.951147173	7.521177787
9	6/30/2018	4	0.1	5.511518085	5.51180085	0.362164228	4.78712034	6.242549829	3.161616374	7.624317189
10	9/30/2018	4	0.1	5.52022178	5.586705763	0.288611718	5.42013951	6.177777142	3.511254047	7.680113316
12	12/31/2018	4	0.1	5.521333373	5.454810129	0.285164129	4.884174447	6.371779432	3.171779432	7.521734274
13	3/1/2019	4	0.1	5.523914809	5.29914426	0.341837624	4.884276932	6.215551877	4.131261702	7.696112410
14	6/30/2019	4	0.1	5.620242021	5.420470907	0.182533912	4.493402044	5.180359139	2.781590346	6.820363466
15	9/30/2019	4	0.1	5.719797023	5.102707729	0.297492088	4.503585798	5.698765681	2.004066344	7.115490514
15	12/31/2019	4	0.1	5.811228958	5.211453308	0.245839694	4.781231237	5.704390592	3.145094781	7.220882876
16	3/1/2020	4	0.1	5.900842857	5.300687212	0.2377501001	4.593632184	5.450598772	2.720882876	7.220882876
17	6/30/2020	4	0.1	5.920591524	5.236059617	0.203666677	4.205751587	6.546005303	3.185113313	7.202977077
18	9/30/2020	4	0.1	5.84131774	5.384287597	0.205794629	4.375511044	5.797056459	3.33650812	7.632063474
19	12/31/2020	4	0.1	5.906534937	5.424523202	0.2135881027	4.2135881027	5.271188303	2.68682754	8.818770965
20	3/1/2021	4	0.1	5.979936306	4.561552407	0.22114408	4.17788354	5.005306496	2.507304446	6.615800467
21	6/30/2021	4	0.1	6.078770289	4.22045753	0.221249591	4.486484377	5.192177573	2.11777573	6.932173753
22	9/30/2021	4	0.1	6.762819381	4.77925389	0.18677582	4.378809564	5.00548814	2.682128469	7.651477909
23	12/31/2021	4	0.1	7.136281933	5.32953931	0.162725246	3.602465134	4.256417342	1.897238114	5.961743106
24	3/1/2022	4	0.1	5.30240161	3.17688825	0.250687288	2.861242372	6.036934478	1.110641763	5.247393507
25	6/30/2022	4	0.1	5.668578741	3.594915685	0.19654976	2.225739025	6.025357965	0.695617527	5.965617527
26	9/30/2022	4	0.1	5.945205094	2.597313818	0.263736966	2.068211025	5.312636612	0.522082538	4.671451385
27	12/31/2022	4	0.1	5.818451781	2.834399071	0.378255215	2.075707166	5.309097975	0.689957226	4.978848815
3/1/2023	4	0.1	6.349770209	2.13757858	0.241218086	1.451105345	2.822797128	5.01768725	4.257880517	5.274680517
29	6/30/2023	4	0.1	7.370316743	3.161579623	0.212316088	1.555114885	5.367091361	1.042941945	5.109780173
30	9/30/2023	4	0.1	7.940269678	3.546321662	0.189790012	1.461493395	5.446889012	0.446889012	6.821785448
31	12/31/2023	4	0.1	7.70895775	3.146881127	0.306576139	2.812534504	5.661123401	1.196739098	5.299635135
32	3/1/2010	4	0.1	4.140031241	3.028181547	0.248066393	2.709277877	3.13724276	5.468193434	5.468193434
33	6/30/2010	4	0.1	4.094359566	3.109023837	0.191330858	2.752628325	3.492783154	1.068898113	5.11512362
34	9/30/2010	4	0.1	3.274210468	2.595911748	0.217133683	2.523779038	3.59481291	0.969881341	5.011891245
35	12/31/2010	4	0.1	2.544488161	2.148500417	0.148500417	2.080991355	4.075211321	0.547211321	5.004741709
36	3/31/2011	4	0.1	1.069693625	1.844220064	0.177543005	1.488114491	2.200126367	-0.150289015	3.881132843
37	6/30/2011	4	0.1	2.635734444	1.841118815	0.239709089	0.982323271	1.949159139	-0.596478737	5.526855054
38	9/30/2011	4	0.1	2.429446665	1.069321026	0.112504516	0.350499554	1.427744667	-1.0460935	3.052735351
39	12/31/2011	4	0.1	1.417408082	0.215449139	0.215449139	0.612701916	1.850957129	2.296645424	5.762794564
40	3/1/2012	4	0.1	1.991751005	0.101606058	0.2421605084	0.218055524	2.38704749	-2.38704749	1.702749154
41	6/30/2012	4	0.1	1.599797979	-0.24004348	0.286621192	-0.814911789	0.334848827	-3.220502558	1.884652896
42	9/30/2012	4	0.1	0.618440705	0.078280061	0.342747827	-0.674061606	0.705282608	-2.041143397	2.197845959
43	12/31/2012	4	0.1	1.002027604	0.472796603	0.215521326	0.040480547	0.90204726	-1.578937616	5.254786523
44	3/1/2013	4	0.1	0.831764041	0.215443127	-0.318115117	-0.589771448	1.166016058	-2.14545449	2.14545449
45	6/30/2013	4	0.1	0.609176042	0.016084128	-0.34686795	-1.116040084	1.101875107	-1.451115237	2.678191312
46	9/30/2013	4	0.1	2.319467872	0.06180381	0.248007712	0.102590698	1.098478135	-1.485457316	2.665743022
47	12/31/2013	4	0.1	1.774460855	0.589760058	0.214406897	0.153370391	1.02817925	-1.460414537	2.641377135
48	3/1/2014	4	0.1	1.697739839	0.749354304	0.288326647	0.041453317	1.850742331	-1.043097511	3.130998922
49	6/30/2014	4	0.1	0.901279054	0.185138126919	0.17294389	0.187722472	1.872722472	-0.782902621	3.895918152
50	9/30/2014	4	0.1	0.607795892	1.476511504	0.18857349	1.098240674	1.857792317	-0.566851887	3.515081934
51	12/31/2014	4	0.1	2.218746573	2.047441494	0.208811196	1.629500424	2.468586265	-0.00148339	4.098368379
52	3/1/2015	4	0.1	2.681179575	2.483887226	0.3075074	1.789048436	3.310999615	0.389353495	5.852261206
53	6/30/2015	4	0.1	3.652106026	2.458307949	0.184769368	1.943128905	4.328397401	0.4223931	6.051775986
54	9/30/2015	4	0.1	2.845772003	2.531276028	0.248577038	2.034917875	4.026344075	1.459739878	6.051775986
55	12/31/2015	4	0.1	3.352167282	3.21777472	0.308969231	2.5959758	3.836669639	1.118928265	5.314654754
56	3/1/2016	4	0.1	3.04545331	3.04545516	0.461178197	2.47925793	3.31761302	1.196071275	5.614817957
Partition groups    PLS target    Data    Term structure    Multiple projections    T-shape fit    Scenario test    Historical distribution    Conditional quantiles    Quant reg coefficients    Output loadings    Chi-sqr    ( )										

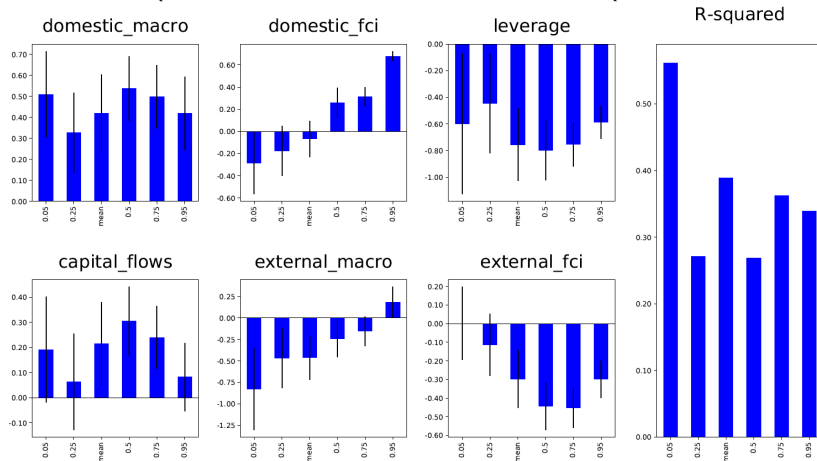
# Non-Linearities in Quantile Regressions Coefficients

## Quantile Regression Coefficients for X5



# Quantile Regressions Output

## Quantile Coefficients for Growth at Horizon 4-Quarter



*Source: IMF Article IV (2018)*

# Parameters for distribution fit

- Remember that a distribution is fitted on a given date:

$$Y_{2021} = \beta^q * X_{2020}$$

- The tool allows to project a density for a given date and horizon
- Possibility also to fix the mode: constrained optimization

# Parameters for distribution fit: type of distribution, conditioning

57 **Skewed T-Distribution Fit Parameters**

58 Type of skewed T-distribution T-skew

59 Input date for the projection (last date available) 6/30/2018

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64 Location (mode of the distribution) Fixed Value if fixed 4.5

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66 Covariates smoothing Option Smooth Period if NOT None

67 None

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69 Skewed T distribution fit sheet name (default: Asymmetric T/T-skew fit)

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73 **Skewed T Fit Parameters for Advanced Users**

74 Degrees of freedom Default

75 Variance lower bound Default

76 Variance upper bound Default

77 Skewness lower bound Default

78 Skewness upper bound Default

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82 **Historical distribution**

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85 Distribution Start Date 3/1/2002

86 Distribution End Date 6/30/2018

87 Time period increment 1

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91 Historical distribution sheet name (default: Historical)

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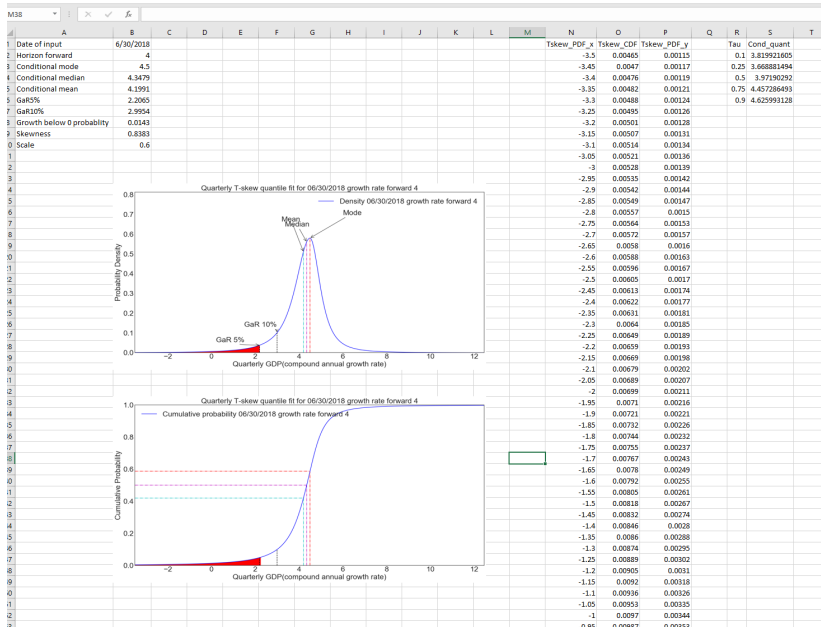
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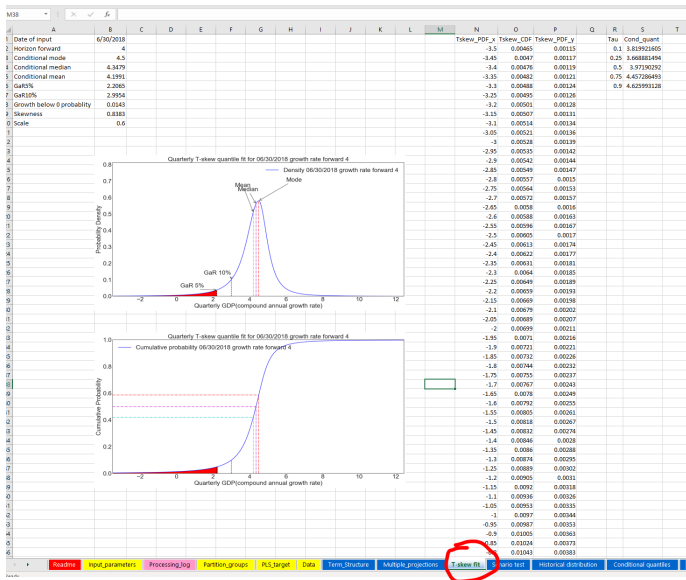
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# Tskew fit output in "Tskew fit"



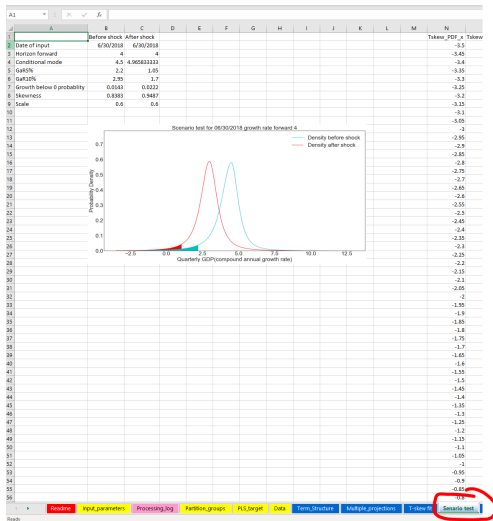
# Tskew fit output in "Tskew fit"



# Scenario design

Scenario Test for Shocks				
Variables to shock	Shock Type	Value by percentage: 100% to 100%	Number by STD (-5 to 5)	<div>5th of 6: Scenario Test</div> <p>Partitions, quantile regressions skewed T12 must be executed before scenario test</p>
ITA_bond_10Y_rate	By +/- STD None None None None None None		2	
Location after shock (mode of the distribution)	<div>Constraint</div> <div>Free</div>	<div>Value if fixed</div> <div></div>		
Scenario test sheet name (default: Scenario test)		Output sheets will be overwritten for pre-existing sheets		

# The projections from the scenarios are in "Scenario Test"



# The term structure

Multiple Horizon Projections				
Horizon list	Input date for the projection		Location Constraint	Value if fixed
	4	6/30/2018	Free	=
	8	6/30/2018	Free	=
	12	6/30/2018	Free	=
	16	6/30/2018	Free	=
			Free	=
			Free	=
			Free	=
			Free	=

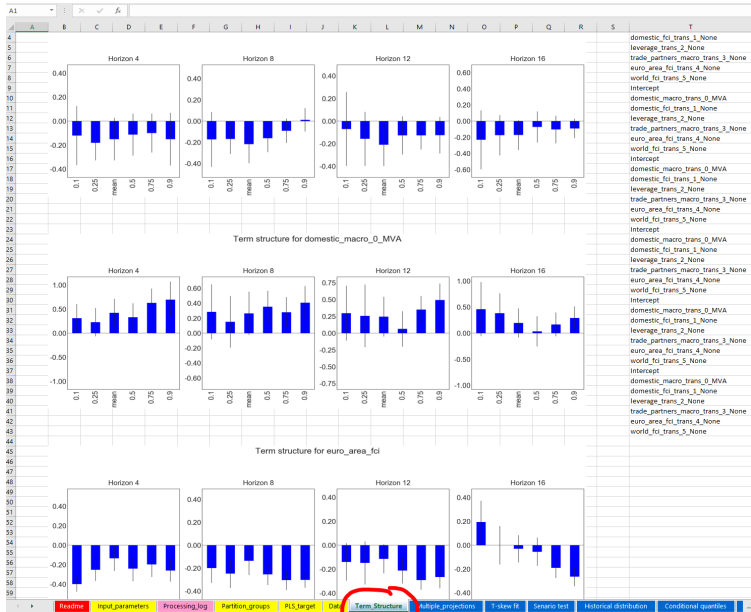
6th of 6:  
Multiple Projections

Previous settings will be used for Multiple Horizons Projections

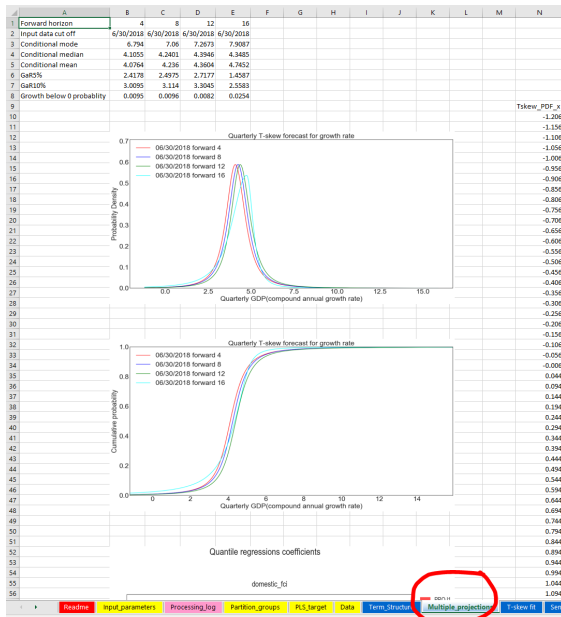
Multiple Horizon Projections sheet name (default: Multiple\_projections)

Term Structure sheet name (default: Term\_Structure) 
Output sheets will be overwritten for pre-existing sheets

# The term quantile coefficients are in "Term Structure"



# The term projections are in "Multiple Projections"



# Support

- The tool, documentation, etc. will be kept updated on the public Github folder: <https://github.com/IMFGAR/GaR/>
- IMF Working paper on *Growth at Risk: Concept and Application in IMF Country Surveillance (2019, IMF WP 19/36)*
- Issues, questions and suggestions? Contact [rlafarguette@imf.org](mailto:rlafarguette@imf.org) or [cwang2@imf.org](mailto:cwang2@imf.org)