

Density Forecasting: Growth at Risk

Part II. Applications

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



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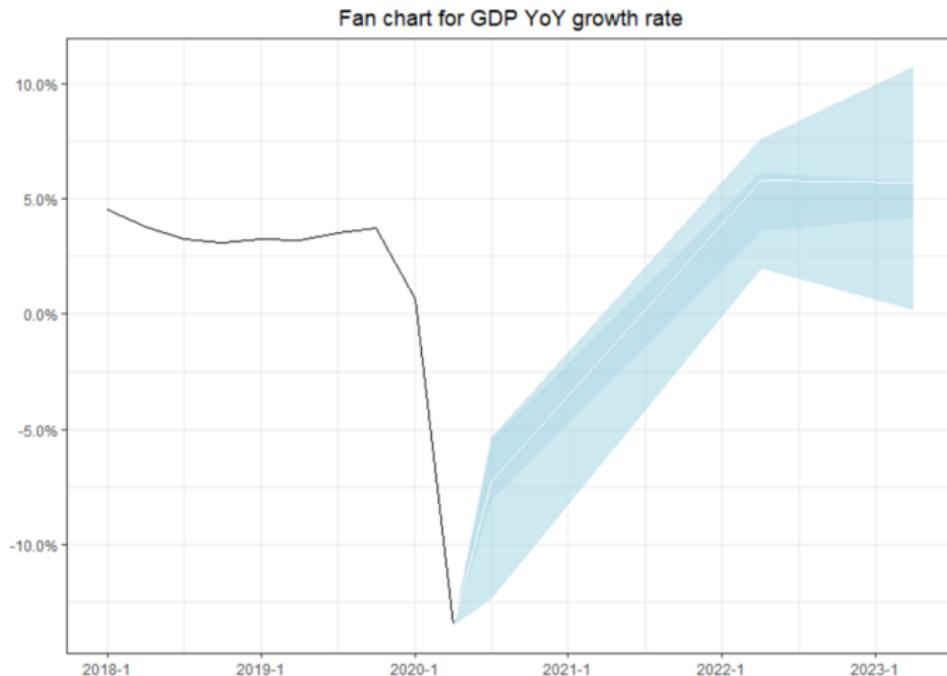
- Fan charts
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- Vulnerabilities Heatmap
- Assessing the Likelihood of a Scenario
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- Shocks Simulation
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2 Excel Tool

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 “ ϵ ”): 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

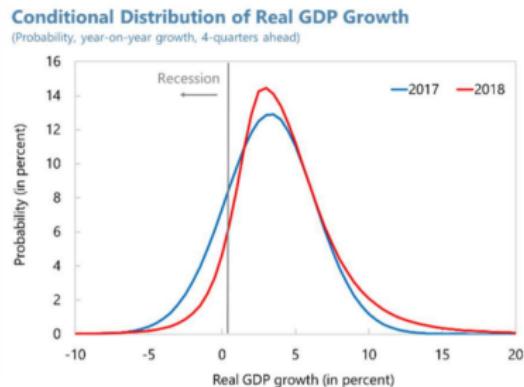
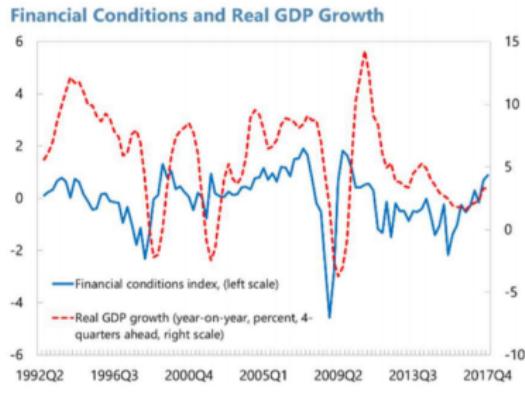
Fan chart: Israel 2020



Source: BoI Financial Stability Report, June 2020

Singapore: Probability of Recessions

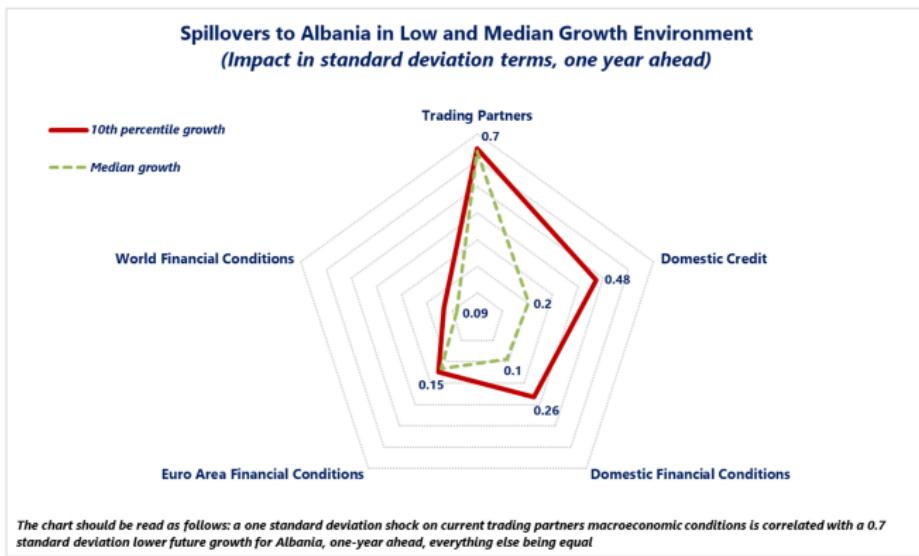
- Probability of recession (growth below zero) in Singapore
- Identify key macrofinancial variables: External factors, financial conditions, housing, China



Source: IMF Article IV (2018)

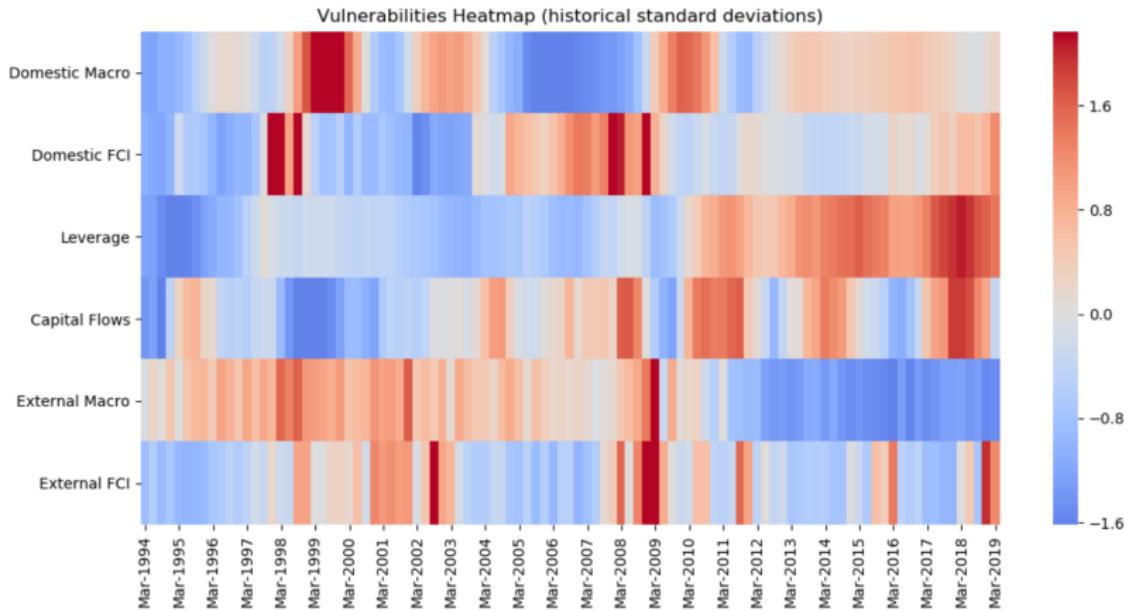
Spillover analysis

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

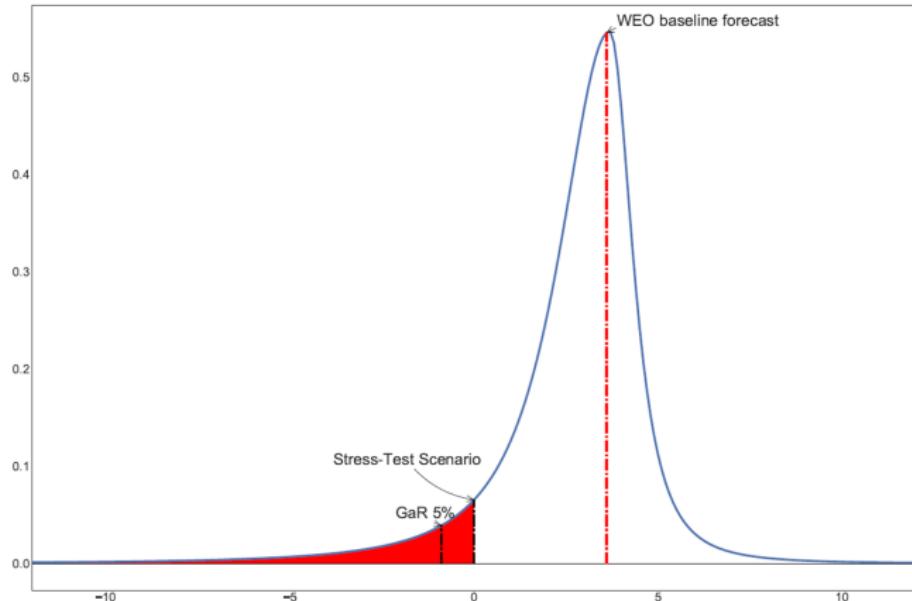
Assessing the Likelihood of a Scenario (II)

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)

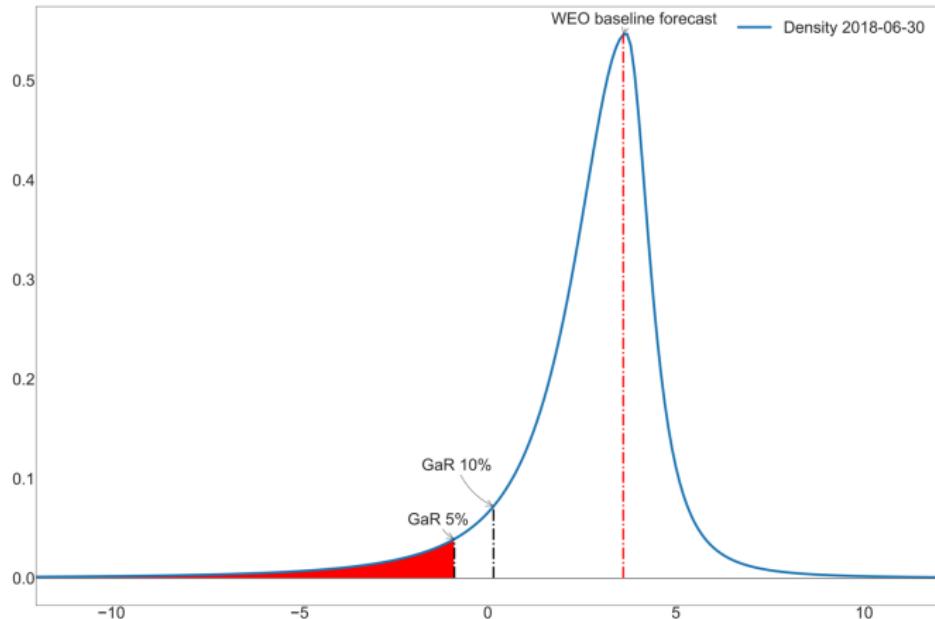
Modeling Tail-Risks Around a Baseline Scenario (II)

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)

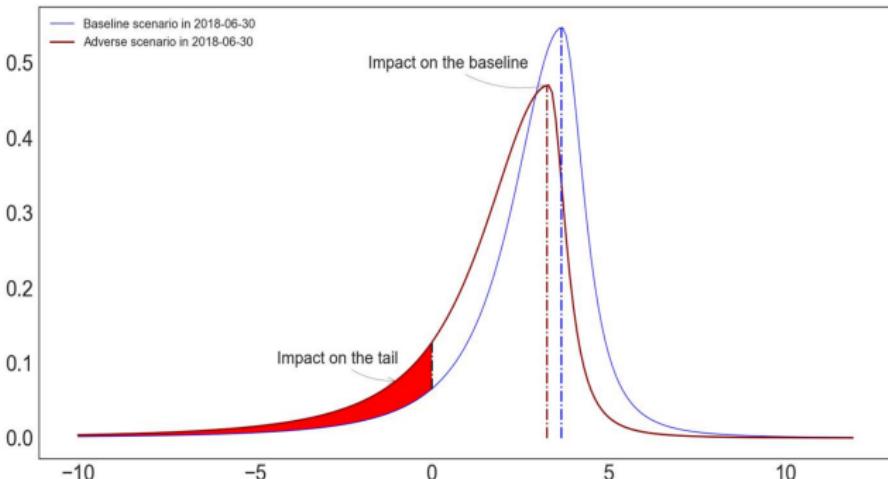
Impact of Tightened Financial Conditions on Growth

Adverse scenario assumes a 1 sd shock on price of risk

Results:

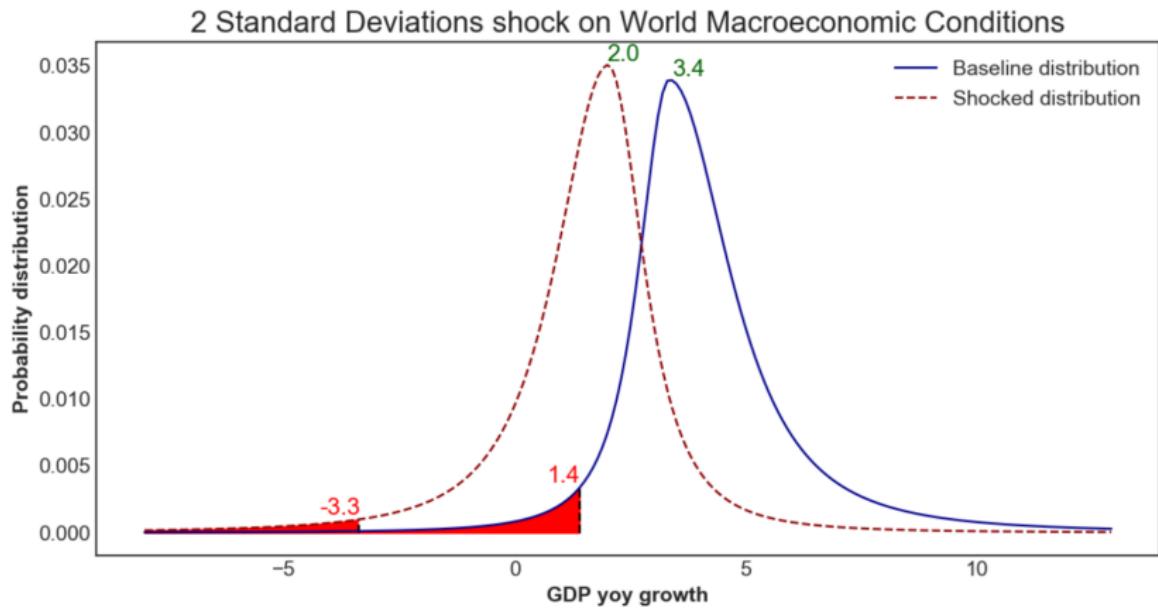
Impact on the average growth:
from 3.6% to 3.25%

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:
 - Risks to the **baseline**
 - Tail**-risks
- Again, this is a comparative statics analysis without clean identification

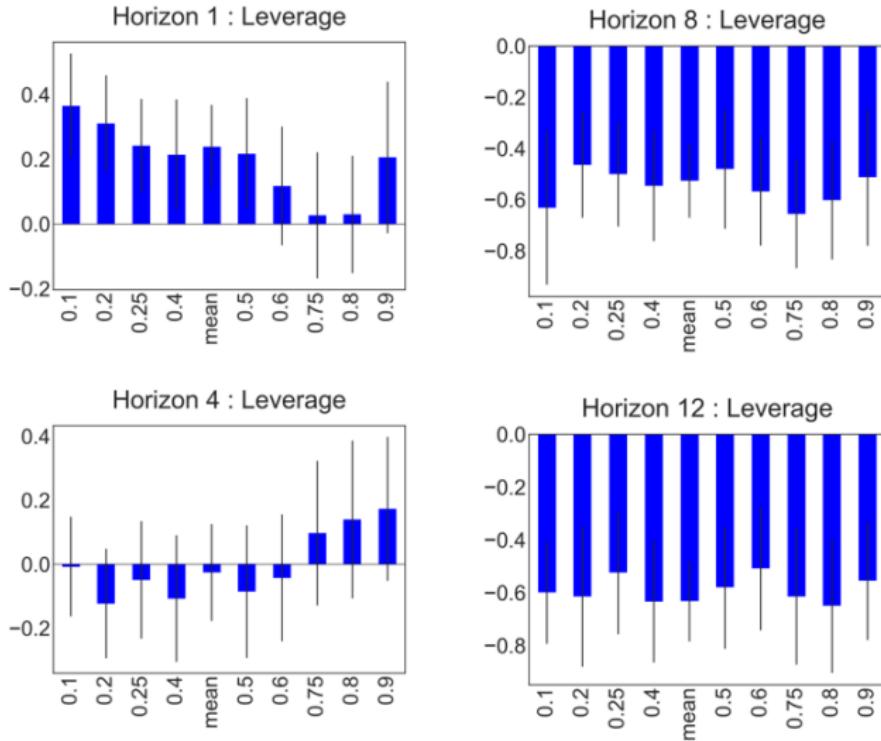
Quantifying the RAM: Albania

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 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 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%

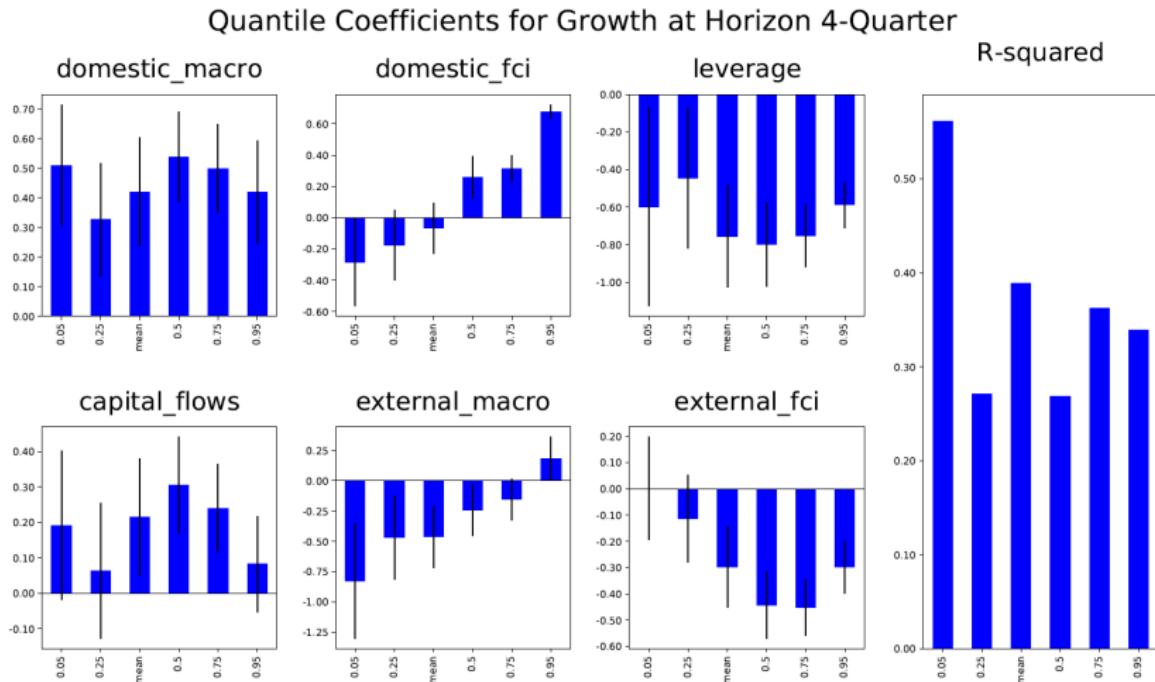
Source: IMF Albania Article IV (2018)

Term Structure of Growth at Risk (Local Projections)



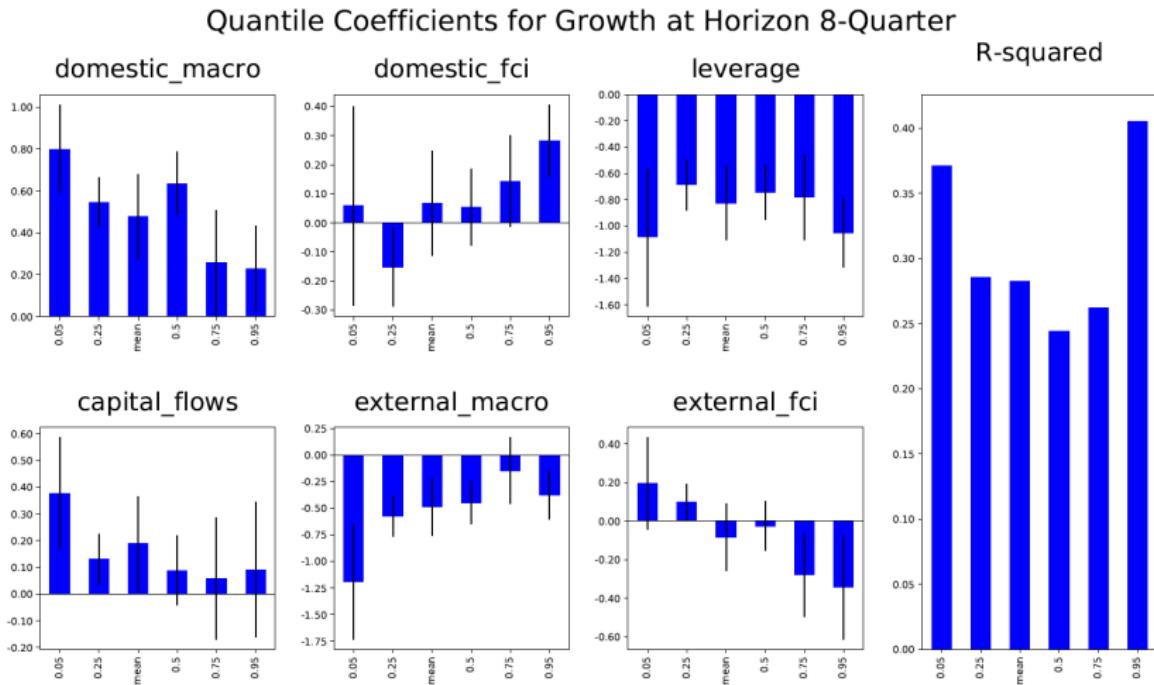
Source: IMF Staff

Quantile Regressions Output 1 year Ahead



Source: IMF Article IV (2018)

Quantile Regressions Output 2 years Ahead



Source: IMF Article IV (2018)

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2 Excel Tool

- Applied Work with GaR
- Installation
- Preparations
- Partitions
- 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)

Screenshot of the GitHub repository page for IMF GAR (IMFGAR/GaR). The repository has 1 branch and 0 tags. The master branch contains 11 files:

File	Description	Last Commit
IMFGAR fixed a bug for possible erro when force negative mode	fixed a bug for possible erro when force negative mode	17 months ago
Documentation	Add files via upload	8 months ago
GAR	fixed a bug for possible erro when force negative mode	8 months ago
EN-logo_large_blue.png	Add log of IMF	8 months ago
GaR license.txt	Add files via upload	8 months ago
IMF disclaimer.txt	Add files via upload	8 months ago
README.md	Update to new version 10/28/2019.	8 months ago
gar.xlsm	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

The repository includes a README file and a logo for the International Monetary Fund (IMF). The GitHub interface shows options to clone the repository via HTTPS or SSH, download it as a ZIP file, or open it with GitHub Desktop. The repository has no releases, packages, or languages listed.

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.

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.xlsxm	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 ribbon interface. A red circle highlights the status bar at the bottom left, which displays the message "SECURITY WARNING Macros have been disabled." Below this, a yellow button labeled "Enable Content" is visible. The main content area of the Excel window displays a title slide for "Excel Tool for Estimating Growth at Risk Model" version v1.6 - October 2019. The slide includes a map of the world and text about the tool's purpose and requirements. A legend at the bottom indicates that yellow worksheets are user inputs, blue worksheets are outputs, and pink worksheets are log files.

SECURITY WARNING Macros have been disabled. **Enable Content**

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). For questions related with the Excel tool, please contact Wang Changchun (ITD, 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
	date	real_gdp_moving_sum real_gdp_moving_sum_yoy	repo_3W_rate
1	3/31/2001	720666.53	
2	6/30/2001	735602.47	
3	9/30/2001	750388.41	
4	3/31/2002	765474.35	
5	6/30/2002	780410.29	0.0129007
6	9/30/2002	785267.87	0.07295435
7	3/31/2003	798125.45	0.06404087
8	6/30/2003	809981.03	0.054226089
9	9/30/2003	815840.61	0.045199606
10	3/31/2004	827119.71	0.047958167
11	6/30/2004	838398.81	0.050459937
12	9/30/2004	849777.91	0.052906788
13	3/31/2005	860957.01	0.055305058
14	6/30/2005	872816.69	0.055248237
15	9/30/2005	884876.37	0.05519755
16	3/31/2006	896336.05	0.055148121
17	6/30/2006	908395.73	0.055099987
18	9/30/2006	920954.1075	5.566887556
19	3/31/2007	933512.485	0.055151807
20	6/30/2007	944970.8925	5.333576051
21	9/30/2007	95629.24	0.055202237
22	3/31/2008	972789.2225	5.055088987
23	6/30/2008	986909.205	0.055213134
24	9/30/2008	1001049.388	5.441636397
25	3/31/2009	1015189.17	5.103044638
26	6/30/2009	1030366.203	5.406681741
27	9/30/2009	1045543.235	5.706851824
28	3/31/2010	1060720.268	5.910178596
29	6/30/2010	1075897.3	5.99712975
30	9/30/2010	1090670.293	6.174875127
31	3/31/2011	1116243.285	6.063767707
32	6/30/2011	1136416.278	6.067620398
33	9/30/2011	1151395.953	6.071362839
34	3/31/2012	1168924.635	6.053628402
35	6/30/2012	1182059.318	6.064468677
36	9/30/2012	1195334	6.058962086
37	3/31/2013	1205576	6.051845194
38	6/30/2013	1212368	5.318154089
39	9/30/2013	1223979	0.063497093
40	3/31/2014	1239945	5.172241464
41	6/30/2014	1255487	0.037136338
42	9/30/2014	1250088	5.248579063
43	3/31/2015	1256685	0.035463265
44	6/30/2015	1271200	5.126502198
45	9/30/2015	1271200	0.03076721047
46	3/31/2016	1286806	5.337630418
47	6/30/2016	1283037	0.025454068
48	9/30/2016	1287393	5.021060932
49	3/31/2017	1289218	4.702357253
50	6/30/2017	1294077	0.024359487
51	9/30/2017	1303636	4.131999403
52	3/31/2018	1295556	0.014174009
53	6/30/2018	1302136	4.043556533
54	9/30/2018	1308102	3.896333333
55	3/31/2019	1311504	0.019191715
56	6/30/2019	1325606	0.0199978
57	9/30/2019		3.74531125
58	3/31/2020		0.006184408
59	6/30/2020		3.581998102
60	9/30/2020		0.010020208
61	3/31/2021		3.388951337
62	6/30/2021		2.926605119
63	9/30/2021		2.677537823
64	3/31/2022		2.518742476

Group variables into partitions in the "Partition" excel sheet

A	C	D
1 Group Names	domestic_macro	domestic_fcl
2	real_gdp_moving_sum	repo_1W_rate
3		c
4		policy_target_deviations
5		repo_on_rate_diff
6		cpi_inflation_yoy
7		eur_all_vol
8		repo_on_vol
9		bond_2y_vol
10	Variables	
11		
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In case of PLS: determine supervising variables in "PLS target" sheet

F43	A	C	D	E	F	G	H	I	J	K	L
1	Group Names	domestic_macro	domestic_fci	leverage	trade_partners_macro	euro_area_fci	world_fci				
2		real_gdp_moving_sum_oy	cpi_inflation_oy	share_non_resident_habitants	FTA_gdp_oy	EA_vla	WRI				
3											
4											
5											
6											
7											
8											
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10											
11	Variables										
12											
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Estimate the partitions: choose horizon, partitioning methods, etc.

There are 6 main functions: Partition, Quantile Regression, Takeover Risk, Historical Distributions, Scenario Design and Multiple Horizons Projections

Common 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 Changjian (changjian@imf.org)

When using the tool, please cite: Pressat, E. (2018). "Growth at Risk: Concept and Application in IMF Country Surveillance", IMF working paper; as well as Lafarguette, R. (2018) "Growth at Risk Toolkit Technical Appendix," release, IMF.

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_mean
Forecasting horizon in periods:
4

Frequency:
Quarterly
Start Date:
3/21/2002
End Date:
3/21/2018

Partition Method:
Benchmark Periods (Cut-off by case of LDA)
Basis for Selection Method (depends on year or level)
Retrospective Partitions
Partition sheet name (default Output_partitions)
Leadings sheet name (default Output_leadings)

Output sheets will be overwritten for pre-existing sheets
Output sheets will be overwritten for pre-existing sheets

Partition Parameters

1st of 6:
Run partition
Results are Z-score

Quantile Regression Specification and Parameters

2nd of 6:
Run quantile reg
Partitions must be run before quantile regression

These values are fixed and required

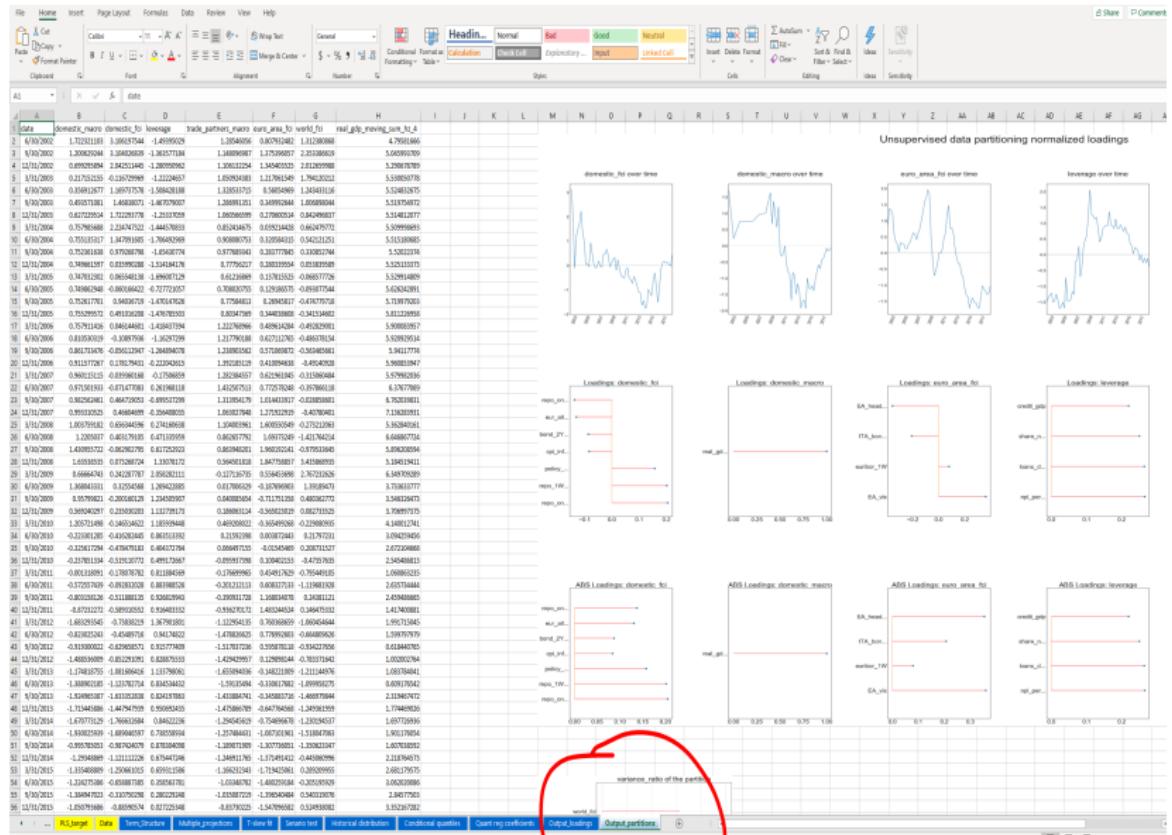
Add quantile additional values - if necessary - in the green area

Quantile regression sheet name (default Quantile regression coefficients)
Conditional quantities sheet name (default Conditional quantiles)

Output sheets will be overwritten for pre-existing sheets
Output sheets will be overwritten for pre-existing sheets

Inputs: Input_parameters, Processing_log, Partition_group, PLS_target, Date, Tech_Structure, Multiple_projections, Calibration, Scenario_test, Historical_distributions, Conditional_quantiles

Estimated partitions are in "Output' partitions"



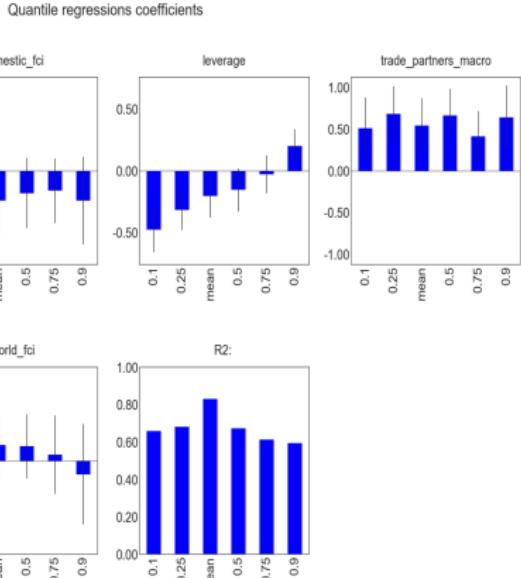
Estimated loadings are in "Output loadings"

A1	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1 variable	cutoff	loadings	group														
2 repo_1W_rate	3/31/2002	0.507431978	domestic_fci	0.455189908													
3 policy_target_deviations	3/31/2002	0.396467252	domestic_fci	0.455189908													
4 repo_on_rate_diff	3/31/2002	-0.344850749	domestic_fci	0.455189908													
5 cpi_inflation_yoy	3/31/2002	-0.209598755	domestic_fci	0.455189908													
6 our_all_vol	3/31/2002	-0.328547846	domestic_fci	0.455189908													
7 repo_on_vol	3/31/2002	0.516571596	domestic_fci	0.455189908													
8 bond_2Y_vol	3/31/2002	-0.21836421	domestic_fci	0.455189908													
9 real_gdp_moving_sum_yoy	3/31/2002	1	domestic_macro	1													
10 EA_vix	3/31/2002	0.651894169	euro_area_fci	0.53292724													
11 ITA_bond_10Y_rate	3/31/2002	-0.375464767	euro_area_fci	0.53292724													
12 EA_headline_cpi_yoy	3/31/2002	-0.648133423	euro_area_fci	0.53292724													
13 euribor_1W	3/31/2002	0.142976131	euro_area_fci	0.53292724													
14 credit_gdp	3/31/2002	0.438792881	leverage	0.779865997													
15 share_non_resident_liabilities	3/31/2002	0.498816684	leverage	0.779865997													
16 loans_deposits_ratio	3/31/2002	0.527276804	leverage	0.779865997													
17 npf_percent_total_loans	3/31/2002	0.529737571	leverage	0.779865997													
18 ITA_gdp_yoy	3/31/2002	0.51229369	trade_partners_macro	0.695338053													
19 ITA_unemployment_rate	3/31/2002	-0.571190289	trade_partners_macro	0.695338053													
20 GRE_gdp_yoy	3/31/2002	0.209632841	trade_partners_macro	0.695338053													
21 GRE_unemployment_rate	3/31/2002	-0.58188913	trade_partners_macro	0.695338053													
22 vix	3/31/2002	0.707106781	world_fci	0.629645548													
23 oil_price	3/31/2002	-0.707106781	world_fci	0.629645548													
24																	
25																	
26																	
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28																	
29																	
30																	
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Parameters for the quantile regressions

Results of the quantile regressions in "Quant Reg Coefficients"

G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG		
1	lower	upper	R2	in sample	normalized	errors																						
2	-0.571341412	-0.35738995	0.658155707	TRUE	0.106975731																							
3	0.026077663	0.465351958	0.658155707	TRUE	0.29518187																							
4	-0.367302384	0.126361265	0.658155707	TRUE	0.246811864																							
5	-0.057892702	-0.296672747	0.658155707	TRUE	0.180716727																							
6	0.141883047	0.878533165	0.658155707	TRUE	0.368322559																							
7	-0.474720666	-0.32051953	0.658155707	TRUE	0.078454888																							
8	0.002602408	0.241210823	0.658155707	TRUE	0.120478334																							
9	-0.317243899	-0.156043254	0.681994867	TRUE	0.0806060322																							
10	-0.064567952	0.522983362	0.681994867	TRUE	0.29775641																							
11	-0.323892679	-0.051503124	0.681994867	TRUE	0.146911793																							
12	-0.478985954	-0.152291779	0.681994867	TRUE	0.163803408																							
13	0.358800184	1.010899497	0.681994867	TRUE	0.326042157																							
14	-0.366152859	-0.115790179	0.681994867	TRUE	0.114314531																							
15	-0.011404012	0.055715701	0.681994867	TRUE	0.09210649																							
16	-0.134059511	0.055715701	0.674120554	TRUE	0.08950555																							
17	0.047056655	0.548818822	0.674120554	TRUE	0.270658554																							
18	-0.287875471	0.083348259	0.674120554	TRUE	0.178959025																							
19	-0.320004343	0.018534849	0.674120554	TRUE	0.1727205																							
20	0.34156582	0.98600971	0.674120554	TRUE	0.12272345																							
21	-0.366481534	-0.111570398	0.674120554	TRUE	0.128455558																							
22	-0.094601102	0.169855377	0.674120554	TRUE	0.118331199																							
23	0.17957285	0.363291938	0.614018947	TRUE	0.055668327																							
24	0.12692129	0.25862418	0.614018947	TRUE	0.30125964																							
25	0.204645810	0.062119215	0.614018947	TRUE	0.162218805																							
26	-0.1816203775	0.2587869	0.614018947	TRUE	0.153749707																							
27	0.111591303	0.715931033	0.614018947	TRUE	0.302170556																							
28	-0.323820575	-0.065486361	0.614018947	TRUE	0.130462113																							
29	-0.113603938	0.186570112	0.614018947	TRUE	0.147273025																							
30	0.38370186	0.59527009	0.594234407	TRUE	0.118284119																							
31	0.322037862	1.070529119	0.594234407	TRUE	0.374245629																							
32	-0.3639090113	0.094931887	0.594234407	TRUE	0.219471481																							
33	0.062647473	0.334691723	0.594234407	TRUE	0.139693487																							
34	0.26178446	1.023615494	0.594234407	TRUE	0.380680113																							
35	0.752944	0.44301718	0.594234407	TRUE	0.303715571																							
36	-0.233877327	0.133877327	0.594234407	TRUE	0.180271977																							
37	0.0943809112	0.0943809112	0.631149589	TRUE	0.054380912																							
38	0.138161162	0.711303856	0.631149589	TRUE	0.289579487																							
39	-0.373096298	0.071794068	0.631149589	TRUE	0.177151813																							
40	-0.379064391	-0.029457848	0.631149589	TRUE	0.174744272																							
41	0.216953883	0.846023667	0.631149589	TRUE	0.125545592																							
42	-0.203441552	-0.00428348	0.631149589	TRUE	0.129579236																							
43	-0.00042223	0.175499399	0.631149589	TRUE	0.117956034																							
44																												
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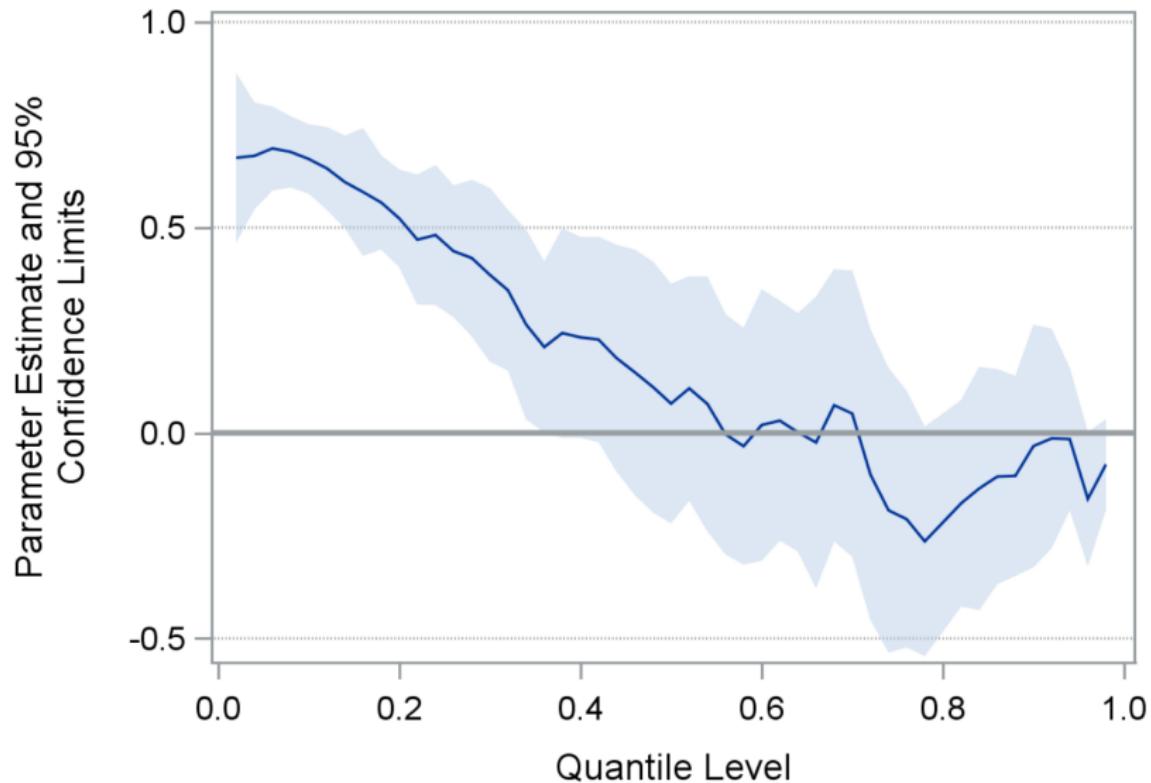


In-sample Conditional Quantiles in "Conditional Quantiles"

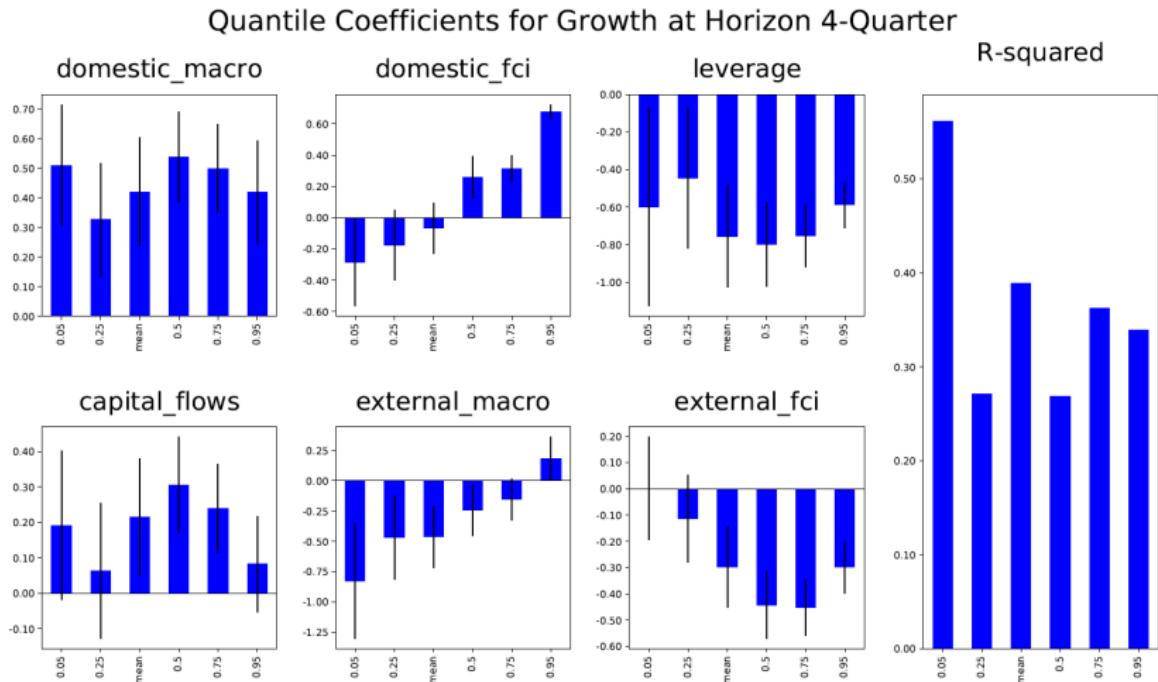
	A1	B	C	D	E	F	G	H	I	J
	date	partition_tau	realized_value	conditional_quantile_mean	conditional_quantile_mean_se	conditional_quantile_mean_ci_lower	conditional_quantile_mean_ci_upper	conditional_quantile_obs_ci_lower	conditional_quantile_obs_ci_upper	seiper
2	9/30/2002	4	0.1	5.045595709	5.045595880	5.038164759	5.054522499	6.526594487	7.2552982054	7.590905559
3	12/31/2002	4	0.1	5.296767879	4.841361771	5.021419151	5.795481707	5.887241835	5.759309141	7.103414401
4	3/31/2003	4	0.1	5.530507078	5.067616166	5.0749517042	4.255627811	5.75990452	2.865539324	7.149695407
5	6/30/2003	4	0.1	5.524832675	5.479046968	5.048478371	4.577506167	6.380583549	3.280002354	6.789038862
6	9/30/2003	4	0.1	5.5157954972	5.5159750125	5.049658888	4.617855911	6.421056938	3.320563607	7.178944642
7	12/31/2003	4	0.1	5.509998690	5.162638552	5.04485444	4.2979579	6.073260725	2.87904749	7.370917719
8	3/31/2004	4	0.1	5.509998690	5.162638552	5.04485444	4.2979579	6.073260725	2.87904749	7.370917719
9	6/30/2004	4	0.1	5.5131189605	5.5131189611	5.036425238	4.787812034	5.625249629	3.185101938	7.668741789
10	9/30/2004	4	0.1	5.513023324	5.518785378	5.084476118	5.02019361	6.177377242	5.511254437	7.693156121
11	12/31/2004	4	0.1	5.5130233373	5.4548051752	5.080141029	4.892558082	6.017144467	3.371779442	7.579124072
12	3/31/2005	4	0.1	5.529314409	5.529314423	5.041376204	4.844274982	6.21535587	3.410216702	7.649612149
13	6/30/2005	4	0.1	5.623019391	5.182533912	4.820470931	4.454302034	5.180533169	2.781209348	6.02931334
14	9/30/2005	4	0.1	5.719979703	5.102075729	5.027490288	5.05385779	5.608705681	3.009465344	7.194693511
15	12/31/2005	4	0.1	5.811229958	5.211432028	5.045619649	4.781323137	5.70450692	1.149479381	7.276882126
16	3/31/2006	4	0.1	5.900088957	5.057668752	5.027750101	5.059747482	5.924362684	3.450905387	7.586341627
17	6/30/2006	4	0.1	5.929295214	5.236859051	5.023666877	4.827515987	5.640590033	3.189133131	7.262978707
18	9/30/2006	4	0.1	5.94117774	5.384249797	5.025796249	4.971513044	5.790569549	3.33690912	7.452083474
19	12/31/2006	4	0.1	5.94117774	5.384249797	5.025796249	4.971513044	5.790569549	3.33690912	7.452083474
20	3/31/2007	4	0.1	5.979942029	4.561515342	5.021414608	4.137798334	5.005350669	2.507904446	6.615989057
21	6/30/2007	4	0.1	6.376776709	4.220467673	5.032294691	5.394071128	4.864640177	2.119177735	6.321735753
22	9/30/2007	4	0.1	6.763019831	4.717357538	5.048775782	4.788039564	5.055448414	2.663212389	6.754373909
23	12/31/2007	4	0.1	7.132625931	5.32953391	5.042972546	5.026545749	4.256417442	5.901730114	5.901730114
24	3/31/2008	4	0.1	5.362840161	3.176884245	5.026067288	2.646023272	3.690534478	1.106417643	5.247359207
25	6/30/2008	4	0.1	6.644687724	2.954959941	5.031569892	1.945659795	3.223539625	0.459557963	4.699641757
26	9/30/2008	4	0.1	5.896205954	2.597313839	5.031766696	2.088321055	3.126396182	0.522925318	4.671645139
27	12/31/2008	4	0.1	5.184519411	2.834399071	5.078259215	2.075707166	3.59039075	0.680957216	4.978840815
28	3/31/2009	4	0.1	6.349705929	2.137573885	5.042128995	1.451352009	2.623797228	0.017087235	4.257480517
29	6/30/2009	4	0.1	3.731633377	1.810359423	5.023268888	6.263551346	5.367039161	1.042399145	5.160758707
30	9/30/2009	4	0.1	5.362527875	5.362527875	5.040252785	5.052552301	4.089510748	5.020951074	5.020951074
31	12/31/2009	4	0.1	5.709957975	5.346802157	5.050571819	2.812549584	3.001231401	1.198730999	5.290913155
32	3/31/2010	4	0.1	4.140012741	5.462018357	5.048633839	2.899770787	3.896931217	1.137214216	5.008919434
33	6/30/2010	4	0.1	5.0345249456	3.193023937	5.013130958	2.735260253	3.492783114	1.066891115	5.1511523162
34	9/30/2010	4	0.1	2.672106668	2.595117148	5.027138383	2.523279038	3.394841521	0.509831341	5.010831341
35	12/31/2010	4	0.1	5.2454886813	5.025971709	5.045840417	2.034956033	2.009919185	0.47521211	4.530741709
36	3/31/2011	4	0.1	1.096365235	1.844220094	5.0177543205	1.488113491	2.200326437	-0.150893815	3.881325243
37	6/30/2011	4	0.1	2.635734444	1.4613118815	5.023970689	0.982323271	1.943914559	-0.559447873	3.552685504
38	9/30/2011	4	0.1	4.254948665	1.008822109	5.021054581	0.580499554	1.427144657	-1.046019393	3.053733561
39	12/31/2011	4	0.1	1.417400881	0.194839652	5.023499139	0.337402082	0.627070786	-1.856957219	2.246643434
40	3/31/2012	4	0.1	1.991751045	-0.310600698	5.024263056	-0.787185041	0.180505264	-2.364877495	1.762439549
41	6/30/2012	4	0.1	1.000000000	-0.310600698	5.024263056	-0.848373939	0.33486228	-2.414130395	1.848873939
42	9/30/2012	4	0.1	0.034488760	0.078020693	5.024267037	-0.607841096	0.305003008	-2.041131397	2.190745499
43	12/31/2012	4	0.1	0.200252764	0.472964943	5.0235512196	0.040655457	0.905247204	-1.578031716	2.534786552
44	3/31/2013	4	0.1	1.081764041	0.100919187	5.034433237	-0.385576704	0.569717648	-1.961600056	2.104541889
45	6/30/2013	4	0.1	0.0003120542	0.510853828	5.024405795	0.138640084	1.101278571	-1.454113252	2.075011312
46	9/30/2013	4	0.1	2.3134647472	0.403018381	5.044007772	0.103559859	1.099871533	-1.404571518	2.067548102
47	12/31/2013	4	0.1	1.774468920	0.589700538	5.021406897	0.135700391	1.023187125	-1.462434457	2.041535773
48	3/31/2014	4	0.1	1.697217936	1.074535334	5.028816647	0.049414537	1.050785372	-1.014997511	3.139980222
49	6/30/2014	4	0.1	1.901170054	1.305338531	5.028612691	0.725403063	1.677228472	-0.782906251	3.389513192
50	9/30/2014	4	0.1	1.607305859	1.474515194	5.038573742	1.098204374	1.652743311	-0.596685187	3.315698109
51	12/31/2014	4	0.1	2.218764573	0.207444194	5.0208611196	1.629520243	2.466892565	-0.001043339	4.093636739
52	3/31/2015	4	0.1	2.681159752	1.486527226	5.0208611196	2.030170557	3.100399615	0.385593245	4.522615106
53	6/30/2015	4	0.1	3.000000000	2.620794643	5.031049038	2.059430009	4.826279459	0.4223813	4.017765166
54	9/30/2015	4	0.1	2.584577935	2.552311703	5.024419703	2.030161705	3.000200102	0.650000000	4.579980398
55	12/31/2015	4	0.1	3.215874782	3.217747472	5.030692311	2.5987598	3.835649639	1.116932385	5.316496574
56	3/31/2016	4	0.1	3.405545533	1.4655456516	5.041811917	2.47952973	4.331761302	1.196272275	5.614817975

Non-Linearities in Quantile Regressions Coefficients

Quantile Regression Coefficients for X5



Quantile Regressions Output



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

Skewed T-Distribution Fit Parameters

Type of skewed T-distribution: T-skew
Input date for the projection (last date available): 6/30/2018
Location (mode of the distribution): Constraint: Fixed, Value if fixed: -4.5
Covariates smoothing: Option: Smooth Period if NOT None
Skewed T distribution fit sheet name (default: Asymmetric T/T-skew fit)

Skewed T Fit Parameters for Advanced Users

Degrees of freedom: Default
Variance lower bound: Default
Variance upper bound: Default
Skewness lower bound: Default
Skewness upper bound: Default

Historical distribution

Distribution Start Date: 3/31/2002
Distribution End Date: 6/30/2018
Time period increment: 1

Historical distribution sheet name (default: Historical): Output sheets will be overwritten for pre-existing sheets

Partitions, quantile regressions must be executed before Historical distribution

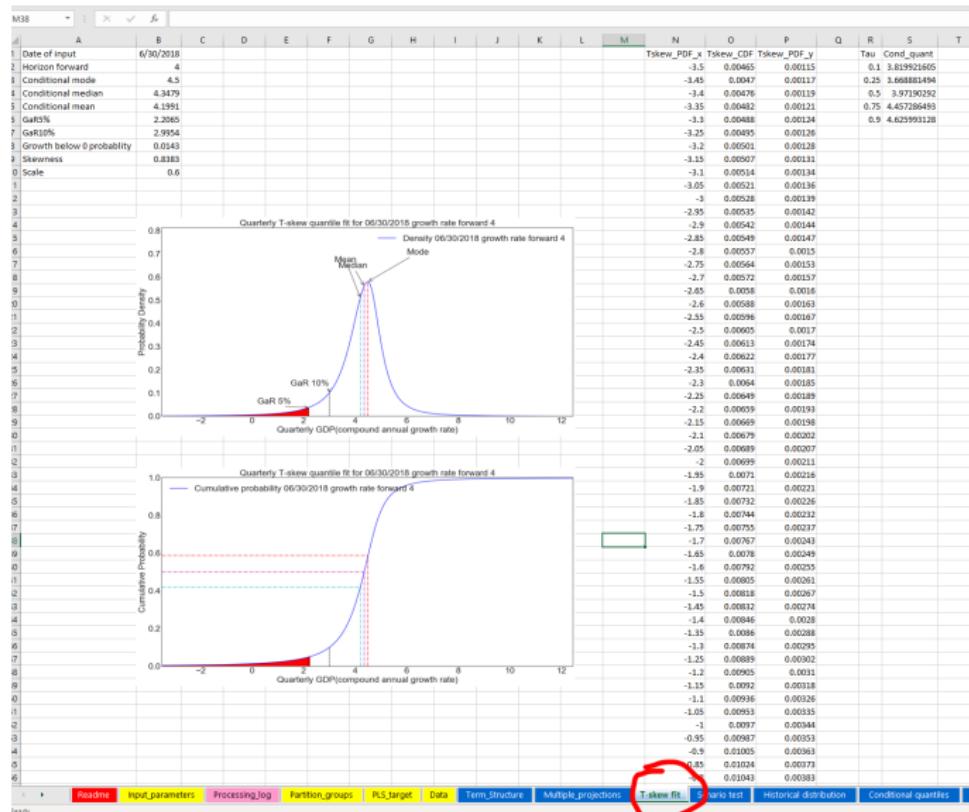
4th of 6: Historical Distribution

Input parameters (highlighted with red circles)

Tskew fit output in "Tskew fit"

M38	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Date of input	6/30/2018											Tskew_PDF_x	Tskew_CDF	Tskew_PDF_y	Tau	Cond_quant			
2	Horizon forward	4											-3.5	0.00465	0.00115	0.1	3.8199121605			
3	Conditional mode	4.5											-3.45	0.00447	0.00117	0.25	3.668831494			
4	Conditional median	4.3479											-3.4	0.00476	0.00119	0.5	3.97190292			
5	Conditional mean	4.1991											-3.35	0.00482	0.00121	0.75	4.457286493			
6	GaR5%	2.2065											-3.3	0.00488	0.00124	0.9	4.625993128			
7	GaR10%	2.9954											-3.25	0.00495	0.00126					
8	Growth below 0 probability	0.0143											-3.2	0.00501	0.00128					
9	Skewness	0.8383											-3.15	0.00507	0.00131					
0	Scale	0.6											-3.1	0.00514	0.00134					
1													-3.05	0.00521	0.00136					
2													-3	0.00528	0.00139					
3													-2.95	0.00535	0.00142					
4													-2.9	0.00542	0.00144					
5													-2.85	0.00549	0.00147					
6													-2.8	0.00557	0.0015					
7													-2.75	0.00564	0.00153					
8													-2.7	0.00572	0.00157					
9													-2.65	0.0058	0.0016					
10													-2.6	0.00588	0.00163					
11													-2.55	0.00595	0.00167					
12													-2.5	0.00603	0.0017					
13													-2.45	0.00613	0.00174					
14													-2.4	0.00622	0.00177					
15													-2.35	0.00631	0.00181					
16													-2.3	0.0064	0.00185					
17													-2.25	0.00649	0.00189					
18													-2.2	0.00659	0.00193					
19													-2.15	0.00669	0.00198					
20													-2.1	0.00679	0.00202					
21													-2.05	0.00689	0.00207					
22													-2	0.00699	0.00211					
23													-1.95	0.0071	0.00216					
24													-1.9	0.00721	0.00221					
25													-1.85	0.00732	0.00226					
26													-1.8	0.00744	0.00232					
27													-1.75	0.00755	0.00237					
28													-1.7	0.00767	0.00243					
29													-1.65	0.00778	0.00249					
30													-1.6	0.00792	0.00255					
31													-1.55	0.00803	0.00261					
32													-1.5	0.00818	0.00267					
33													-1.45	0.00832	0.00274					
34													-1.4	0.00846	0.0028					
35													-1.35	0.0086	0.00288					
36													-1.3	0.00874	0.00295					
37													-1.25	0.00889	0.00302					
38													-1.2	0.00906	0.0031					
39													-1.15	0.0092	0.00318					
40													-1.1	0.00936	0.00326					
41													-1.05	0.00953	0.00335					
42													-1	0.0097	0.00344					
43													-0.95	0.00987	0.00353					

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 (1-5 to 5)
ITA_bond_10Y_rate	By +/- STD None None None None None None None None		2

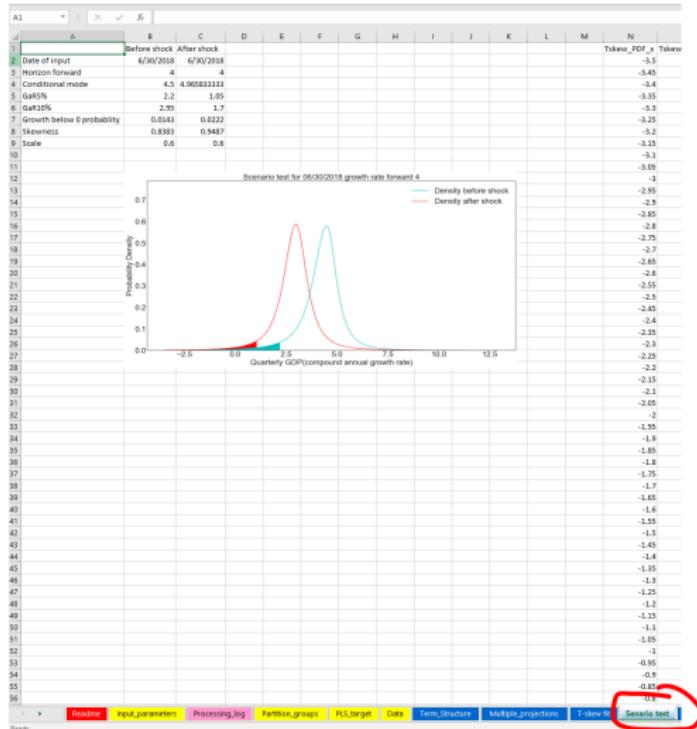
5th of 6:
Scenario Test

Partitions, quantile regressions skewed T fit must be executed before scenario test

Location after shock (mode of the distribution)
 Free
 Value if fixed

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 Constrains	Value if fixed
4	6/30/2018	Free	=
6	6/30/2018	Free	=
12	6/30/2018	Free	=
16	6/30/2018	Free	=
		Free	=

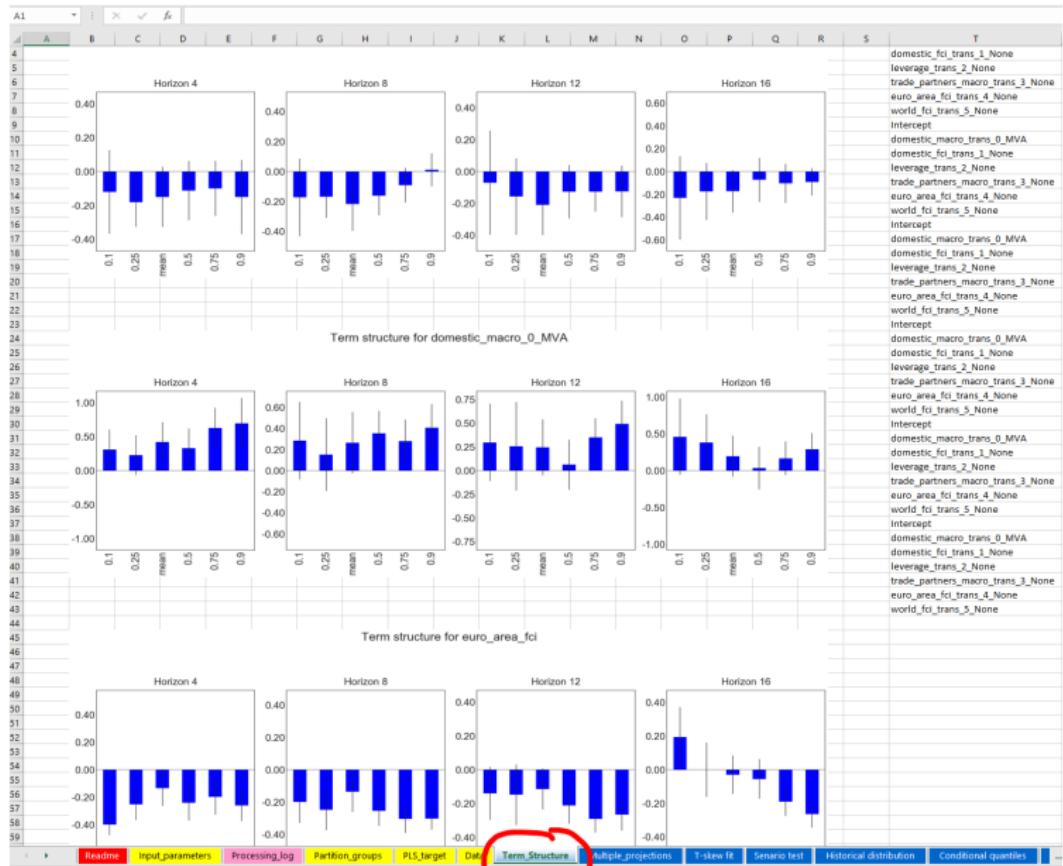
6th of 6:
Multiple Projections

Previous settings will be used for
Multiple Horizons Projections

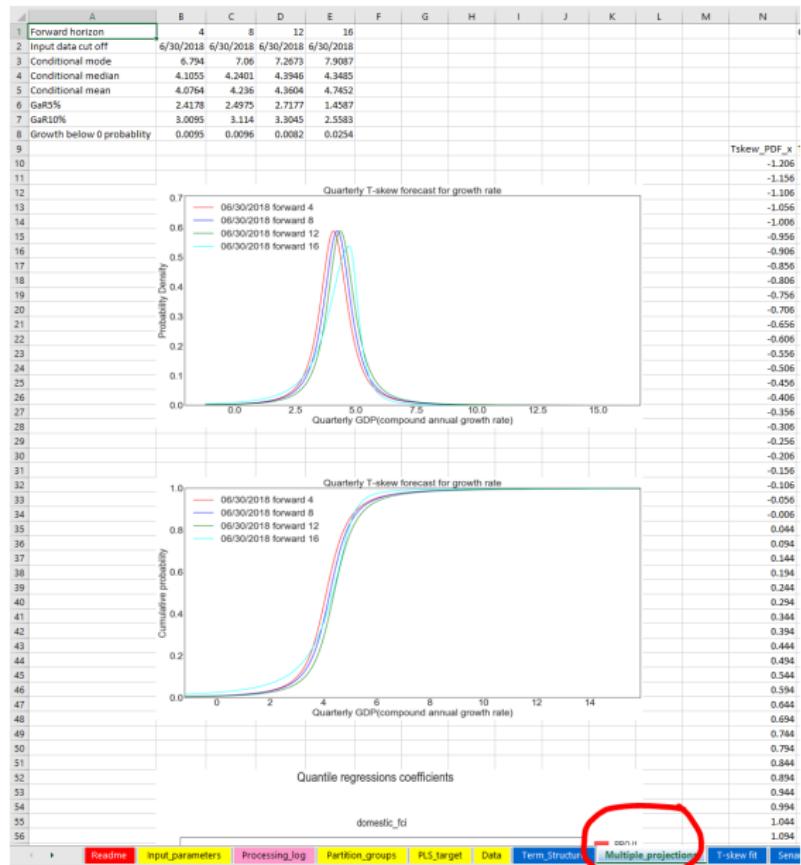
Multiple Horizon Projections sheet name (default: Multiple_projections)

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
r.lafarguette@imf.org