Density Forecasting: Growth at Risk
Part II. Applications

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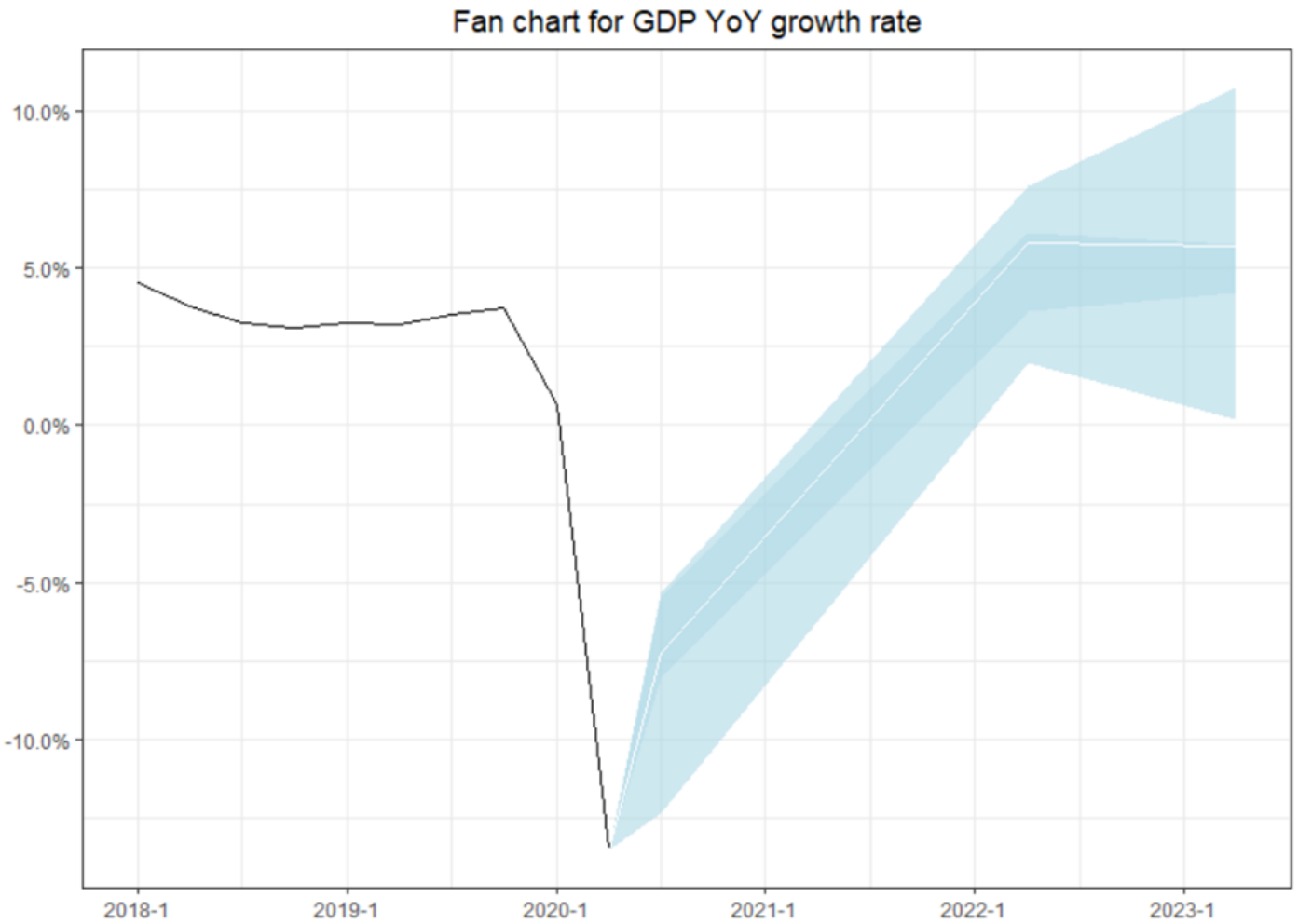
Fan Charts

- 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

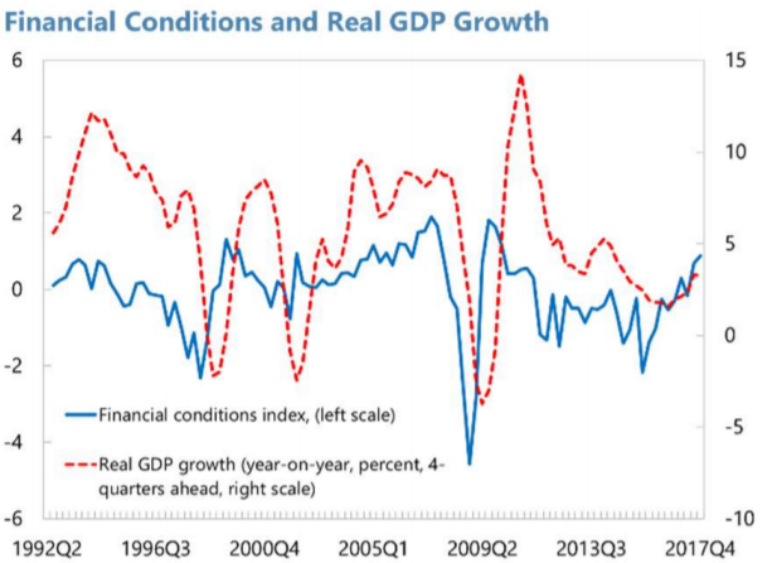
Fan chart: Israel 2020

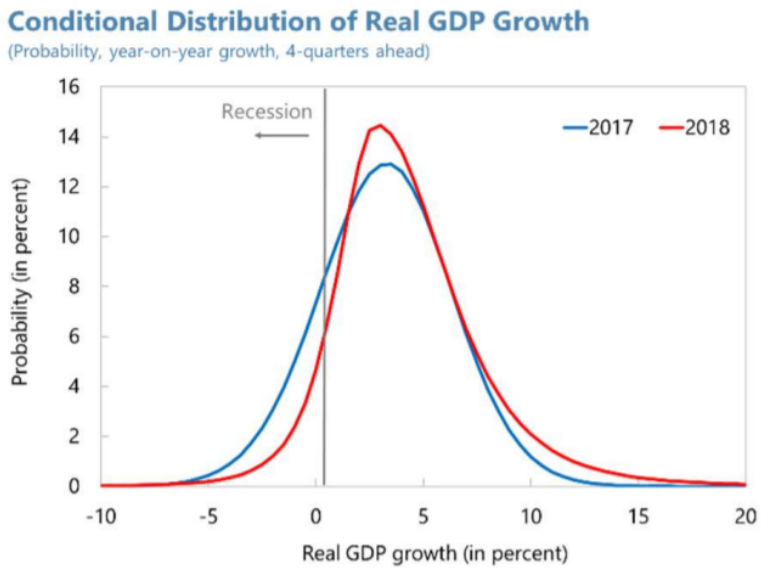


Source: BoI Financial Stability Report, June 2020

Singapore: Probability of Recessions

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

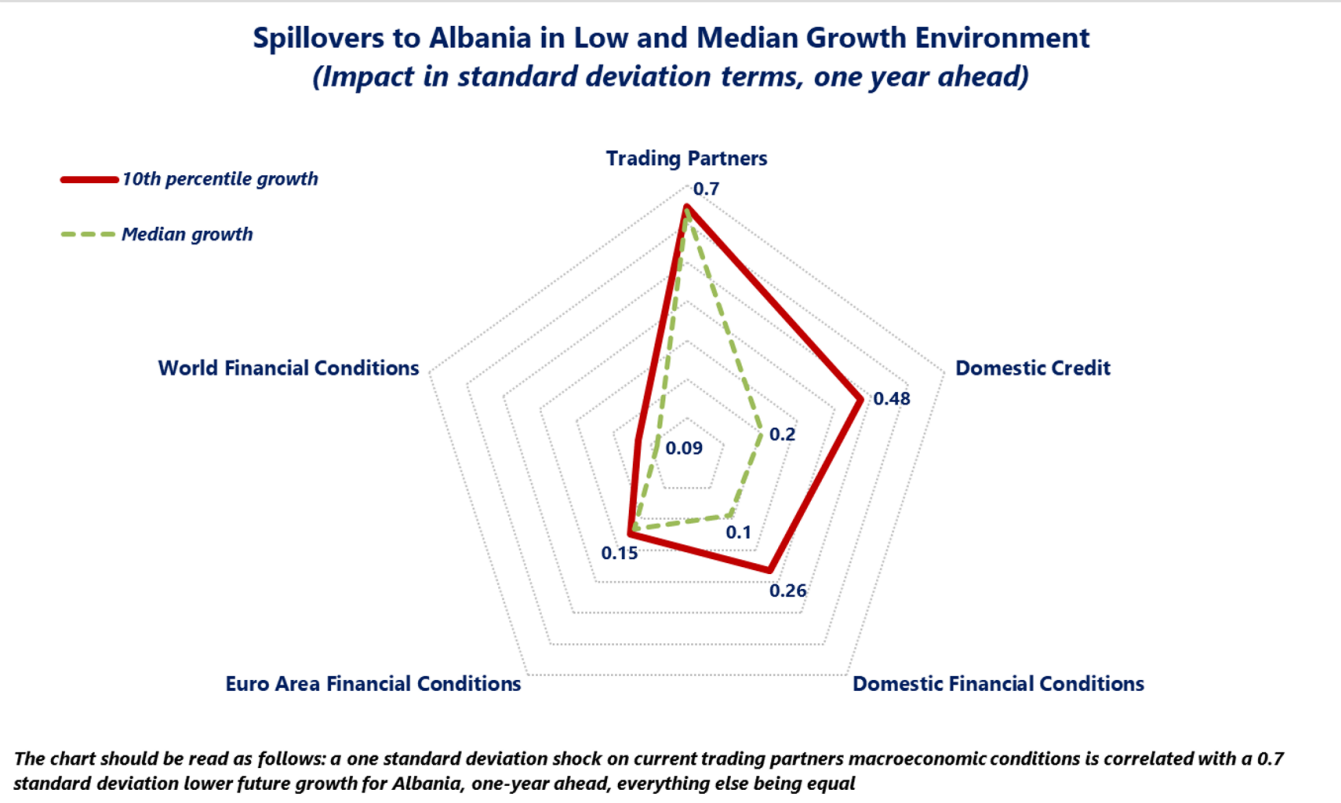




Source: IMF Article IV (2018)

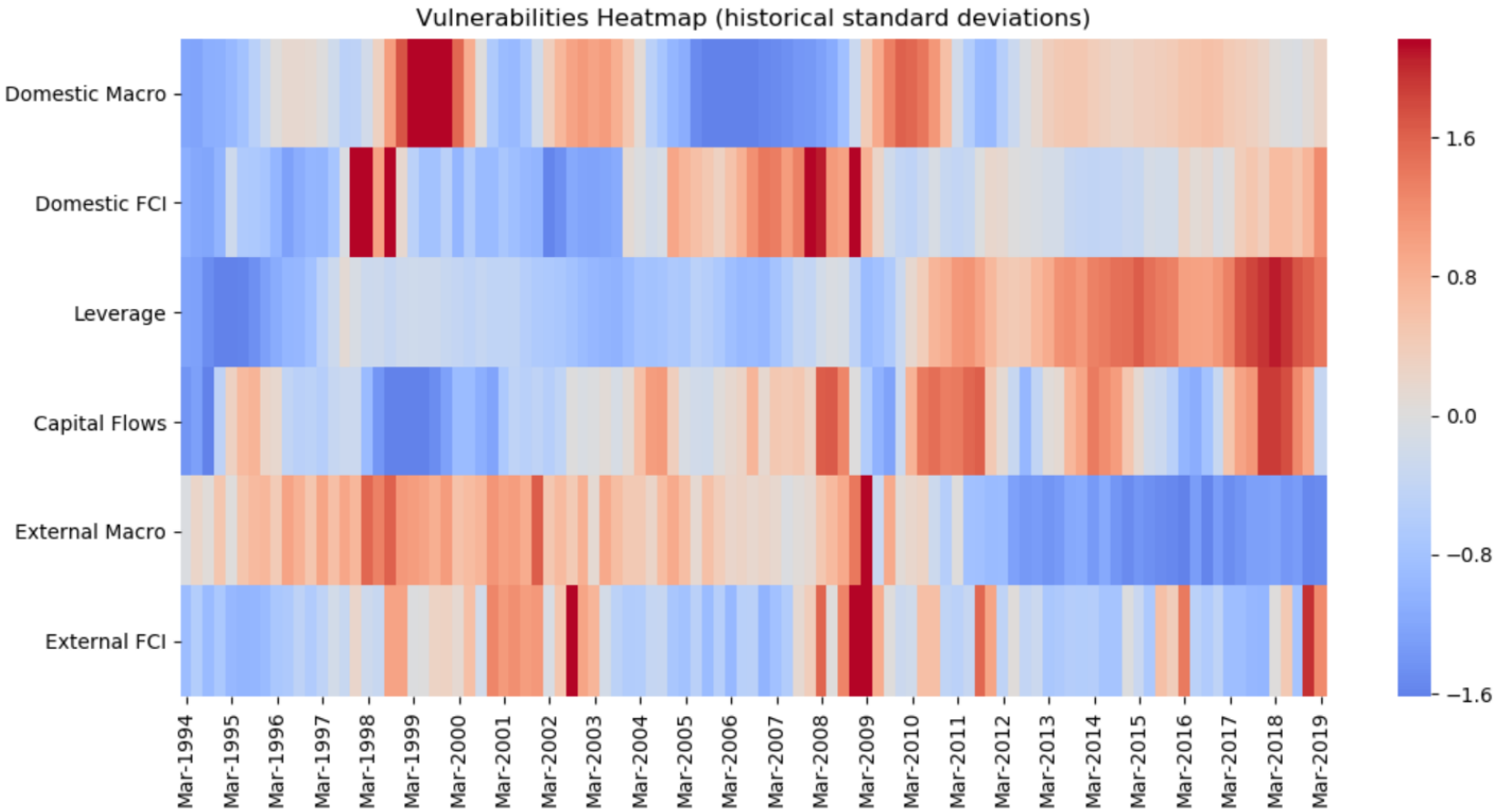
Spillover analysis

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

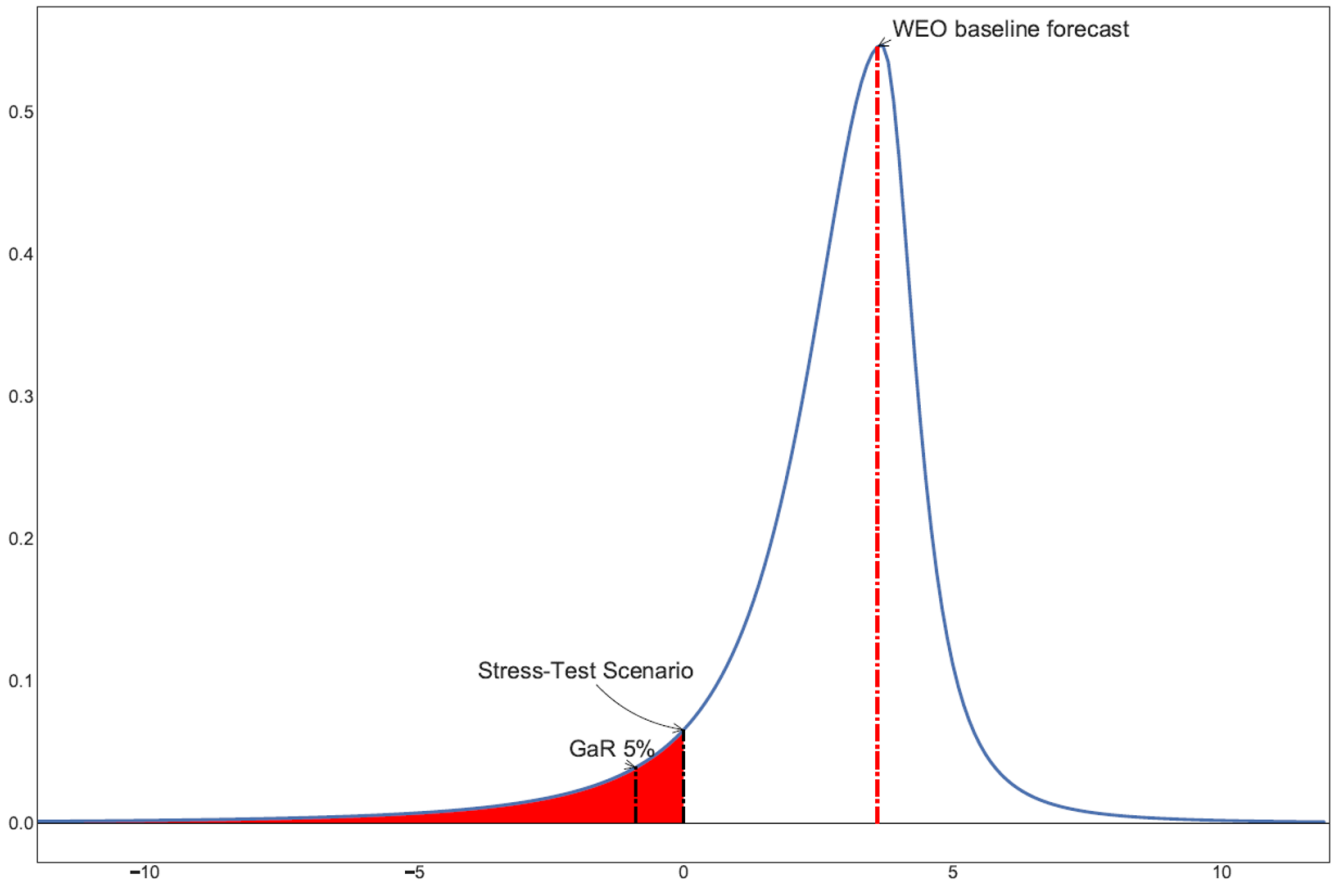
Assessing the Likelihood of a Scenario (II)

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, possbility 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)

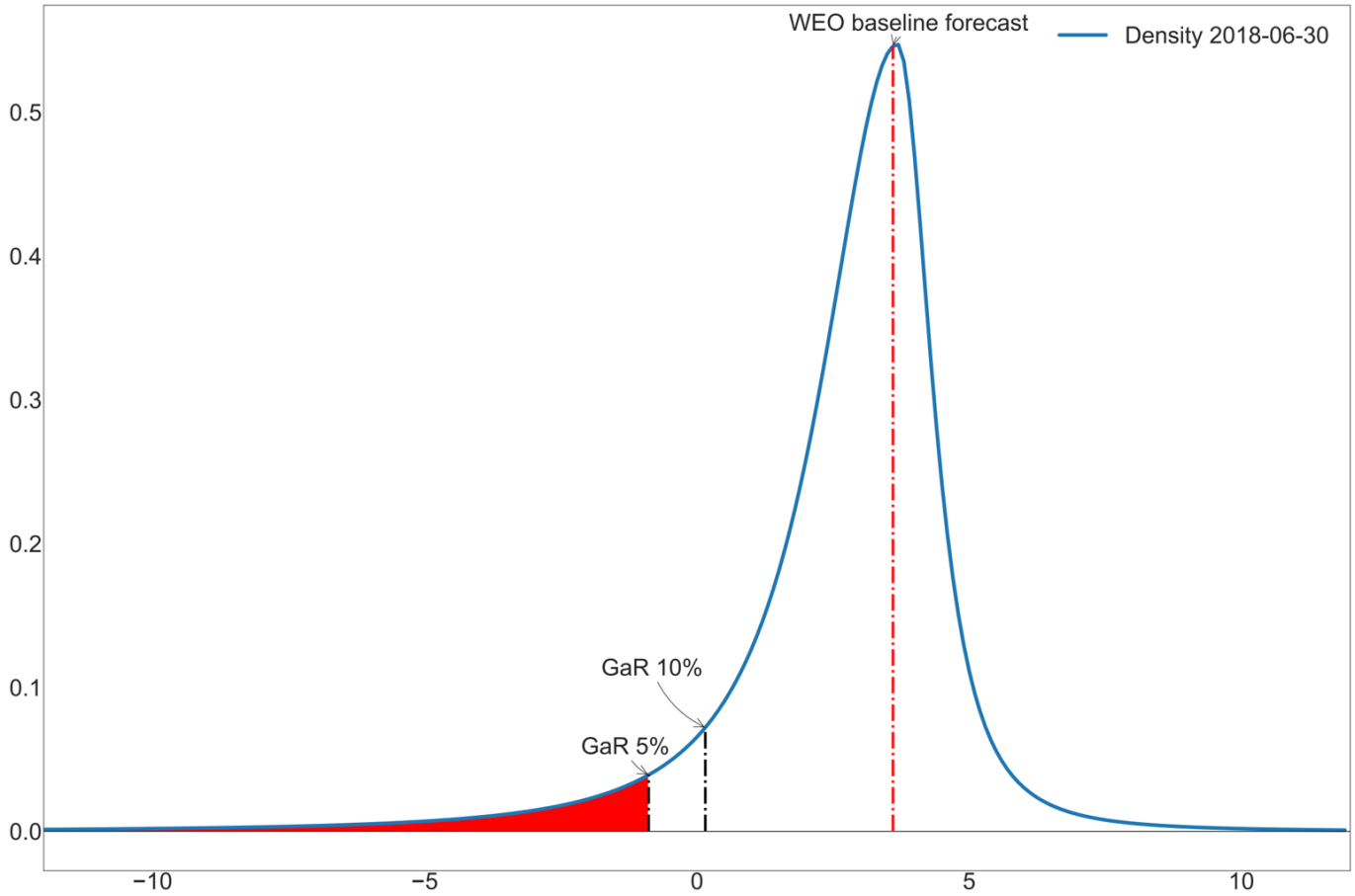
Modeling Tail-Risks Around a Baseline Scenario (II)

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)

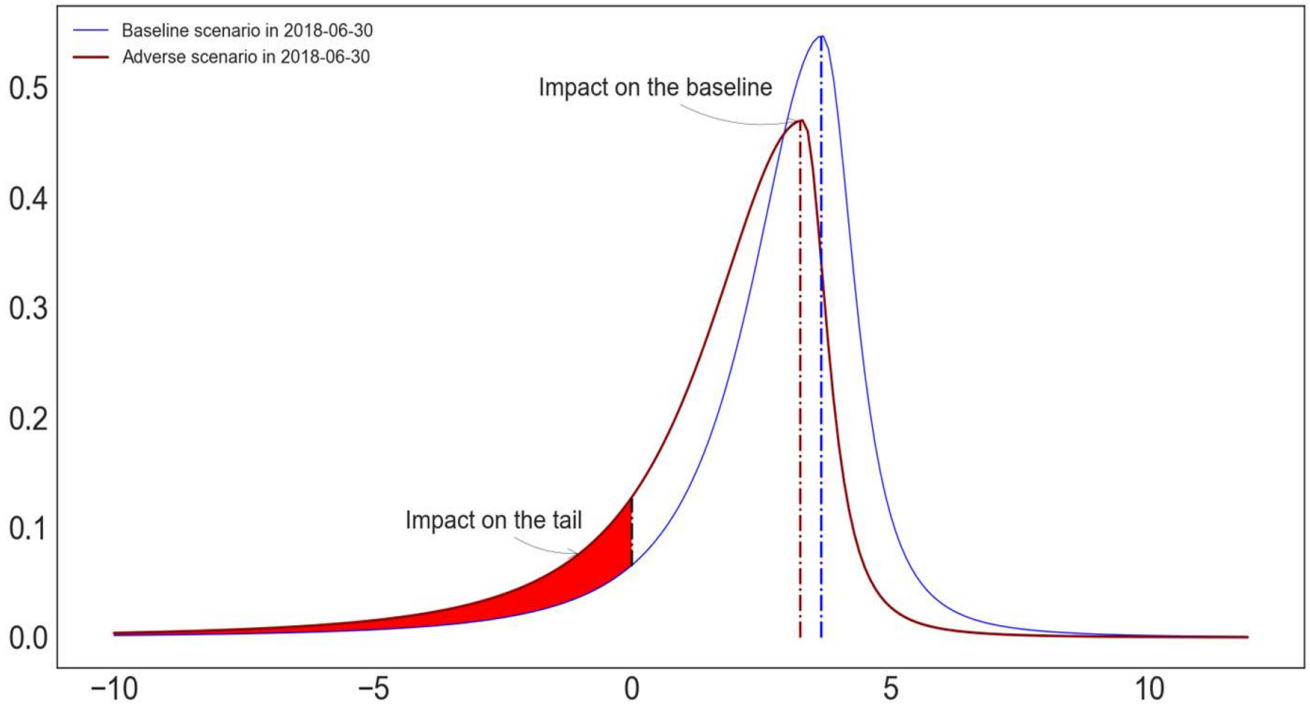
Impact of Tightened Financial Conditions on Growth

Adverse scenario assumes a 1 sd shock on price of risk

Results:

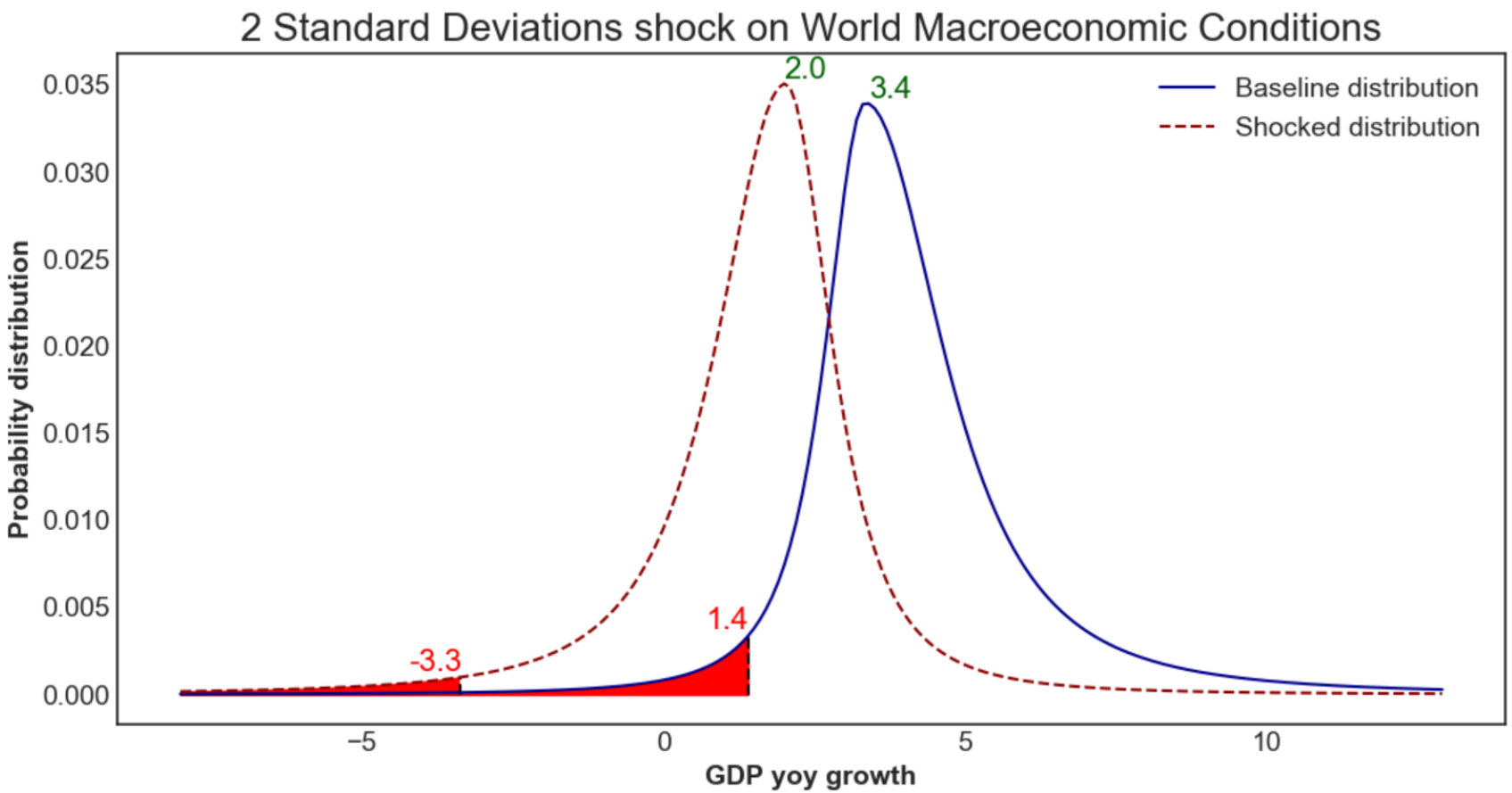
Impact on the average growth: from 3.6% to 3.25%

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 straigthforward 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

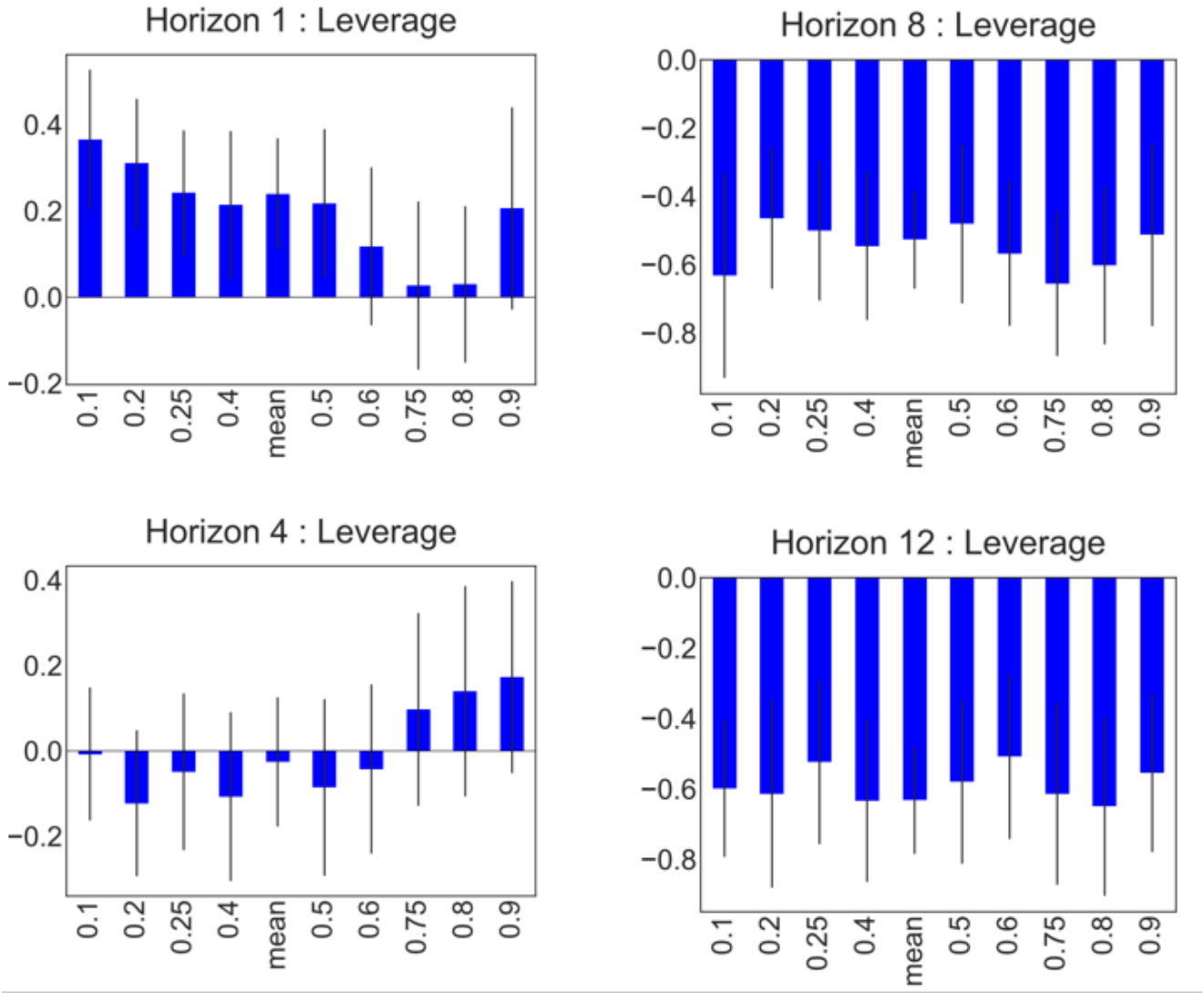
Quantifying the RAM: Albania

Quantitative Risk Assessment, One-Year Horizon

Source of Risk	Relative Likelihood compared with the no-shock scenario	Simulated Shock *(in standard deviations)*	Estimated Impact on the Median vs. 10th percentile *(in p.p. real growth)*	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%

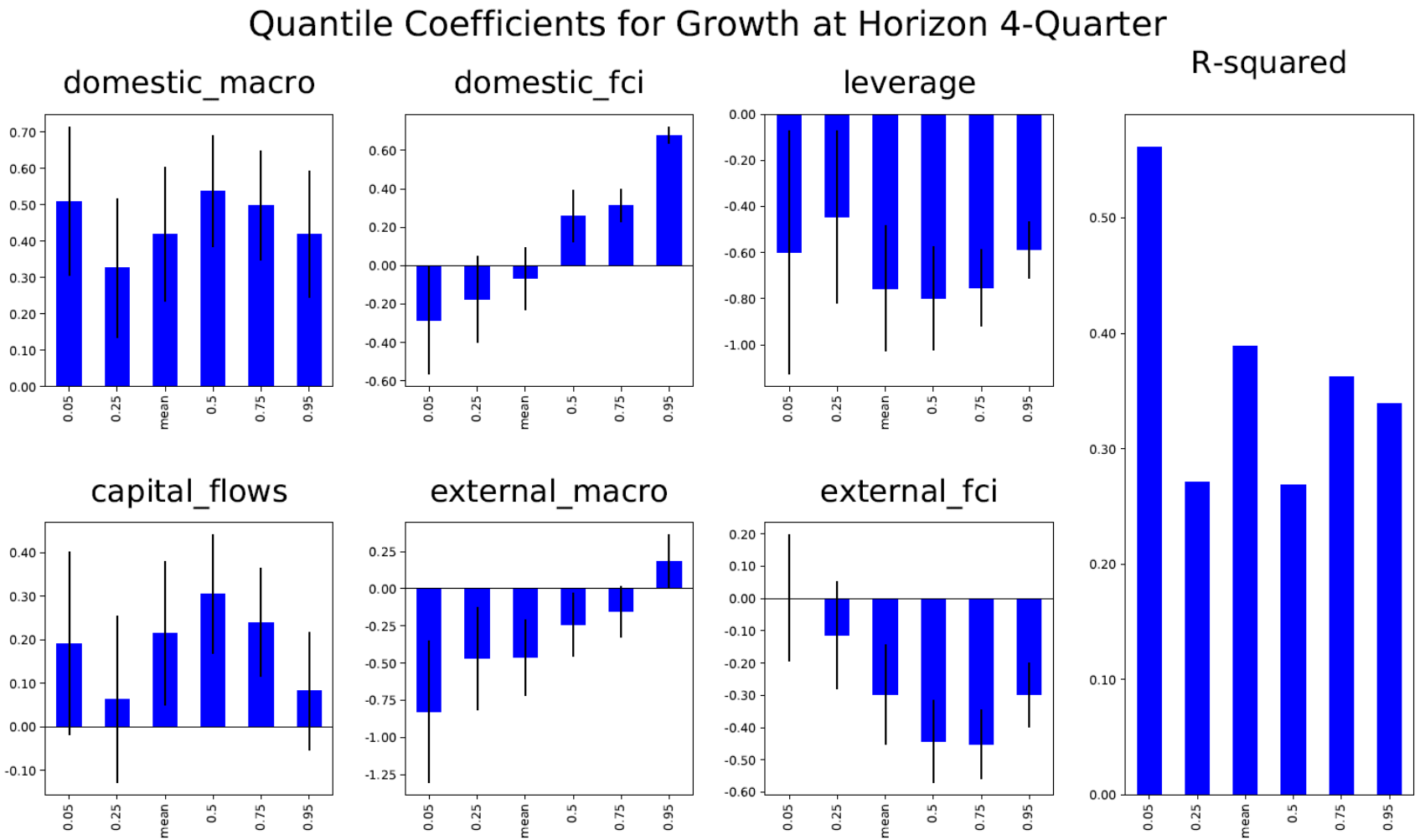
Source: IMF Albania Article IV (2018)

Term Structure of Growth at Risk (Local Projections)



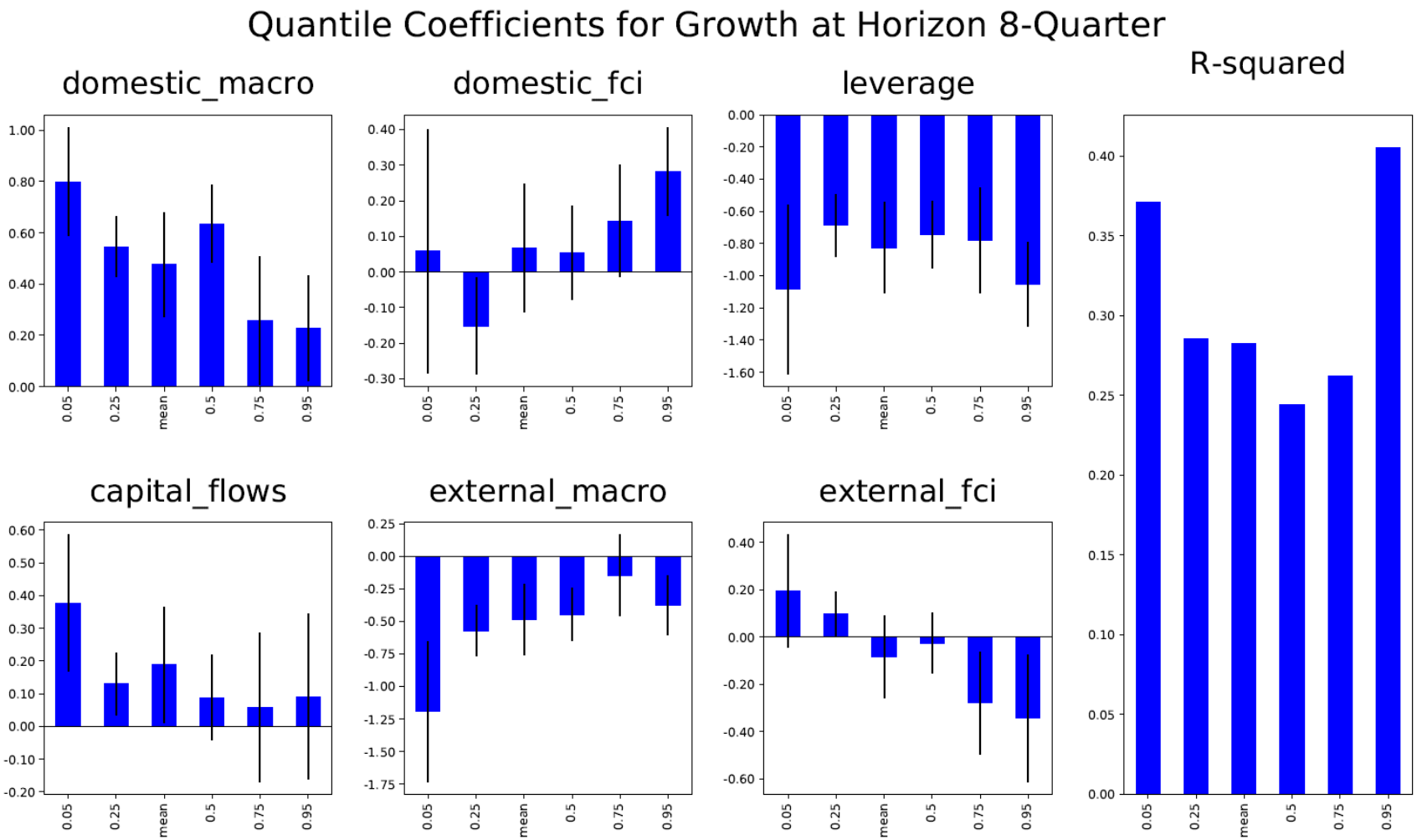
Source: IMF Staff

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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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

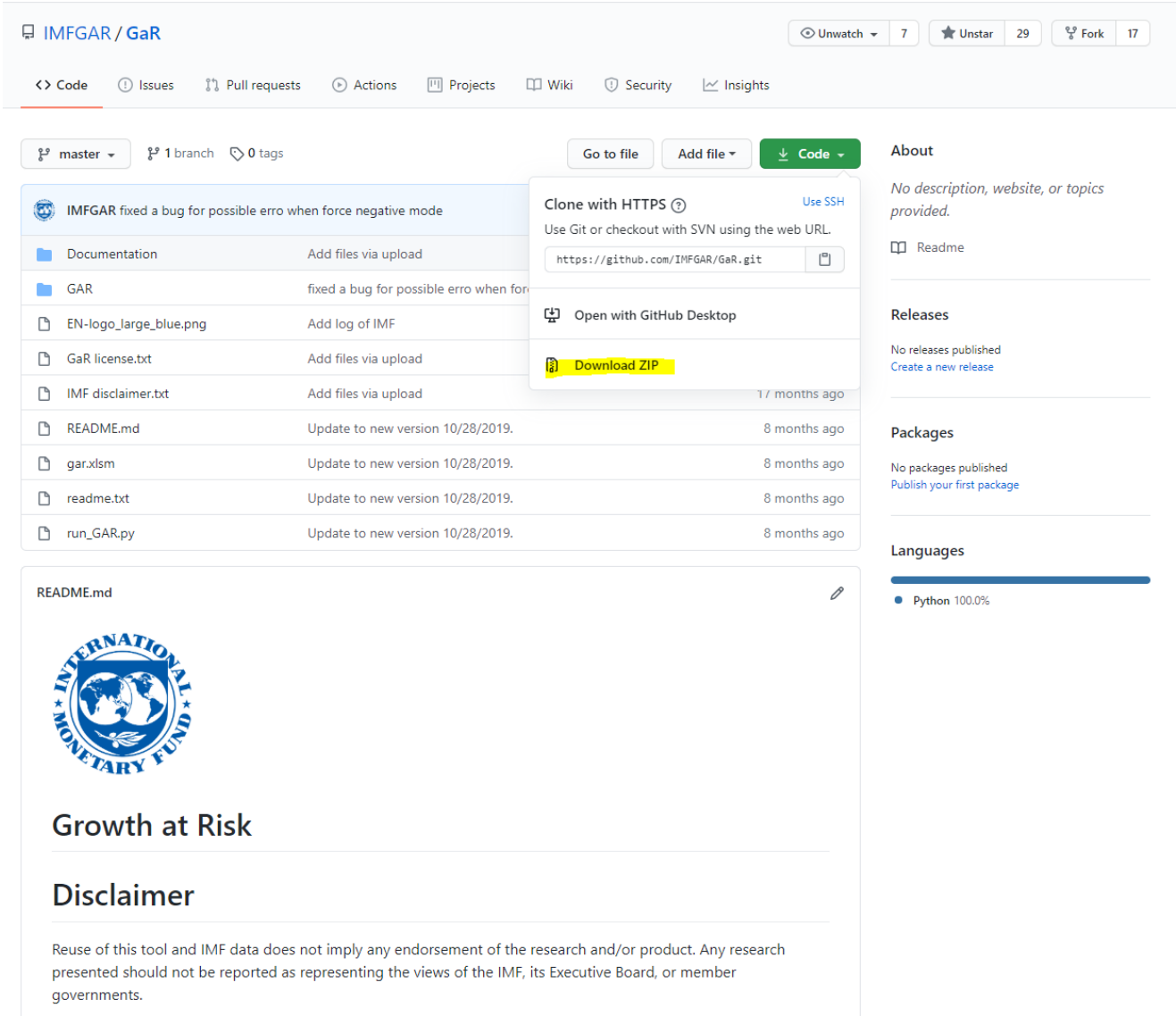
Applied Work with GaR

- Identify key macro-financial factors and vulnerabilities guided by economic intuition, experience, theory
- Understand what variables shift the mean and 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

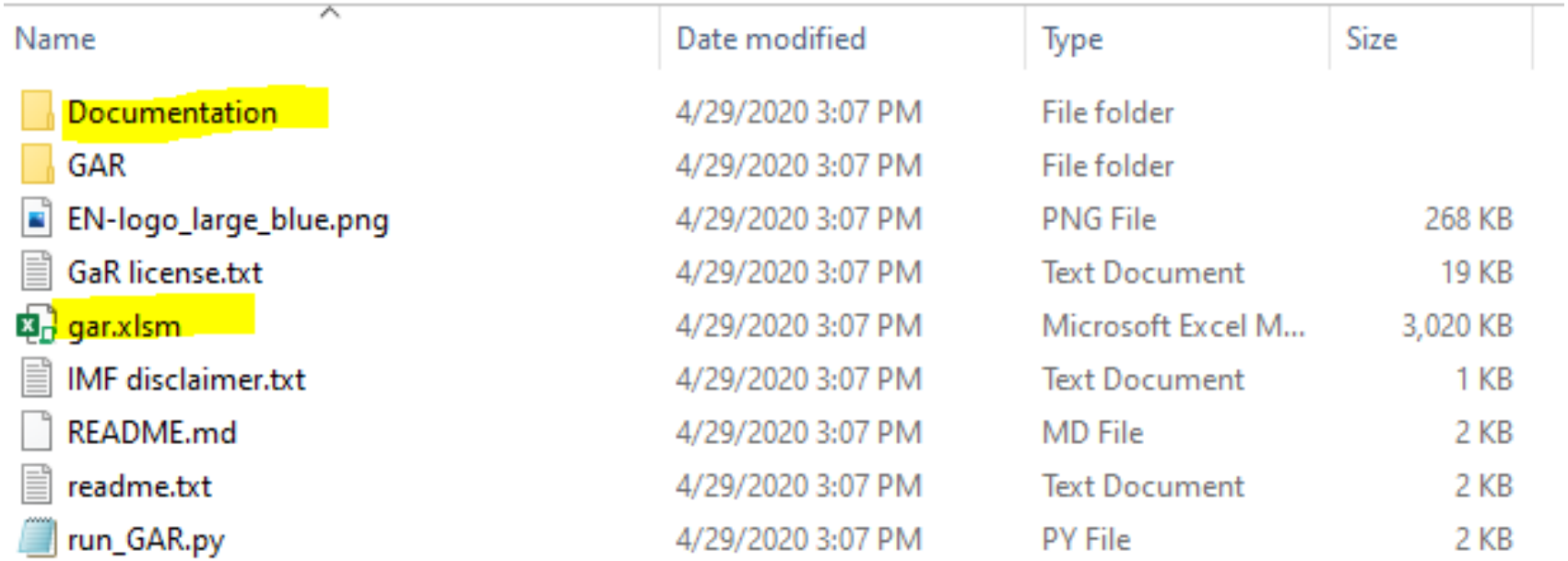
Source: https://www.anaconda.com/products/individual

Download GaR from Github (Official IMF Repo)



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

Unzip the folder: Documentation and Main Excel File



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GAR	4/29/2020 3:07 PM	File folder	
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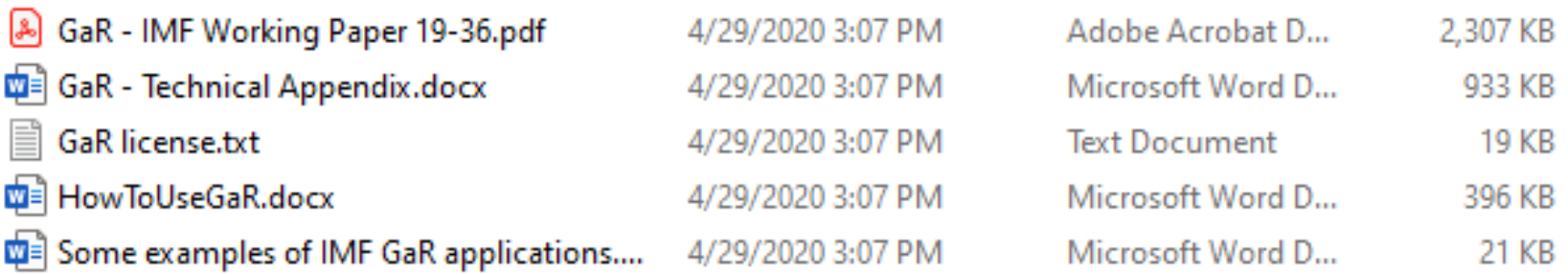
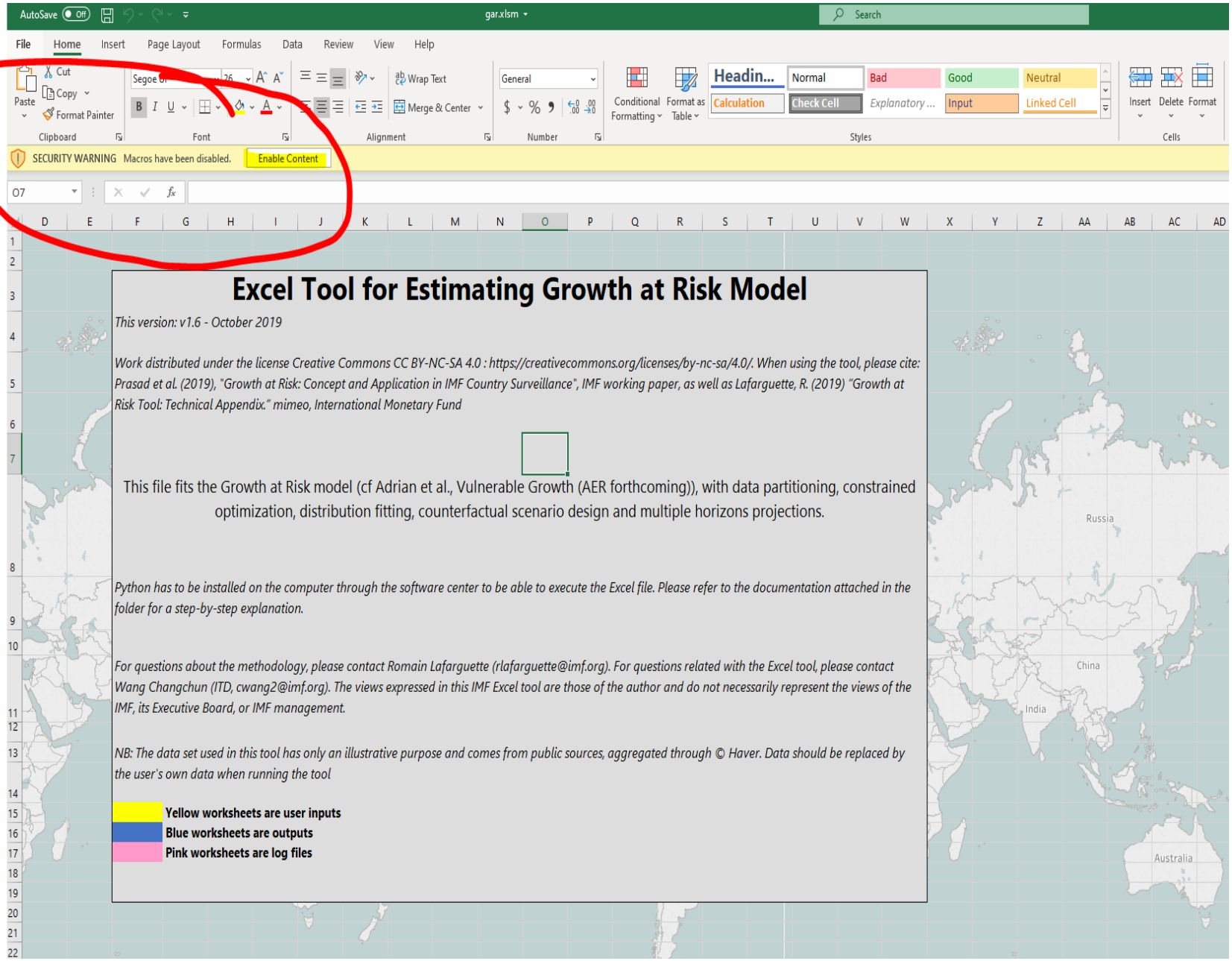
GaR license.txt	4/29/2020 3:07 PM	Text Document	19 KB
gar.xlsm	4/29/2020 3:07 PM	Microsoft Excel M...	3,020 KB
IMF disclaimer.txt	4/29/2020 3:07 PM	Text Document	1 KB
README.md	4/29/2020 3:07 PM	MD File	2 KB
readme.txt	4/29/2020 3:07 PM	Text Document	2 KB
run_GAR.py	4/29/2020 3:07 PM	PY File	2 KB

Documentation

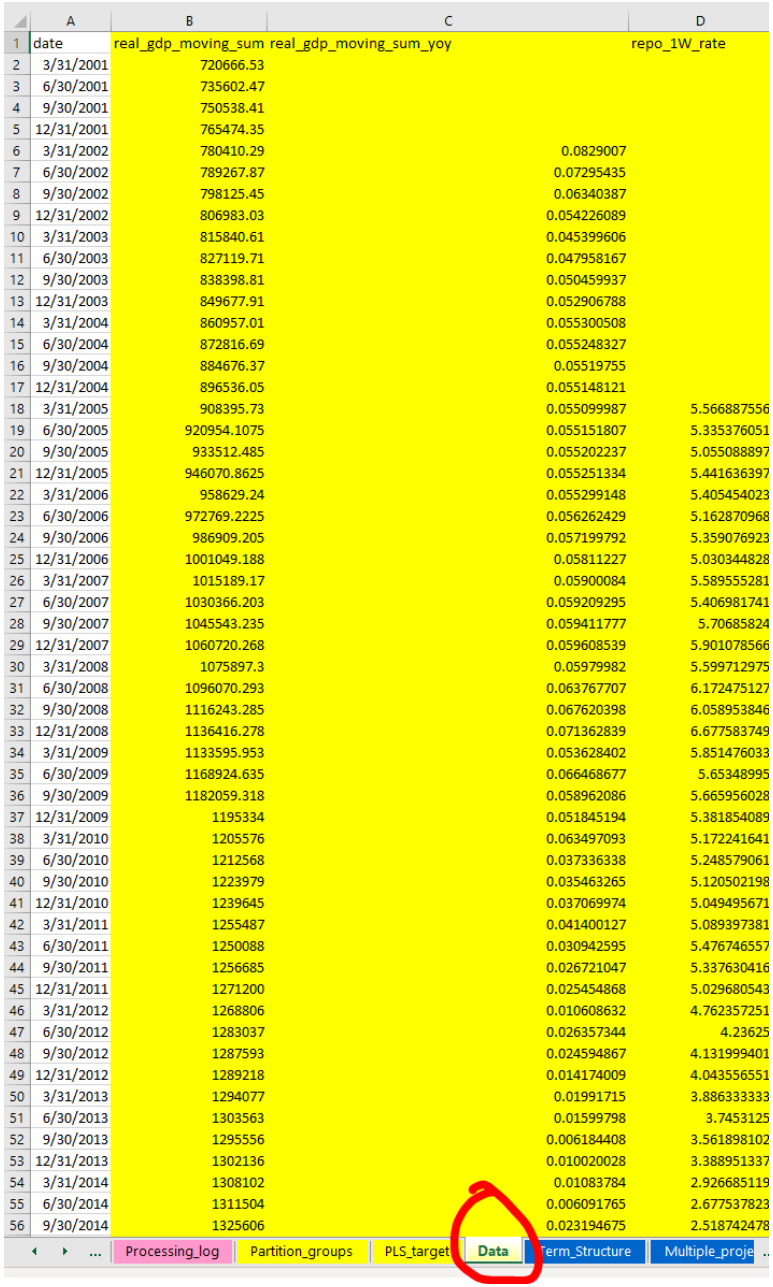


GaR - IMF Working Paper 19-36.pdf	4/29/2020 3:07 PM	Adobe Acrobat D...	2,307 KB
GaR - Technical Appendix.docx	4/29/2020 3:07 PM	Microsoft Word D...	933 KB
GaR license.txt	4/29/2020 3:07 PM	Text Document	19 KB
HowToUseGaR.docx	4/29/2020 3:07 PM	Microsoft Word D...	396 KB
Some examples of IMF GaR applications....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

Open the Excel tool and enable content



Input data on the ”Data” yellow sheet



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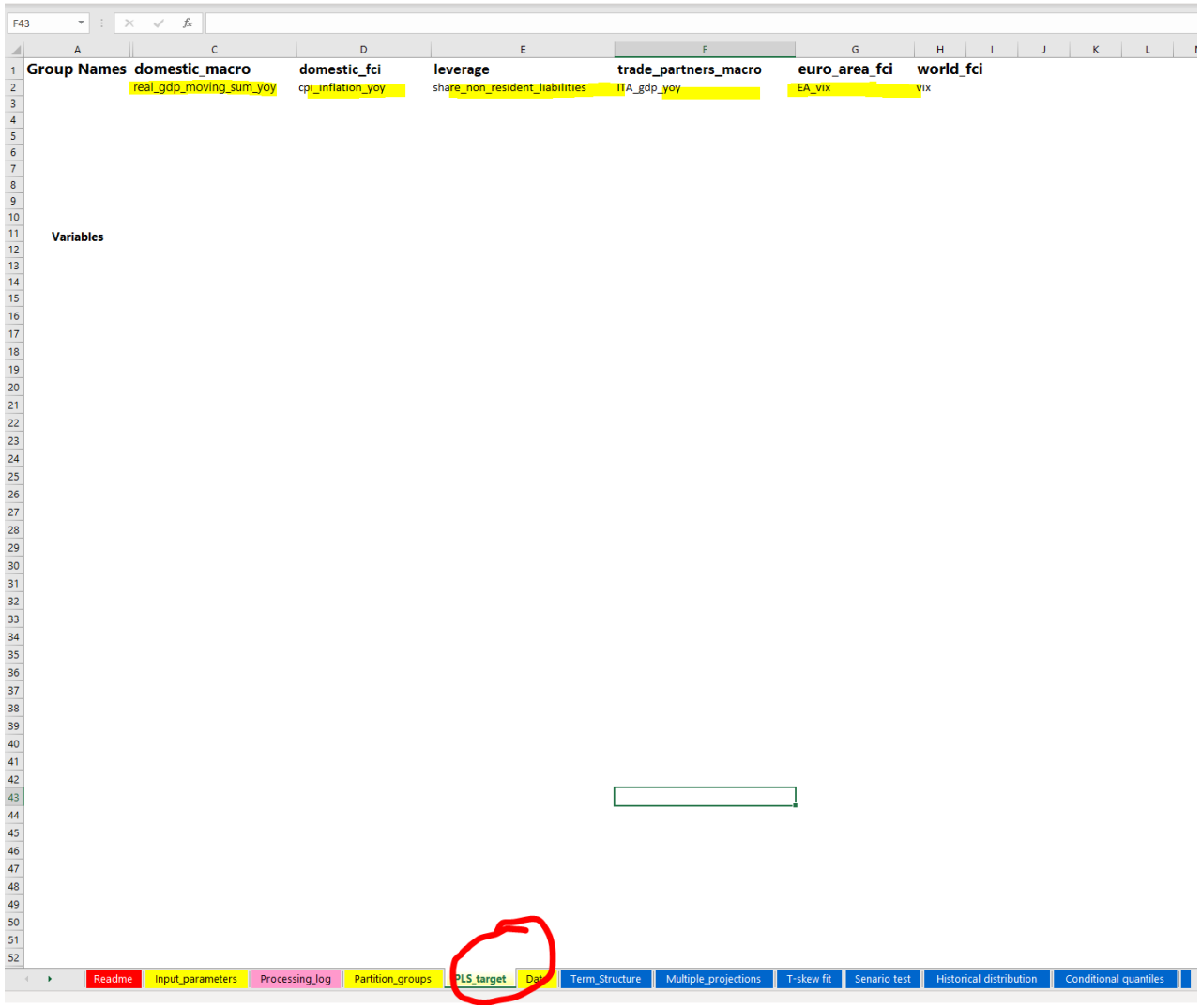
3	6/30/2001	735602.47		
4	9/30/2001	750538.41		
5	12/31/2001	765474.35		
6	3/31/2002	780410.29	0.0829007	
7	6/30/2002	789267.87	0.07295435	
8	9/30/2002	798125.45	0.06340387	
9	12/31/2002	806983.03	0.054226089	
10	3/31/2003	815840.61	0.045399606	
11	6/30/2003	827119.71	0.047958167	
12	9/30/2003	838398.81	0.050459937	
13	12/31/2003	849677.91	0.052906788	
14	3/31/2004	860957.01	0.055300508	
15	6/30/2004	872816.69	0.055248327	
16	9/30/2004	884676.37	0.05519755	
17	12/31/2004	896536.05	0.055148121	
18	3/31/2005	908395.73	0.055099987	5.566887556
19	6/30/2005	920954.1075	0.055151807	5.335376051
20	9/30/2005	933512.485	0.055202237	5.055088897
21	12/31/2005	946070.8625	0.055251334	5.441636397
22	3/31/2006	958629.24	0.055299148	5.405454023
23	6/30/2006	972769.2225	0.056262429	5.162870968
24	9/30/2006	986909.205	0.057199792	5.359076923
25	12/31/2006	1001049.188	0.05811227	5.030344828
26	3/31/2007	1015189.17	0.05900084	5.589555281
27	6/30/2007	1030366.203	0.059209295	5.406981741
28	9/30/2007	1045543.235	0.059411777	5.70685824
29	12/31/2007	1060720.268	0.059608539	5.901078566
30	3/31/2008	1075897.3	0.05979982	5.599712975
31	6/30/2008	1096070.293	0.063767707	6.172475127
32	9/30/2008	1116243.285	0.067620398	6.058953846
33	12/31/2008	1136416.278	0.071362839	6.677583749
34	3/31/2009	1133595.953	0.053628402	5.851476033
35	6/30/2009	1168924.635	0.066468677	5.65348995
36	9/30/2009	1182059.318	0.058962086	5.665956028
37	12/31/2009	1195334	0.051845194	5.381854089
38	3/31/2010	1205576	0.063497093	5.172241641
39	6/30/2010	1212568	0.037336338	5.248579061
40	9/30/2010	1223979	0.035463265	5.120502198
41	12/31/2010	1239645	0.037069974	5.049495671
42	3/31/2011	1255487	0.041400127	5.089397381
43	6/30/2011	1250088	0.030942595	5.476746557
44	9/30/2011	1256685	0.026721047	5.337630416
45	12/31/2011	1271200	0.025454868	5.029680543
46	3/31/2012	1268806	0.010608632	4.762357251
47	6/30/2012	1283037	0.026357344	4.23625
48	9/30/2012	1287593	0.024594867	4.131999401
49	12/31/2012	1289218	0.014174009	4.043556551
50	3/31/2013	1294077	0.01991715	3.886333333
51	6/30/2013	1303563	0.01599798	3.7453125
52	9/30/2013	1295556	0.006184408	3.561898102
53	12/31/2013	1302136	0.010020028	3.388951337
54	3/31/2014	1308102	0.01083784	2.926685119
55	6/30/2014	1311504	0.006091765	2.677537823
56	9/30/2014	1325606	0.023194675	2.518742478

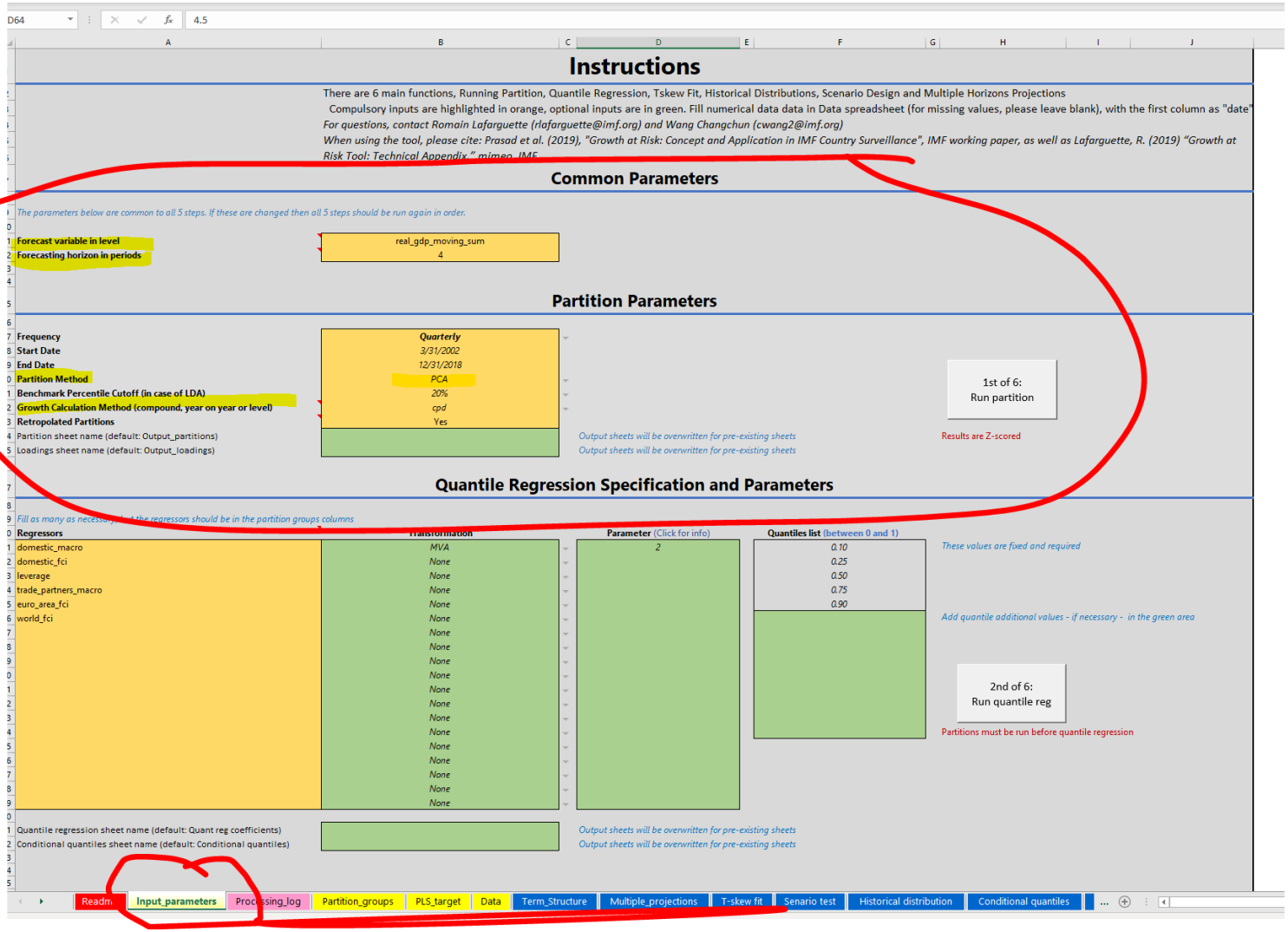
Processing_log | Partition_groups | PLS_target | Data | Term_Structure | Multiple_proje

Group variables into partitions in the ”Partition” excel sheet

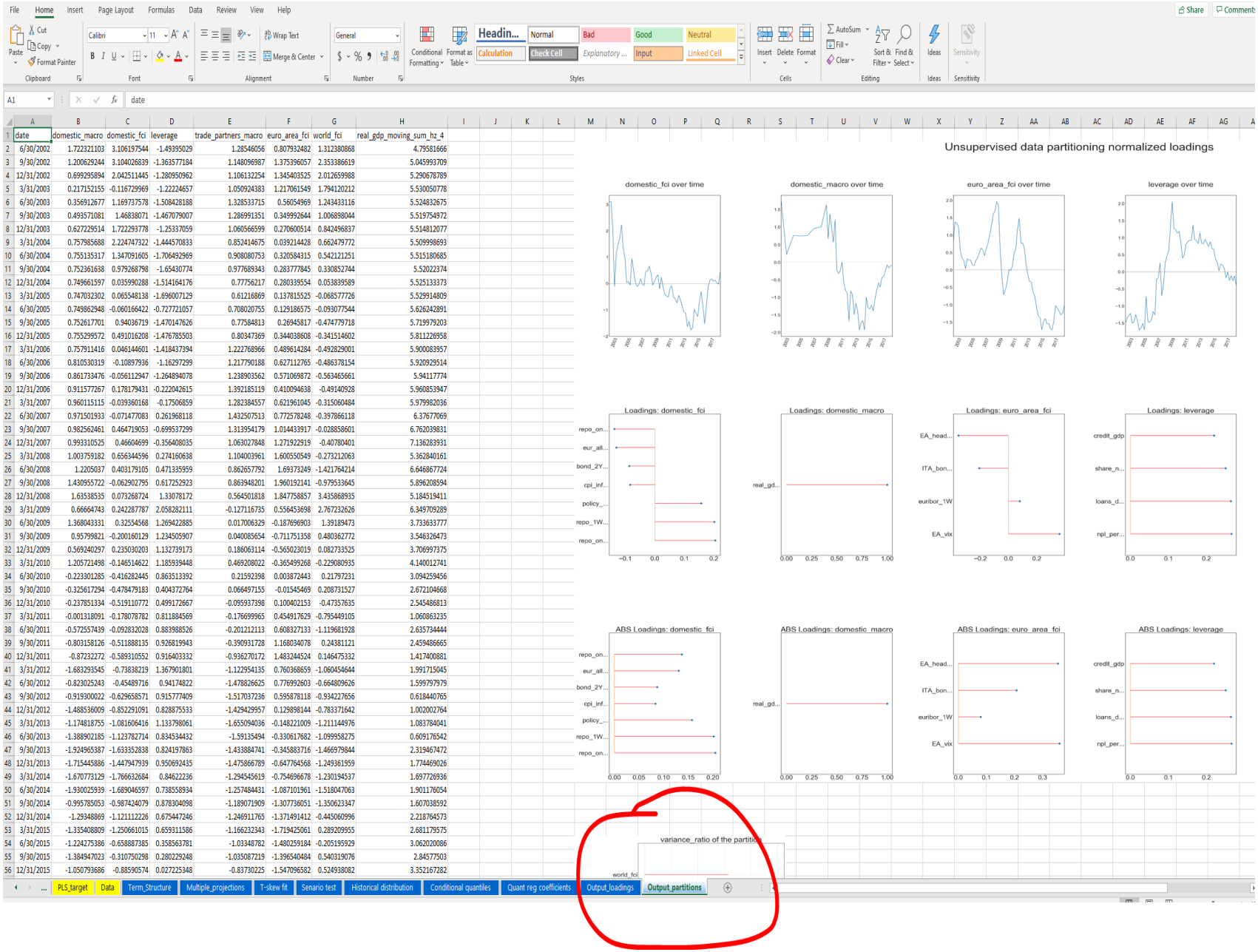
In case of PLS: determine supervising variables in ”PLS target” sheet



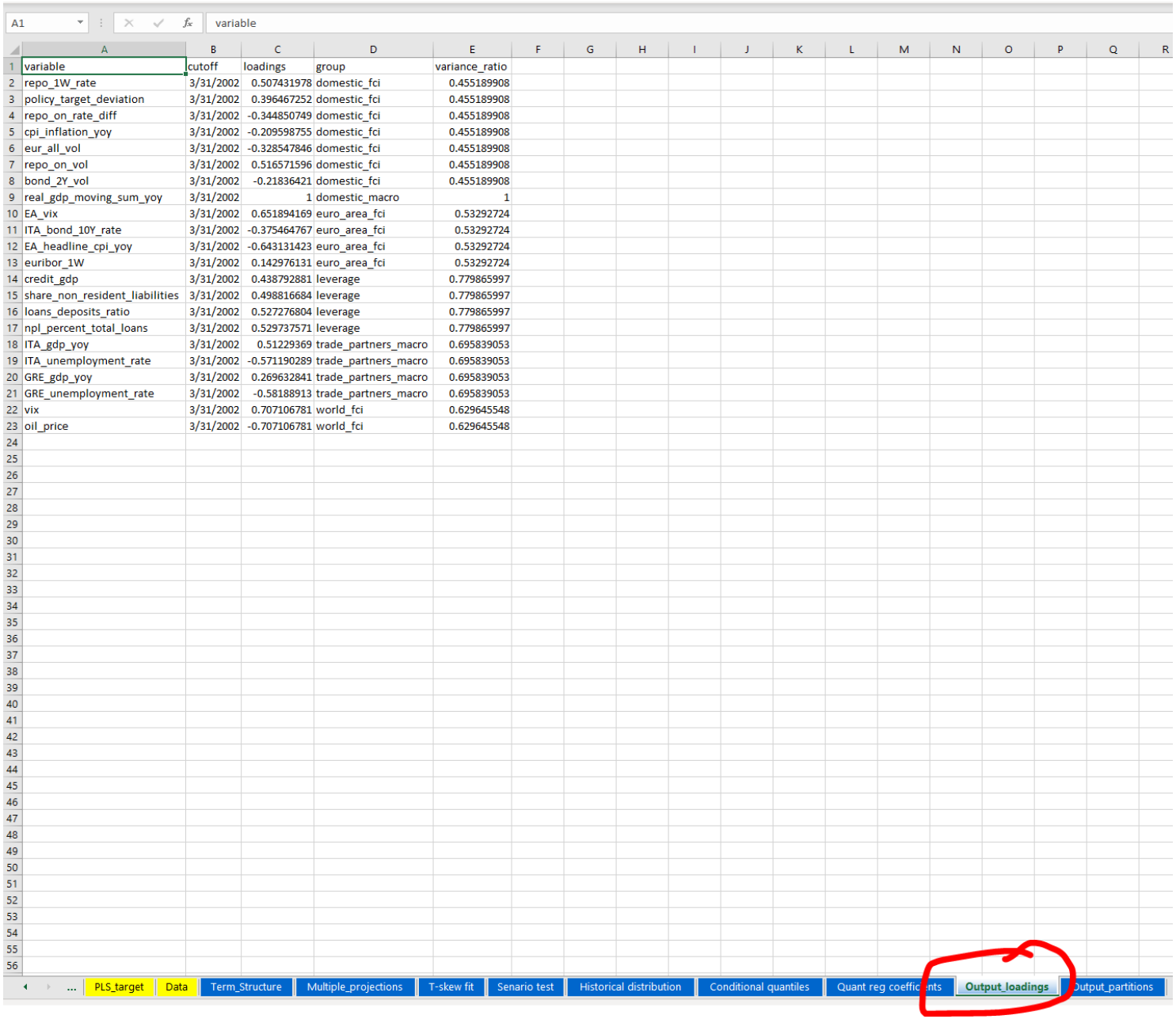
Estimate the partitions: choose horizon, partitioning methods, etc.



Estimated partitions are in ”Output˙partitions”

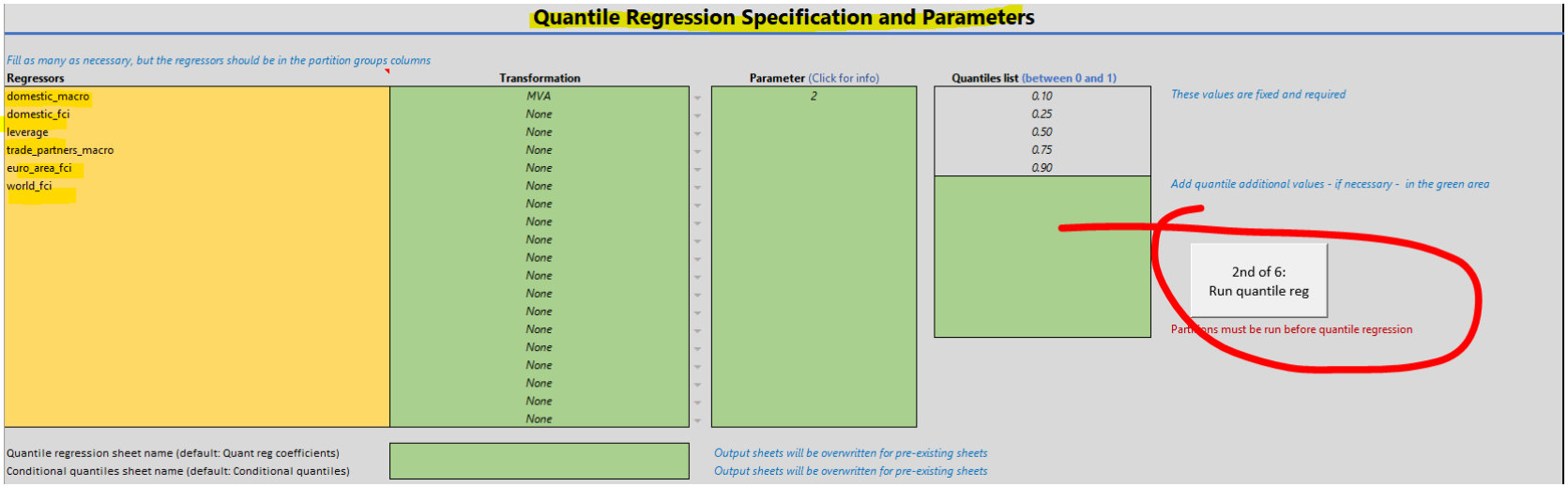


Estimated loadings are in "Output˙loadings"



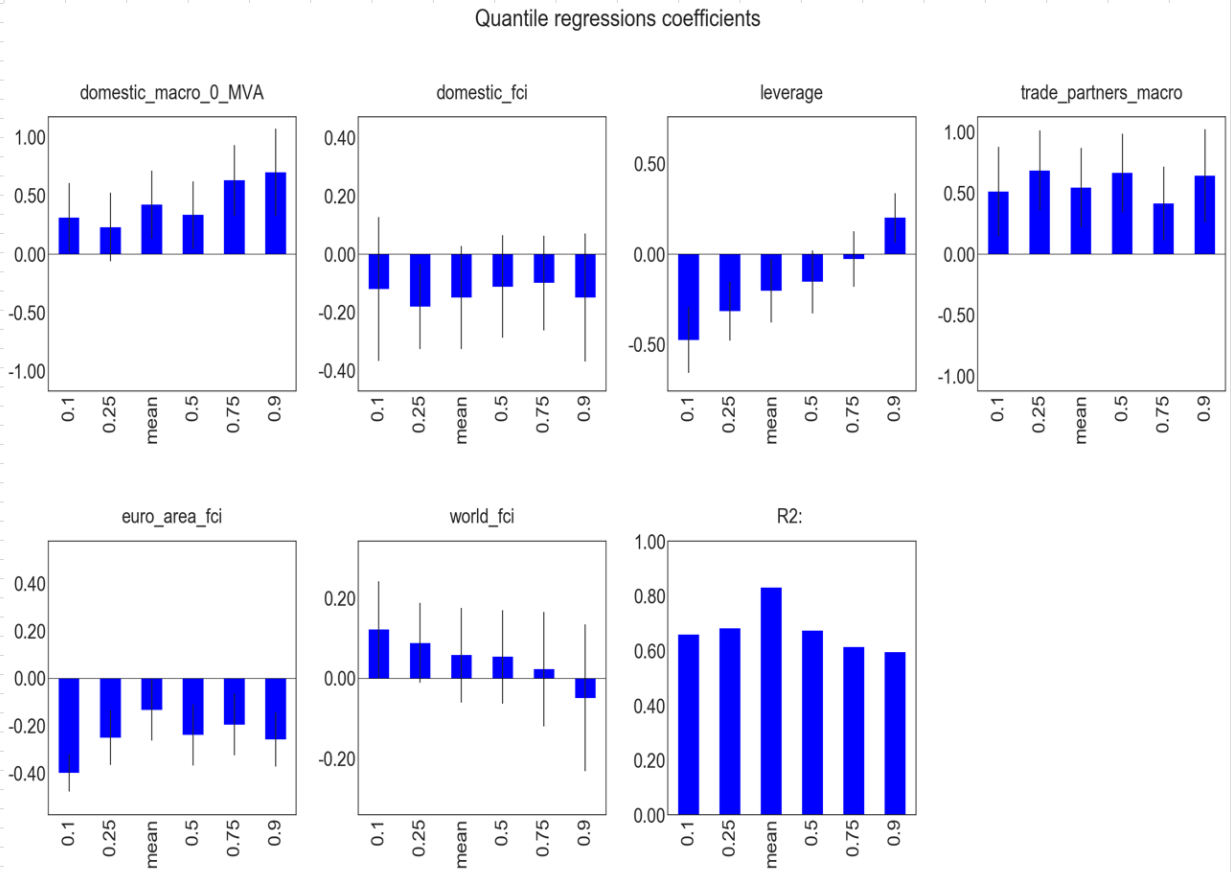
	A	B	C	D	E
1	variable	cutoff	loadings	group	variance_ratio
2	repo_1W_rate	3/31/2002	0.507431978	domestic_fci	0.455189908
3	policy_target_deviation	3/31/2002	0.396467252	domestic_fci	0.455189908
4	repo_on_rate_diff	3/31/2002	-0.344850749	domestic_fci	0.455189908
5	cpi_inflation_yoy	3/31/2002	-0.209598755	domestic_fci	0.455189908
6	eur_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	-0.643131423	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	npl_percent_total_loans	3/31/2002	0.529737571	leverage	0.779865997
18	ITA_gdp_yoy	3/31/2002	0.51229369	trade_partners_macro	0.695839053
19	ITA_unemployment_rate	3/31/2002	-0.571190289	trade_partners_macro	0.695839053
20	GRE_gdp_yoy	3/31/2002	0.269632841	trade_partners_macro	0.695839053
21	GRE_unemployment_rate	3/31/2002	-0.58188913	trade_partners_macro	0.695839053
22	vix	3/31/2002	0.707106781	world_fci	0.629645548
23	oil_price	3/31/2002	-0.707106781	world_fci	0.629645548

Parameters for the quantile regressions



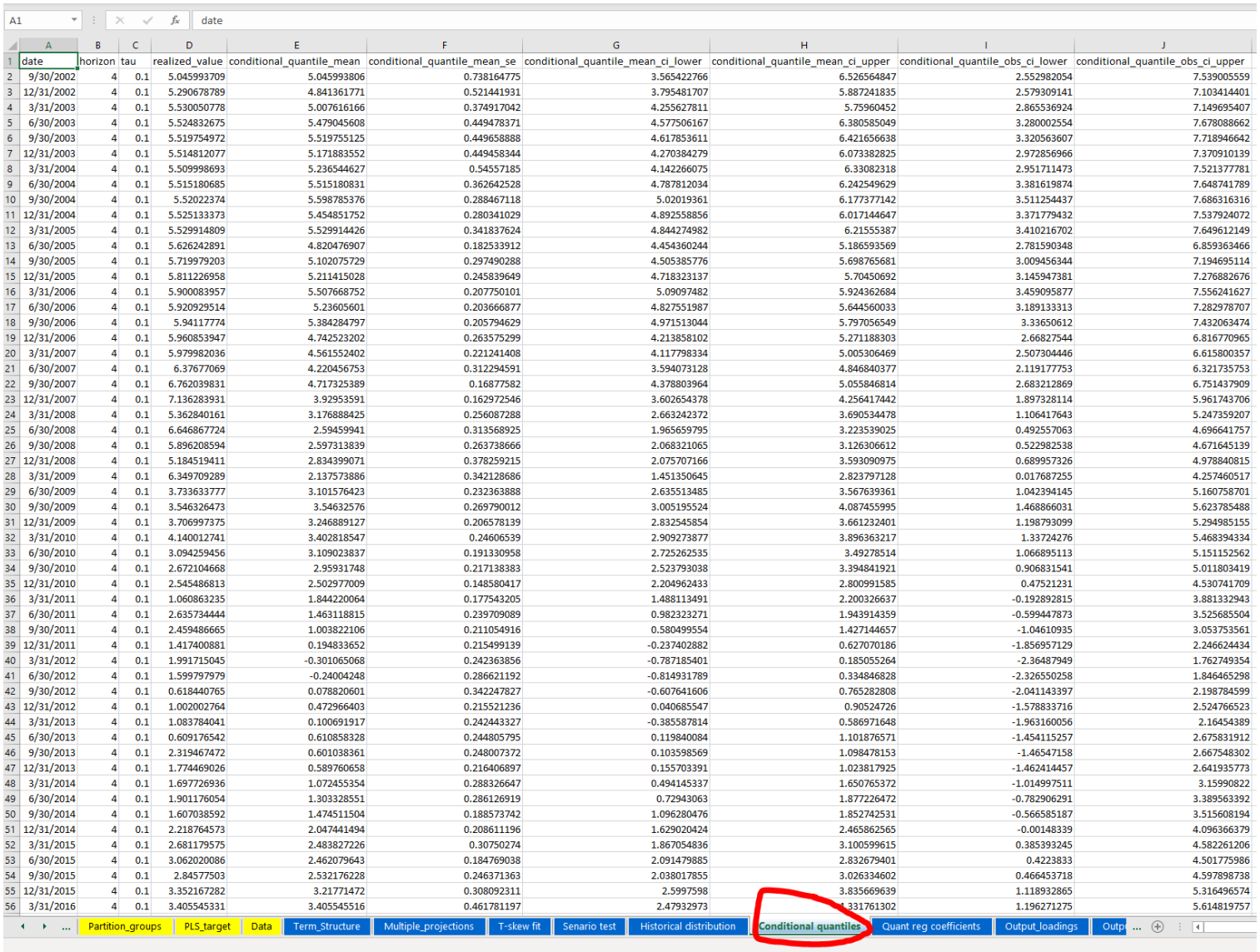
Results of the quantile regressions in ”Quant Reg Coefficients”

	G	H	I	J	K
1	lower	upper	R2_in_sample	normalized	errors
2	-0.571341412	-0.35738995	0.658155707	TRUE	0.106975731
3	0.020377963	0.603541598	0.658155707	TRUE	0.291581817
4	-0.367302364	0.126361365	0.658155707	TRUE	0.246831864
5	-0.657800702	-0.296327247	0.658155707	TRUE	0.180736727
6	0.141888047	0.878533165	0.658155707	TRUE	0.368322559
7	-0.477429066	-0.32051933	0.658155707	TRUE	0.078454868
8	0.00025406	0.241210828	0.658155707	TRUE	0.120478384
9	-0.317243899	-0.156043254	0.681094367	TRUE	0.080600322
10	-0.06456792	0.522983362	0.681094367	TRUE	0.293775641
11	-0.326926709	-0.035103124	0.681094367	TRUE	0.145911793
12	-0.479898594	-0.152291779	0.681094367	TRUE	0.163803408
13	0.358806184	1.010890497	0.681094367	TRUE	0.326042157
14	-0.366152859	-0.137503797	0.681094367	TRUE	0.114324531
15	-0.011445451	0.186988247	0.681094367	TRUE	0.099216849
16	-0.124389031	0.062735701	0.674326954	TRUE	0.093562366
17	0.045746653	0.619883822	0.674326954	TRUE	0.287068584
18	-0.287875471	0.063342579	0.674326954	TRUE	0.175609025
19	-0.328002432	0.018554568	0.674326954	TRUE	0.1732785
20	0.341356282	0.986800971	0.674326954	TRUE	0.322722345
21	-0.368481514	-0.111570398	0.674326954	TRUE	0.128455558
22	-0.064011021	0.169855377	0.674326954	TRUE	0.116933199
23	0.171957285	0.363293938	0.614018947	TRUE	0.095668327
24	0.3260329	0.92862418	0.614018947	TRUE	0.30129564
25	-0.262458516	0.062119215	0.614018947	TRUE	0.162288865
26	-0.181620735	0.12587868	0.614018947	TRUE	0.153749707
27	0.111591921	0.715933033	0.614018947	TRUE	0.302170556
28	-0.326260575	-0.06545631	0.614018947	TRUE	0.130402133
29	-0.119835938	0.165670112	0.614018947	TRUE	0.142753025
30	0.36270186	0.599270098	0.594234407	TRUE	0.118284119
31	0.322037862	1.070529119	0.594234407	TRUE	0.374245629
32	-0.369509115	0.069433847	0.594234407	TRUE	0.219471481
33	0.062564749	0.336491723	0.594234407	TRUE	0.136963487
34	0.261514872	1.022875499	0.594234407	TRUE	0.380680313
35	-0.37260646	-0.144375718	0.594234407	TRUE	0.114115371
36	-0.231871827	0.133572127	0.594234407	TRUE	0.182721977
37	-0.094380812	0.094380812	0.831549589	TRUE	0.094380812
38	0.131861362	0.711020856	0.831549589	TRUE	0.289579747
39	-0.327096298	0.027194068	0.831549589	TRUE	0.177145183
40	-0.379046391	-0.029457848	0.831549589	TRUE	0.174794272
41	0.216938883	0.868029667	0.831549589	TRUE	0.325545392
42	-0.263441952	-0.00428348	0.831549589	TRUE	0.129579236
43	-0.06042223	0.175489939	0.831549589	TRUE	0.117956084



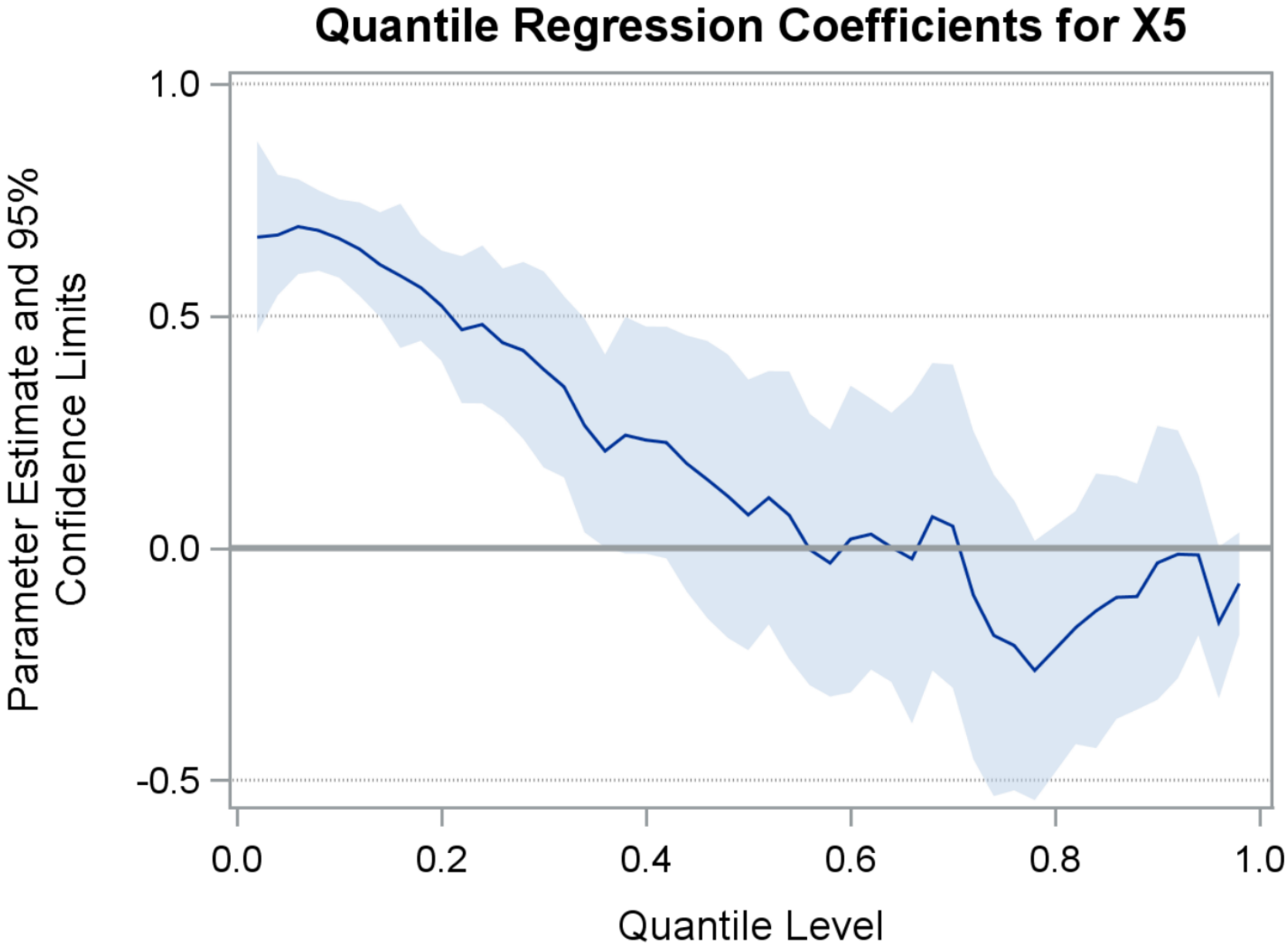
Partition_groups | PLS_target | Data | Term_Structure | Multiple_projections | T-skew fit | Senario test | Historical distribution | Conditional quantiles | Quant reg coefficients | Output_loadings

In-sample Conditional Quantiles in "Conditional Quantiles"

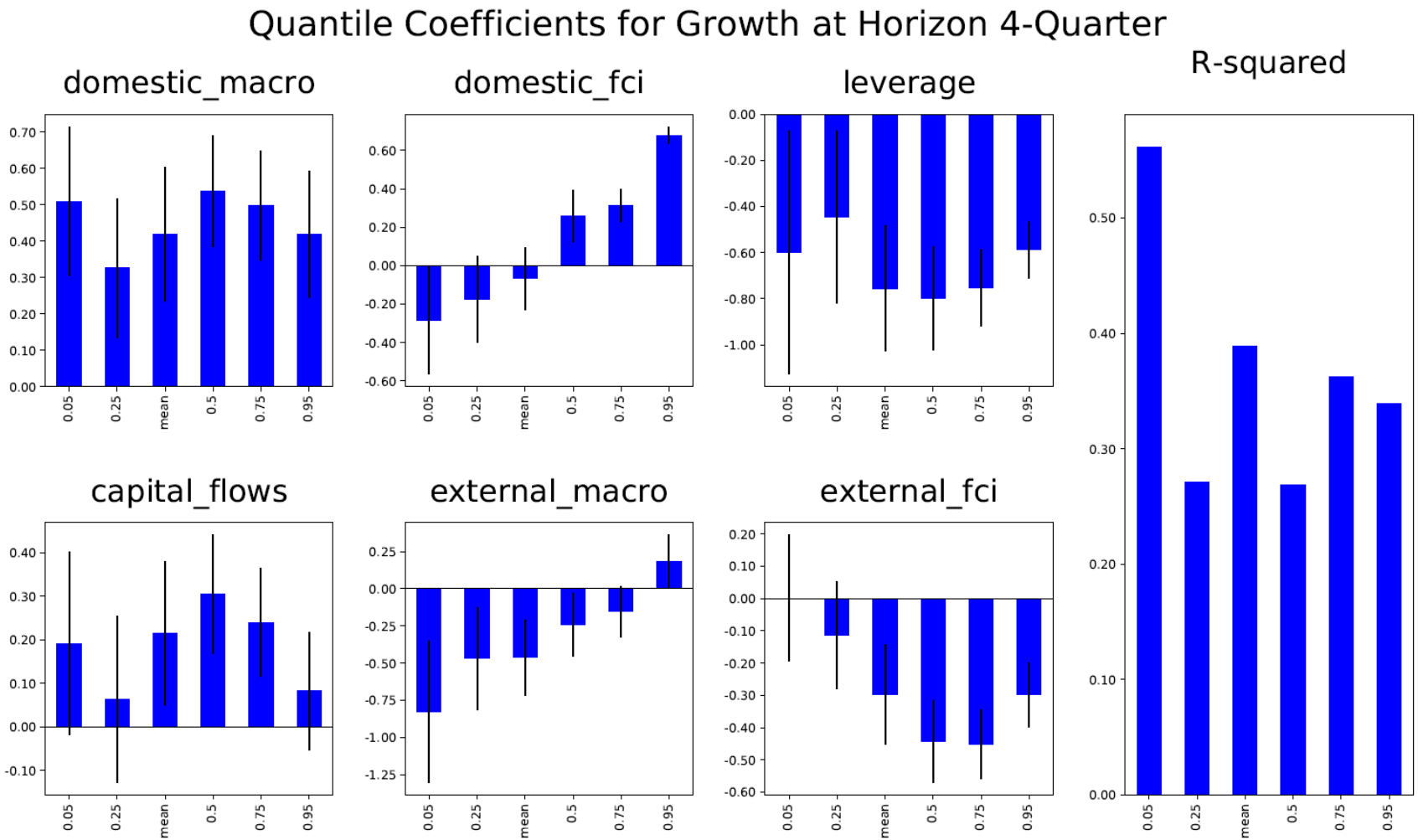


date	horizon	tau	realized_value	conditional_quantile_mean	conditional_quantile_mean_se	conditional_quantile_mean_ci_lower	conditional_quantile_mean_ci_upper	conditional_quantile_obs_ci_lower	conditional_quantile_obs_ci_upper
9/30/2002	4	0.1	5.045993709	5.045993806	0.738164775	3.565422766	6.526564847	2.552982054	7.539005559
12/31/2002	4	0.1	5.290678789	4.841361771	0.521441931	3.795481707	5.887241835	2.579309141	7.103414401
3/31/2003	4	0.1	5.530050778	5.007616166	0.374917042	4.255627811	5.75960452	2.865536924	7.149695407
6/30/2003	4	0.1	5.524832675	5.479045608	0.449478371	4.577506167	6.380585049	3.280002554	7.678088662
9/30/2003	4	0.1	5.519754972	5.519755125	0.449658888	4.617853611	6.421656638	3.320563607	7.718946642
12/31/2003	4	0.1	5.514812077	5.171883552	0.449458344	4.270384279	6.073382825	2.972856966	7.370910139
3/31/2004	4	0.1	5.509998693	5.236544627	0.54557185	4.142266075	6.33082318	2.951711473	7.521377781
6/30/2004	4	0.1	5.515180685	5.515180831	0.362642528	4.787812034	6.242549629	3.381619874	7.648741789
9/30/2004	4	0.1	5.52022374	5.598785376	0.288467118	5.02019361	6.177377142	3.511254437	7.686316316
12/31/2004	4	0.1	5.525133373	5.454851752	0.280341029	4.892558856	6.017144647	3.371779432	7.537924072
3/31/2005	4	0.1	5.529914809	5.529914426	0.341837624	4.844274982	6.21555387	3.410216702	7.649612149
6/30/2005	4	0.1	5.626242891	4.820476907	0.182533912	4.454360244	5.186593569	2.781590348	6.859363466
9/30/2005	4	0.1	5.719979203	5.102075729	0.297490288	4.505385776	5.698765681	3.009456344	7.194695114
12/31/2005	4	0.1	5.811226958	5.211415028	0.245839649	4.718323137	5.70450692	3.145947381	7.276882676
3/31/2006	4	0.1	5.900083957	5.507668752	0.207750101	5.09097482	5.924362684	3.459095877	7.556241627
6/30/2006	4	0.1	5.920929514	5.23605601	0.203666877	4.827551987	5.644560033	3.189133313	7.282978707
9/30/2006	4	0.1	5.94117774	5.384284797	0.205794629	4.971513044	5.797056549	3.33650612	7.432063474
12/31/2006	4	0.1	5.960853947	4.742523202	0.263575299	4.213858102	5.271188303	2.66827544	6.816770965
3/31/2007	4	0.1	5.979982036	4.561552402	0.221241408	4.117798334	5.005306469	2.507304446	6.615800357
6/30/2007	4	0.1	6.37677069	4.220456753	0.312294591	3.594073128	4.846840377	2.119177753	6.321735753
9/30/2007	4	0.1	6.762039831	4.717325389	0.16877582	4.378803964	5.055846814	2.683212869	6.751437909
12/31/2007	4	0.1	7.136283931	3.92953591	0.162972546	3.602654378	4.256417442	1.897328114	5.961743706
3/31/2008	4	0.1	5.362840161	3.176888425	0.256087288	2.663242372	3.690534478	1.106417643	5.247359207
6/30/2008	4	0.1	6.646867724	2.59459941	0.313568925	1.965659795	3.223539025	0.492557063	4.696641757
9/30/2008	4	0.1	5.896208594	2.597313839	0.263738666	2.068321065	3.126306612	0.522982538	4.671645139
12/31/2008	4	0.1	5.184519411	2.834399071	0.378259215	2.075707166	3.593090975	0.689957326	4.978840815
3/31/2009	4	0.1	6.349709289	2.137573886	0.342128686	1.451350645	2.823797128	0.017687255	4.257460517
6/30/2009	4	0.1	3.733633777	3.101576423	0.232363888	2.635513485	3.567639361	1.042394145	5.160758701
9/30/2009	4	0.1	3.546326473	3.54632576	0.269790012	3.005195524	4.087455995	1.468866031	5.623785488
12/31/2009	4	0.1	3.706997375	3.246889127	0.206578139	2.832545854	3.661232401	1.198793099	5.294985155
3/31/2010	4	0.1	4.140012741	3.402818547	0.24606539	2.909273877	3.896363217	1.33724276	5.468394334
6/30/2010	4	0.1	3.094259456	3.109023837	0.191330958	2.725262535	3.49278514	1.066895113	5.151152562
9/30/2010	4	0.1	2.672104668	2.95931748	0.217138383	2.523793038	3.394841921	0.906831541	5.011803419
12/31/2010	4	0.1	2.545486813	2.502977009	0.148580417	2.204962433	2.800991585	0.47521231	4.530741709
3/31/2011	4	0.1	1.060863235	1.844220064	0.177543205	1.488113491	2.200326637	-0.192892815	3.881332943
6/30/2011	4	0.1	2.635734444	1.463118815	0.239709089	0.982323271	1.943914359	-0.599447873	3.525685504
9/30/2011	4	0.1	2.459486665	1.003822106	0.211054916	0.580499554	1.427144657	-1.04610935	3.053753561
12/31/2011	4	0.1	1.417400881	0.194833652	0.215499139	-0.237402882	0.627070186	-1.856957129	2.246624434
3/31/2012	4	0.1	1.991715045	-0.301065068	0.242363856	-0.787185401	0.185055264	-2.36487949	1.762749354
6/30/2012	4	0.1	1.599797979	-0.24004248	0.286621192	-0.814931789	0.334846828	-2.326550258	1.846465298
9/30/2012	4	0.1	0.618440765	0.078820601	0.342247827	-0.607641606	0.765282808	-2.041143397	2.198784599
12/31/2012	4	0.1	1.002002764	0.472966403	0.215521236	0.040685547	0.90524726	-1.578833716	2.524766523
3/31/2013	4	0.1	1.083784041	0.100691917	0.242443327	-0.385587814	0.586971648	-1.963160056	2.16454389
6/30/2013	4	0.1	0.609176542	0.610858328	0.244805795	0.119840084	1.101876571	-1.454115257	2.675831912
9/30/2013	4	0.1	2.319467472	0.601038361	0.248007372	0.103598569	1.098478153	-1.46547158	2.667548302
12/31/2013	4	0.1	1.774469026	0.589760658	0.216406897	0.155703391	1.023817925	-1.462414457	2.641935773
3/31/2014	4	0.1	1.697726936	1.072455354	0.288326647	0.494145337	1.650765372	-1.014997511	3.15990822
6/30/2014	4	0.1	1.901176054	1.303328551	0.286126919	0.72943063	1.877226472	-0.782906291	3.389563392
9/30/2014	4	0.1	1.607038592	1.474511504	0.188573742	1.096280476	1.852742531	-0.566585187	3.515608194
12/31/2014	4	0.1	2.218764573	2.047441494	0.208611196	1.629020424	2.465862565	-0.00148339	4.096366379
3/31/2015	4	0.1	2.681179575	2.483827226	0.30750274	1.867054836	3.100599615	0.385393245	4.582261206
6/30/2015	4	0.1	3.062020086	2.462079643	0.184769038	2.091479885	2.832679401	0.4223833	4.501775986
9/30/2015	4	0.1	2.84577503	2.532176228	0.246371363	2.038017855	3.026334602	0.466453718	4.597898738
12/31/2015	4	0.1	3.352167282	3.21771472	0.308092311	2.5997598	3.835669639	1.118932865	5.316496574
3/31/2016	4	0.1	3.405545331	3.405545516	0.461781197	2.47932973	4.331761302	1.196271275	5.614819757

Non-Linearities in Quantile Regressions Coefficients



Quantile Regressions Output

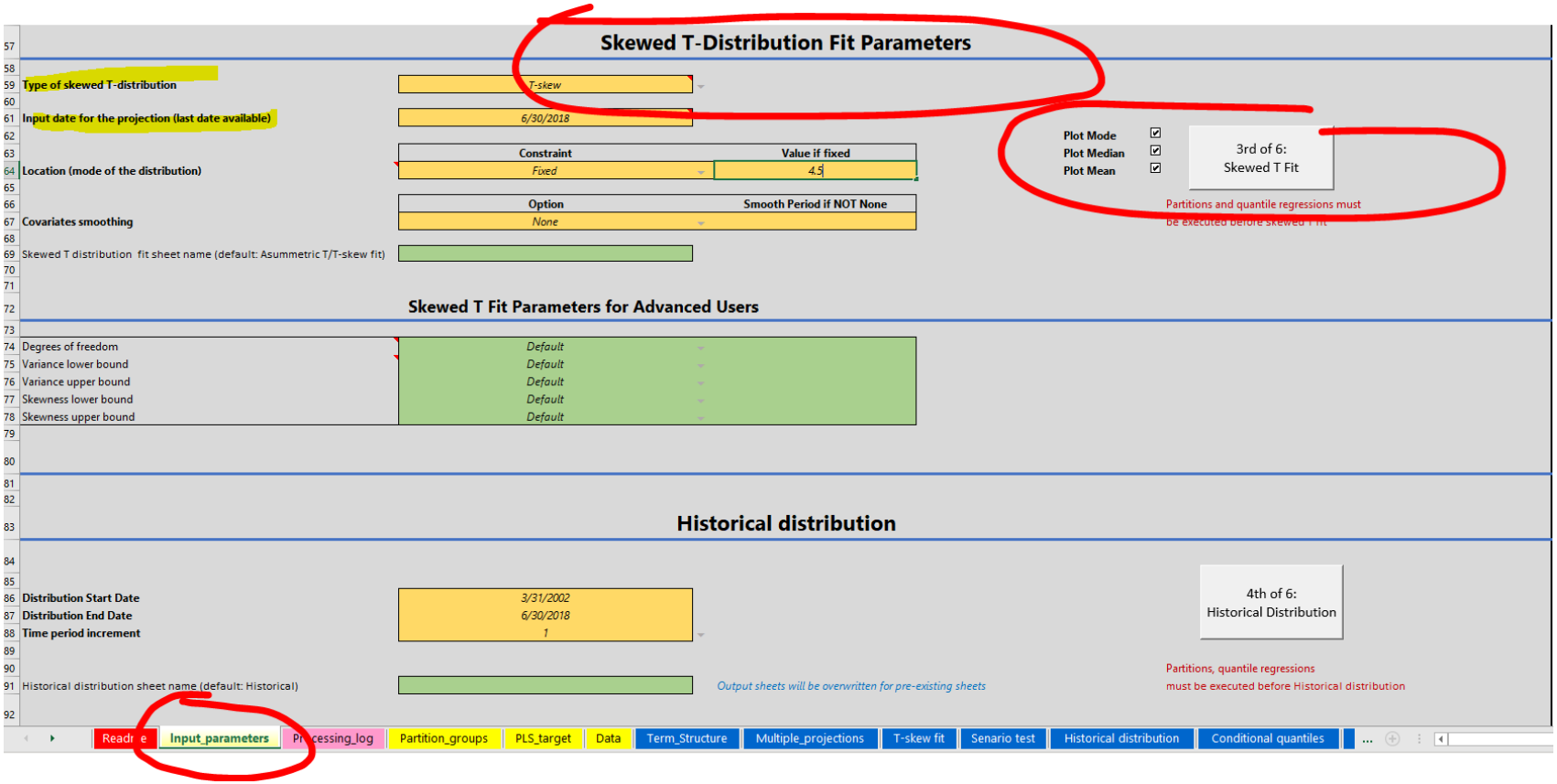


Source: IMF Article IV (2018)

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

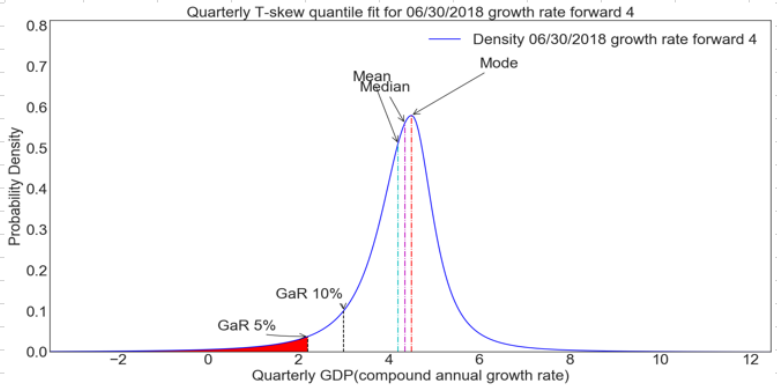
Parameters for distribution fit: type of distribution, conditioning

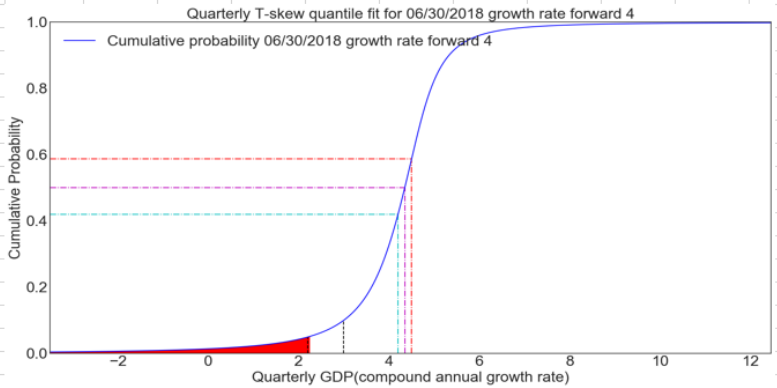


Tskew fit output in ”Tskew fit”

M38

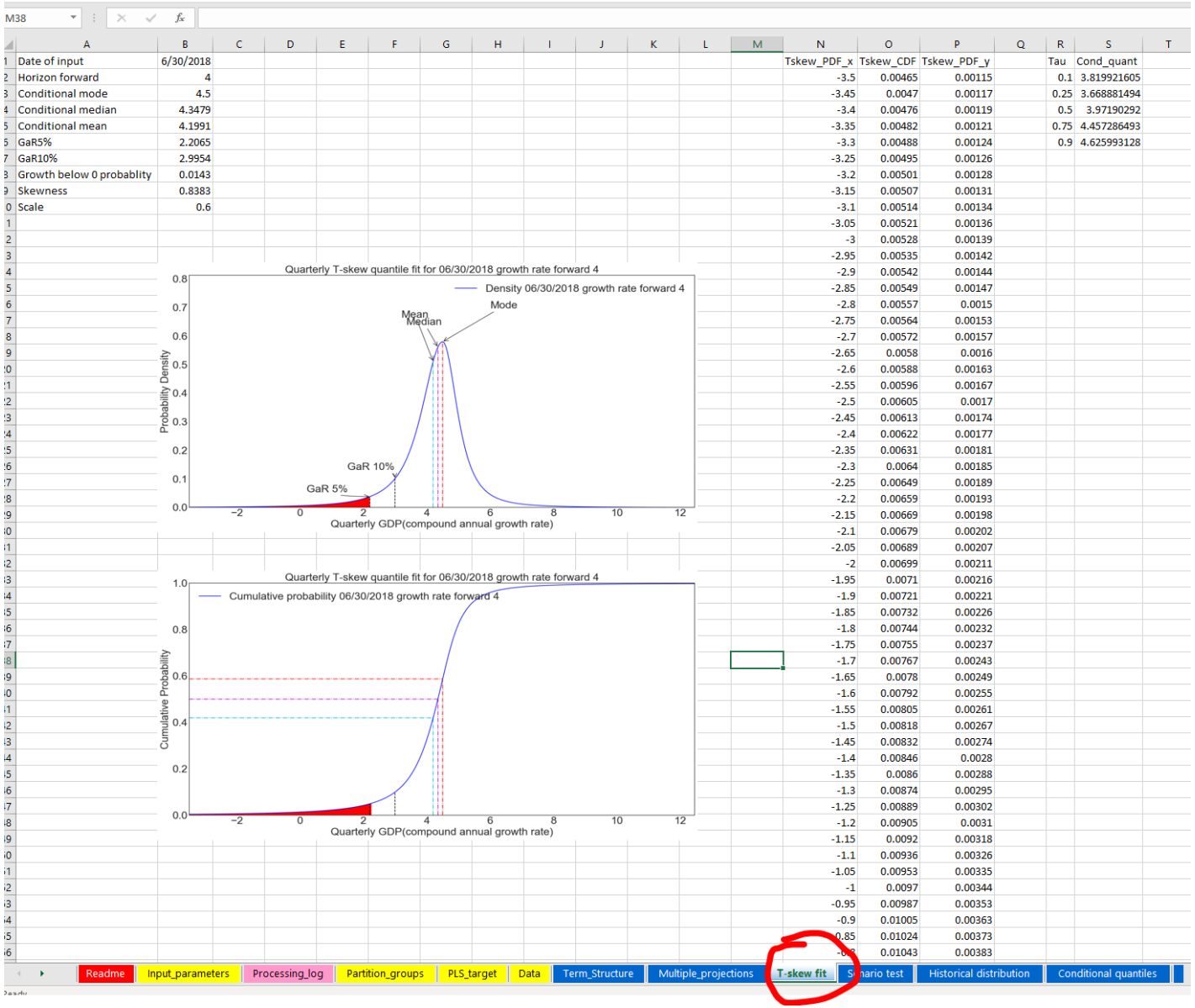
	A	B
1	Date of input	6/30/2018
2	Horizon forward	4
3	Conditional mode	4.5
4	Conditional median	4.3479
5	Conditional mean	4.1991
6	GaR5%	2.2065
7	GaR10%	2.9954
8	Growth below 0 probablity	0.0143
9	Skewness	0.8383
10	Scale	0.6





	N	O	P	R	S
1	Tskew_PDF_x	Tskew_CDF	Tskew_PDF_y	Tau	Cond_quant
2	-3.5	0.00465	0.00115	0.1	3.819921605
3	-3.45	0.0047	0.00117	0.25	3.668881494
4	-3.4	0.00476	0.00119	0.5	3.97190292
5	-3.35	0.00482	0.00121	0.75	4.457286493
6	-3.3	0.00488	0.00124	0.9	4.625993128
7	-3.25	0.00495	0.00126		
8	-3.2	0.00501	0.00128		
9	-3.15	0.00507	0.00131		
10	-3.1	0.00514	0.00134		
11	-3.05	0.00521	0.00136		
12	-3	0.00528	0.00139		
13	-2.95	0.00535	0.00142		
14	-2.9	0.00542	0.00144		
15	-2.85	0.00549	0.00147		
16	-2.8	0.00557	0.0015		
17	-2.75	0.00564	0.00153		
18	-2.7	0.00572	0.00157		
19	-2.65	0.0058	0.0016		
20	-2.6	0.00588	0.00163		
21	-2.55	0.00596	0.00167		
22	-2.5	0.00605	0.0017		
23	-2.45	0.00613	0.00174		
24	-2.4	0.00622	0.00177		
25	-2.35	0.00631	0.00181		
26	-2.3	0.0064	0.00185		
27	-2.25	0.00649	0.00189		
28	-2.2	0.00659	0.00193		
29	-2.15	0.00669	0.00198		
30	-2.1	0.00679	0.00202		
31	-2.05	0.00689	0.00207		
32	-2	0.00699	0.00211		
33	-1.95	0.0071	0.00216		
34	-1.9	0.00721	0.00221		
35	-1.85	0.00732	0.00226		
36	-1.8	0.00744	0.00232		
37	-1.75	0.00755	0.00237		
38	-1.7	0.00767	0.00243		
39	-1.65	0.0078	0.00249		
40	-1.6	0.00792	0.00255		
41	-1.55	0.00805	0.00261		
42	-1.5	0.00818	0.00267		
43	-1.45	0.00832	0.00274		
44	-1.4	0.00846	0.0028		
45	-1.35	0.0086	0.00288		
46	-1.3	0.00874	0.00295		
47	-1.25	0.00889	0.00302		
48	-1.2	0.00905	0.0031		
49	-1.15	0.0092	0.00318		
50	-1.1	0.00936	0.00326		
51	-1.05	0.00953	0.00335		
52	-1	0.0097	0.00344		
53	-0.95	0.00987	0.00353		

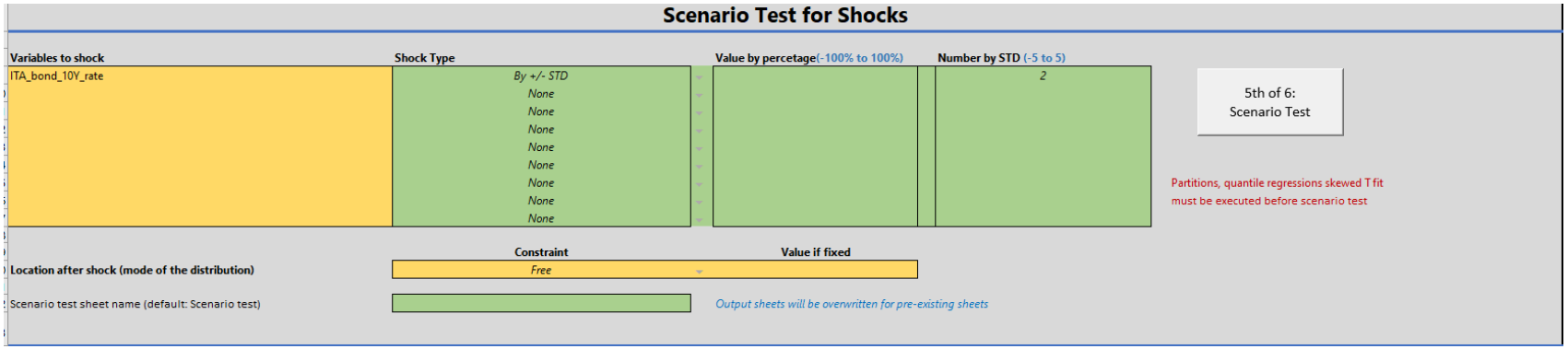
Tskew fit output in ”Tskew fit”



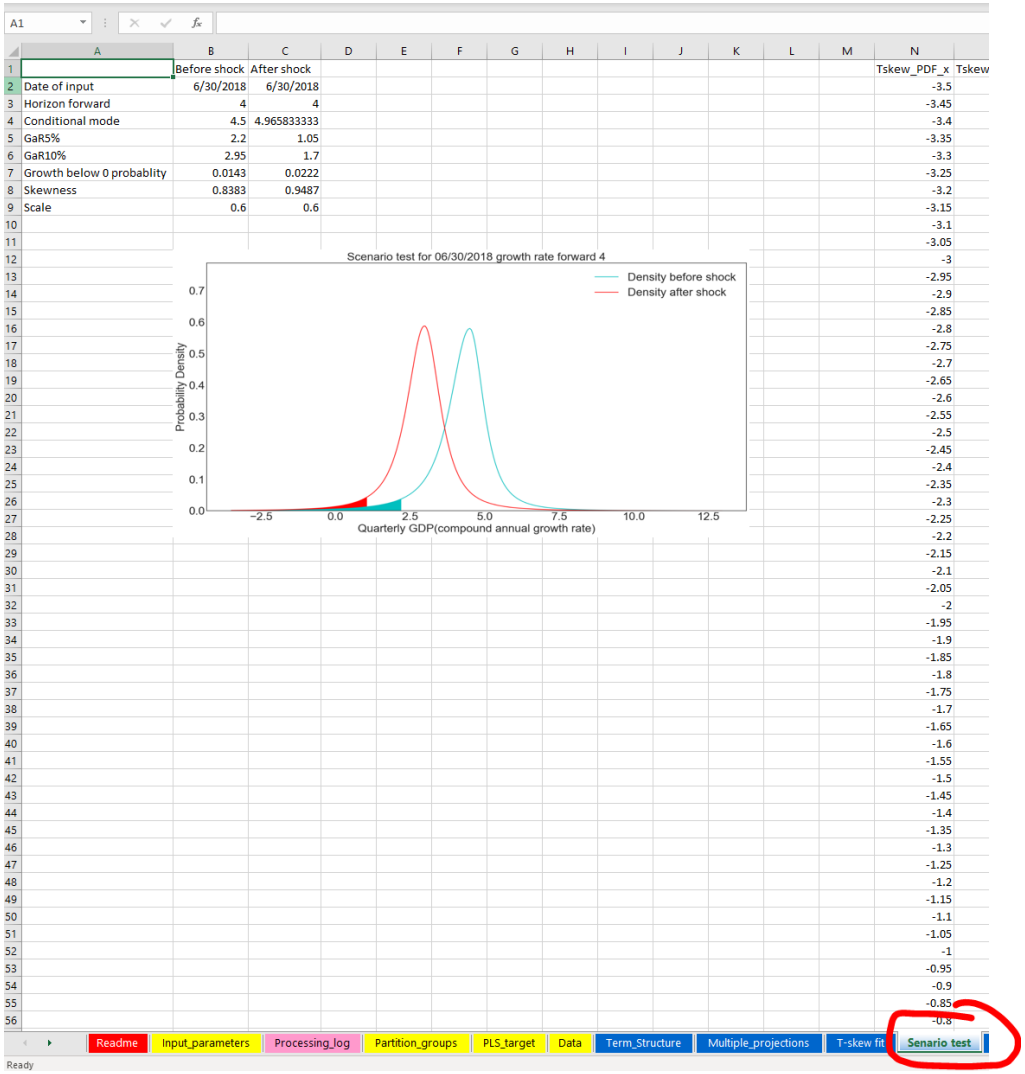
	A	B
1	Date of input	6/30/2018
2	Horizon forward	4
3	Conditional mode	4.5
4	Conditional median	4.3479
5	Conditional mean	4.1991
6	GaR5%	2.2065
7	GaR10%	2.9954
8	Growth below 0 probablity	0.0143
9	Skewness	0.8383
10	Scale	0.6

Tskew_PDF_x	Tskew_CDF	Tskew_PDF_y	Tau	Cond_quant
-3.5	0.00465	0.00115	0.1	3.819921605
-3.45	0.0047	0.00117	0.25	3.668881494
-3.4	0.00476	0.00119	0.5	3.97190292
-3.35	0.00482	0.00121	0.75	4.457286493
-3.3	0.00488	0.00124	0.9	4.625993128
-3.25	0.00495	0.00126		
-3.2	0.00501	0.00128		
-3.15	0.00507	0.00131		
-3.1	0.00514	0.00134		
-3.05	0.00521	0.00136		
-3	0.00528	0.00139		
-2.95	0.00535	0.00142		
-2.9	0.00542	0.00144		
-2.85	0.00549	0.00147		
-2.8	0.00557	0.0015		
-2.75	0.00564	0.00153		
-2.7	0.00572	0.00157		
-2.65	0.0058	0.0016		
-2.6	0.00588	0.00163		
-2.55	0.00596	0.00167		
-2.5	0.00605	0.0017		
-2.45	0.00613	0.00174		
-2.4	0.00622	0.00177		
-2.35	0.00631	0.00181		
-2.3	0.0064	0.00185		
-2.25	0.00649	0.00189		
-2.2	0.00659	0.00193		
-2.15	0.00669	0.00198		
-2.1	0.00679	0.00202		
-2.05	0.00689	0.00207		
-2	0.00699	0.00211		
-1.95	0.0071	0.00216		
-1.9	0.00721	0.00221		
-1.85	0.00732	0.00226		
-1.8	0.00744	0.00232		
-1.75	0.00755	0.00237		
-1.7	0.00767	0.00243		
-1.65	0.0078	0.00249		
-1.6	0.00792	0.00255		
-1.55	0.00805	0.00261		
-1.5	0.00818	0.00267		
-1.45	0.00832	0.00274		
-1.4	0.00846	0.0028		
-1.35	0.0086	0.00288		
-1.3	0.00874	0.00295		
-1.25	0.00889	0.00302		
-1.2	0.00905	0.0031		
-1.15	0.0092	0.00318		
-1.1	0.00936	0.00326		
-1.05	0.00953	0.00335		
-1	0.0097	0.00344		
-0.95	0.00987	0.00353		
-0.9	0.01005	0.00363		
-0.85	0.01024	0.00373		
-0.8	0.01043	0.00383		

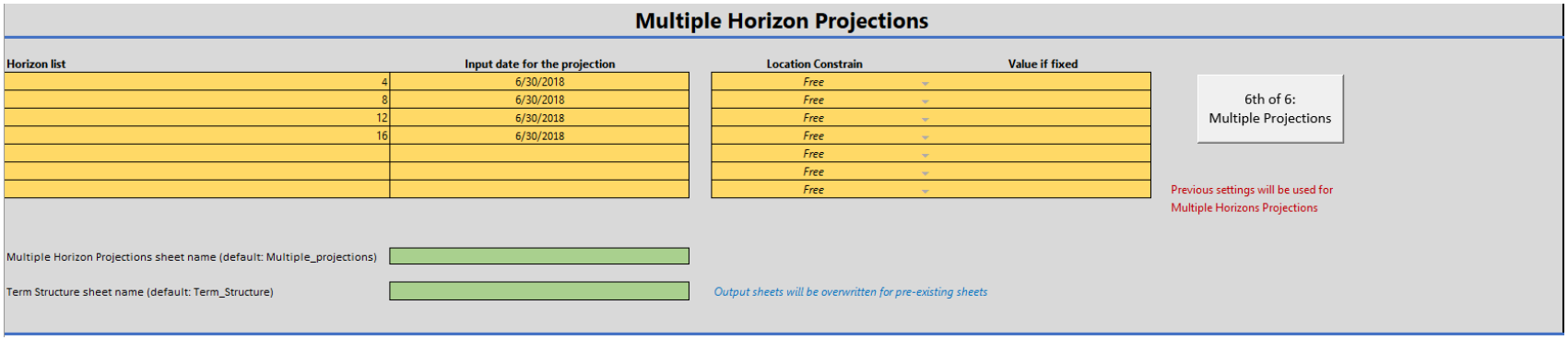
Scenario design



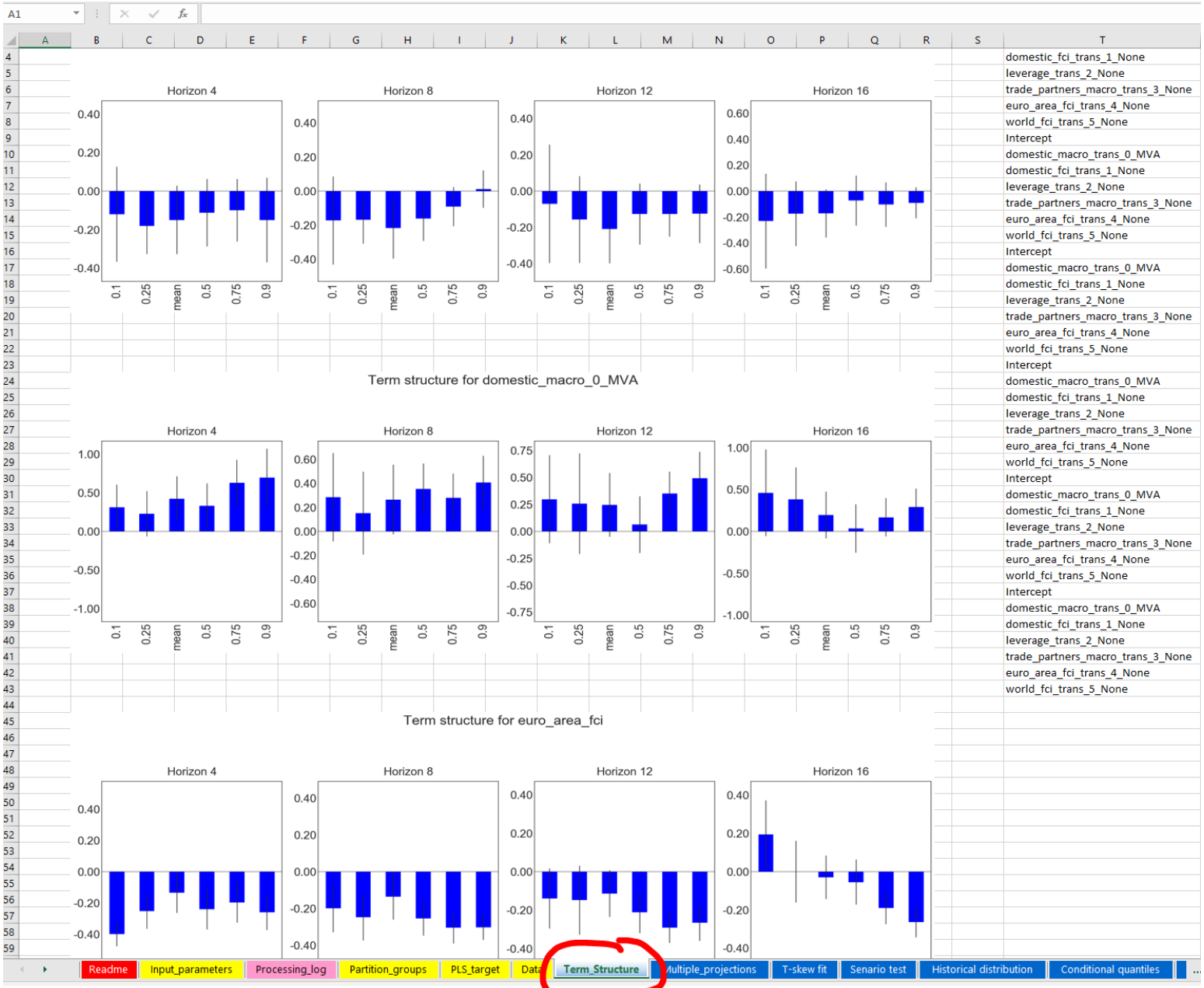
The projections from the scenarios are in ”Scenario Test”



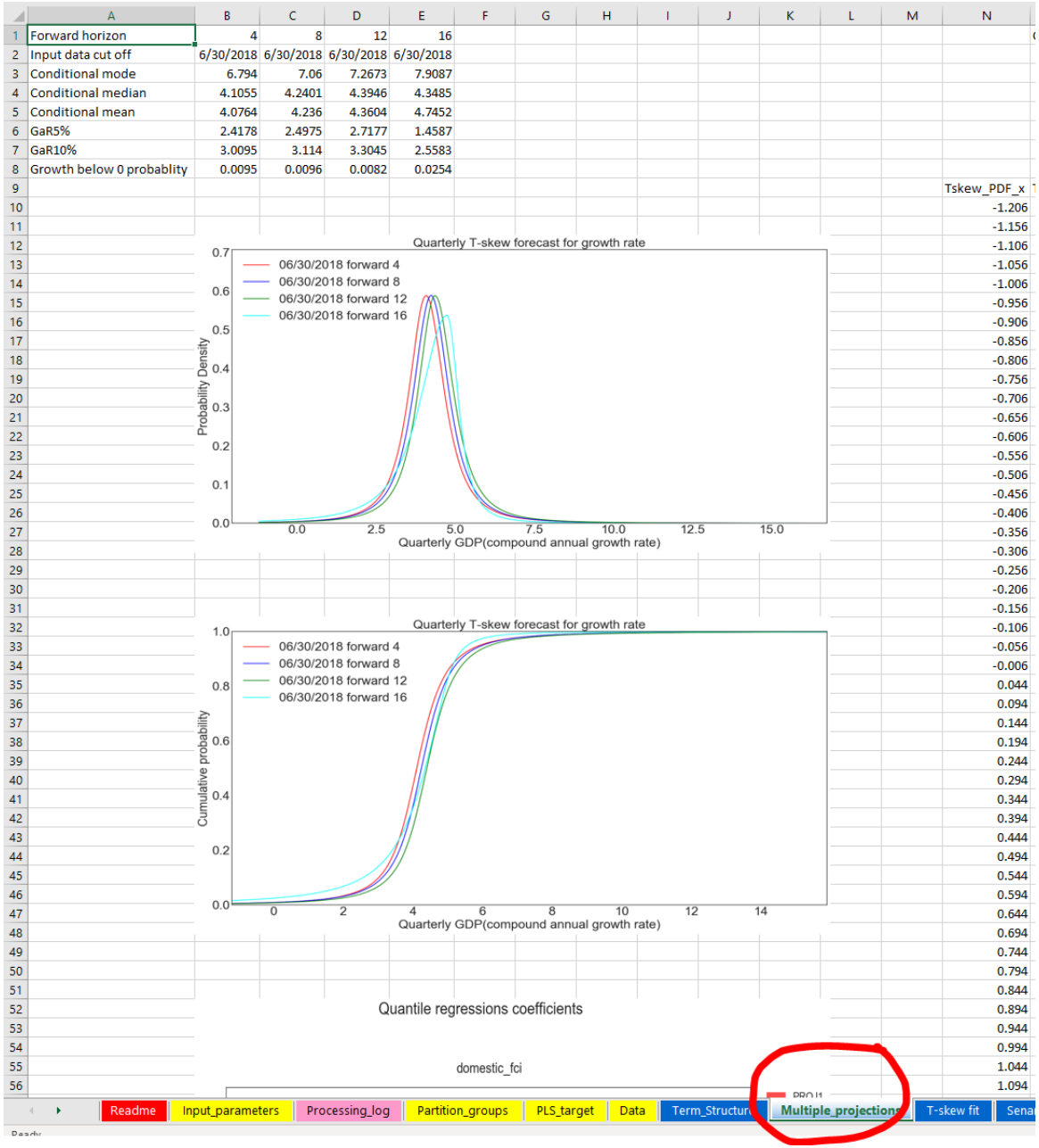
The term structure



The term quantile coefficients are in ”Term Structure”



The term projections are in ”Multiple Projections”



	A	B	C	D	E
1	Forward horizon	4	8	12	16
2	Input data cut off	6/30/2018	6/30/2018	6/30/2018	6/30/2018
3	Conditional mode	6.794	7.06	7.2673	7.9087
4	Conditional median	4.1055	4.2401	4.3946	4.3485
5	Conditional mean	4.0764	4.236	4.3604	4.7452
6	GaR5%	2.4178	2.4975	2.7177	1.4587
7	GaR10%	3.0095	3.114	3.3045	2.5583
8	Growth below 0 probablity	0.0095	0.0096	0.0082	0.0254

	N
9	Tskew_PDF_x
10	-1.206
11	-1.156
12	-1.106
13	-1.056
14	-1.006
15	-0.956
16	-0.906
17	-0.856
18	-0.806
19	-0.756
20	-0.706
21	-0.656
22	-0.606
23	-0.556
24	-0.506
25	-0.456
26	-0.406
27	-0.356
28	-0.306
29	-0.256
30	-0.206
31	-0.156
32	-0.106
33	-0.056
34	-0.006
35	0.044
36	0.094
37	0.144
38	0.194
39	0.244
40	0.294
41	0.344
42	0.394
43	0.444
44	0.494
45	0.544
46	0.594
47	0.644
48	0.694
49	0.744
50	0.794
51	0.844
52	0.894
53	0.944
54	0.994
55	1.044
56	1.094

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` or `cwang2@imf.org`