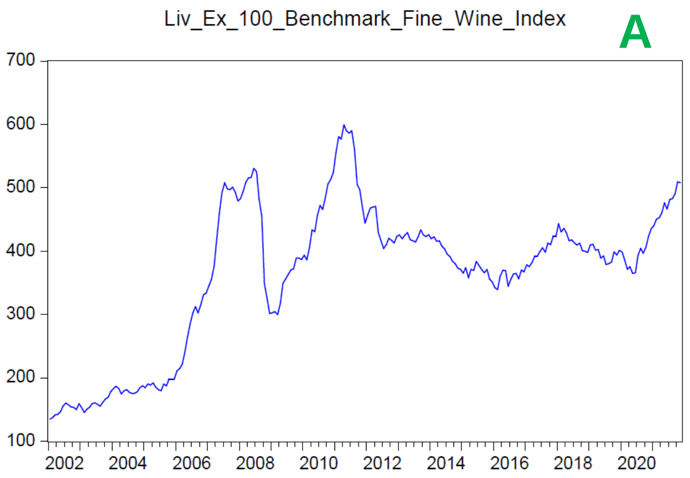
London Business School

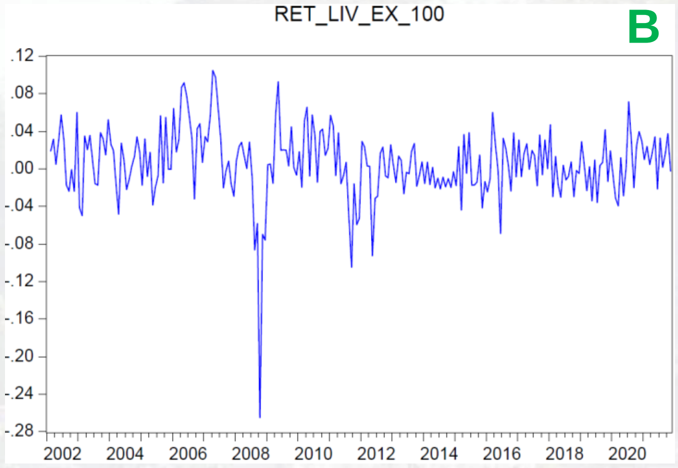
Times Series Analysis Individual Assignment

Liv-ex 100 Benchmark Fine Wine

HP

A. Investigation for trends, stationarity, seasonal and intervention effect (1/3)





LIV EX THE FINE WINE MARKET

- We examine the differences of the Liv Ex 100 (**B**) to analyse the index' behaviour and its relationship with other variables. We use the differences to get rid of spurious trends that may yield misleading results.

- We use monthly data for the Liv Ex 100 and all the other variables from Jan. 2002 to Nov. 2022.

C

Supply factors	Index	Geographical scope
Fertilizers (wineyards)	Fertilizer Prices	North America
Weather in the Bordeaux area	Weather Bordeaux Merignac	France
Brewery equipment	Agricultural & Forestry Machine Index	France
Oak (barrels and corks)	Red Oak Spot Prices	US
Glass (glass bottles)	PPI Manufacture of Glass & Glass Products	France
Conditionning material (cardboard)	PPI Corrugated Cardboard	France
Transportation	CPI Services Related to Transport	France
Energy	CPI Electricity Gas and Other Fuels	France

Demand factors	Index	Geographical scope
Major export markets	Imports from France	China, US, Germany and UK
Domestic market France	France Consumer Staples Index	France

Substitutes factors	Index	Geographical scope
Prices of other wines	CPI Wine from Grapes	France

- The Liv-ex 100 Fine Wine Index (**A**) is computed using bids, offers and transactions of 100 fine wines (mostly Bordeaux) on the Liv-ex's fine wine trading platform. The index is weighted by a combination of price, production and scarcity. The component wines are reviewed quarterly.

- After a qualitative study, we identified several factors (**C**) that may influence the Liv-ex 100 Fine Wine Index. We then used indices from Bloomberg that best represent the behaviors of these factors.

A. Investigation for trends, stationarity, seasonal and intervention effect (2/3)

A

Null Hypothesis: RET_LIV_EX_100 has a unit root
Exogenous: Constant
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.58333	0.0000
Test critical values:	1% level	-3.457865	
	5% level	-2.873543	
	10% level	-2.573242	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RET_LIV_EX_100)
Method: Least Squares
Date: 03/24/22 Time: 17:11
Sample (adjusted): 2002M03 2021M11
Included observations: 237 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RET_LIV_EX_100(-1)	-0.645392	0.060982	-10.58333	0.0000
C	0.003533	0.002312	1.527824	0.1279

R-squared	0.322780	Mean dependent var	-8.95E-05
Adjusted R-squared	0.319898	S.D. dependent var	0.042692
S.E. of regression	0.035207	Akaike info criterion	-3.846733
Sum squared resid	0.291292	Schwarz criterion	-3.817467
Log likelihood	457.8379	Hannan-Quinn criter.	-3.834937
F-statistic	112.0069	Durbin-Watson stat	2.143639
Prob(F-statistic)	0.000000		

- We observe that D(Liv Ex) is stationary (**A**) with a unit root test.
- We then want to investigate the relationship of D(Liv Ex) with the differences of the variables we mentioned.
- First, we run a linear regression with all these variables (**B**), and only keep those which are statistically significant (**C**). This model gives us an adjusted R-squared of 42.93.

B

Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: Least Squares
Date: 03/24/22 Time: 17:17
Sample (adjusted): 2002M02 2021M11
Included observations: 238 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.470158	0.862561	1.704411	0.0897
D(CHINA_IMPORTS_FROM_FRAN	-0.002238	0.002014	-1.111079	0.2677
D(CPI_SERVICES_RELATED_TO_)	-0.093857	0.735151	-0.127670	0.8985
D(FRANCE_CPI_ELECTRICITY_G)	0.547677	0.809199	0.676814	0.4992
D(FRANCE_CPI_WINE_FROM_G	-8.520319	3.026192	-2.815525	0.0053
D(FRANCE_PPI_CORRUGATED_	10.73647	1.617449	6.637901	0.0000
D(GERMANY_IMPORTS_VALUE_	-4.60E-07	1.64E-06	-0.280593	0.7793
D(MANUFACTURE_AGRICULTUR	-0.060189	0.028995	-2.075828	0.0391
D(MSCI_FRANCE_CONSUMER_S	0.329219	0.112409	2.928763	0.0038
D(NORTH_AMERICA_FERTILIZER)	0.096006	0.020222	4.747709	0.0000
D(PPI_MANUFACTURE_OF_GLAS	2.362140	1.259707	1.875150	0.0621
D(UNITED_KINGDOM_IMPORTS_F)	0.005586	0.002584	2.162268	0.0317
D(US_IMPORTS_FROM_FRANCE)	-0.000503	0.001839	-0.273334	0.7848
D(US_RED_OAK_SPOT)	0.012925	0.010950	1.180360	0.2391
D(WEATHER_BORDEAUX_MERIG	0.257364	0.126397	2.036151	0.0429

R-squared	0.457408	Mean dependent var	1.568756
Adjusted R-squared	0.423344	S.D. dependent var	14.46880
S.E. of regression	10.98730	Akaike info criterion	7.692308
Sum squared resid	26920.72	Schwarz criterion	7.911149
Log likelihood	-900.3847	Hannan-Quinn criter.	7.780505
F-statistic	13.42786	Durbin-Watson stat	1.529473
Prob(F-statistic)	0.000000		

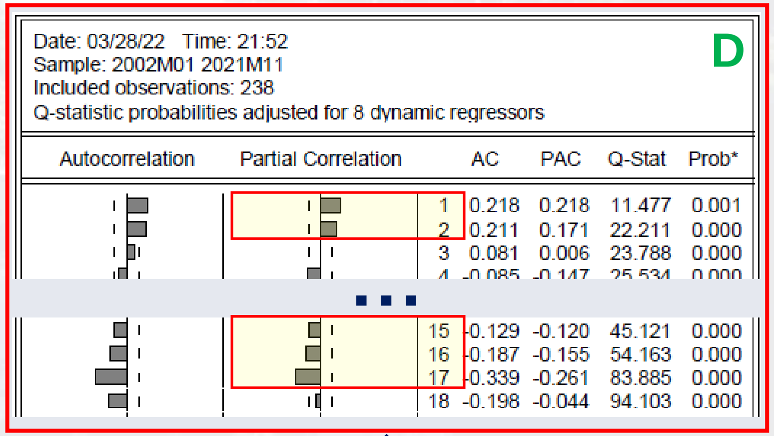
C

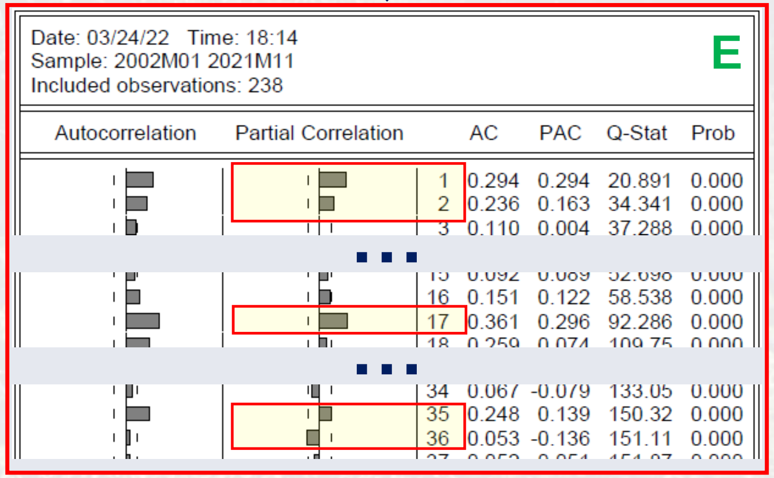
Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: Least Squares
Date: 03/25/22 Time: 15:59
Sample (adjusted): 2002M02 2021M11
Included observations: 238 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.454481	0.824986	1.763037	0.0792
D(FRANCE_CPI_WINE_FROM_GRA)	-7.750740	2.903108	-2.669807	0.0081
D(FRANCE_PPI_CORRUGATED_CA)	10.80420	1.590253	6.794016	0.0000
D(MANUFACTURE_AGRICULTURAL)	-0.063492	0.025831	-2.457999	0.0147
D(MSCI_FRANCE_CONSUMER_STA)	0.335533	0.110343	3.040823	0.0026
D(NORTH_AMERICA_FERTILIZER)	0.101418	0.018520	5.476110	0.0000
D(PPI_MANUFACTURE_OF_GLASS)	2.559067	1.230311	2.080017	0.0386
D(UNITED_KINGDOM_IMPORTS_F)	0.005131	0.002422	2.118681	0.0352
D(WEATHER_BORDEAUX_MERIGNA)	0.236288	0.124531	1.897431	0.0590

R-squared	0.448606	Mean dependent var	1.568756
Adjusted R-squared	0.429344	S.D. dependent var	14.46880
S.E. of regression	10.92999	Akaike info criterion	7.657979
Sum squared resid	27357.41	Schwarz criterion	7.789284
Log likelihood	-902.2995	Hannan-Quinn criter.	7.710897
F-statistic	23.28891	Durbin-Watson stat	1.563113
Prob(F-statistic)	0.000000		

- Then, we examine the partial correlation of the residuals (**D**) and squared residuals (**E**) of the statistically significant variables to examine which lags would be relevant to investigate.
- We notice that the lags 1, 2, 15, 16, 17, 35 and 36 are outside the PACF's confidence intervals (highlighted in red) and worth investigating. This may indicate a seasonality effect.





A. Investigation for trends, stationarity, seasonal and intervention effect (3/3)

A

Dependent Variable: D(LIV EX 100 BENCHMARK FIN)
Method: Least Squares
Date: 03/28/22 Time: 11:52
Sample (adjusted): 2005M02 2021M11
Included observations: 202 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.960638	2.076678	0.944122	0.3467
D(LIV EX 100 BENCHMARK FIN(-1))	0.189821	0.080258	2.365134	0.0194
D(LIV EX 100 BENCHMARK FIN(-2))	0.142722	0.081098	1.759855	0.0806
D(LIV_EX_100_BENCHMARK_FIN(-16))	-0.116681	0.082954	-1.406571	0.1618
...				
D(WEATHER BORDEAUX MERIGNA(-35	0.091981	0.202969	0.453175	0.6511
D(WEATHER BORDEAUX MERIGNA(-36	-0.083263	0.200200	-0.415900	0.6781

R-squared	0.669949	Mean dependent var	1.602743
Adjusted R-squared	0.522732	S.D. dependent var	15.58993
S.E. of regression	10.77024	Akaike info criterion	7.841418
Sum squared resid	16123.72	Schwarz criterion	8.873205
Log likelihood	-728.9833	Hannan-Quinn criter.	8.258881
F-statistic	4.550762	Durbin-Watson stat	1.972532
Prob(F-statistic)	0.000000		

B

Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: Least Squares
Date: 03/25/22 Time: 15:55
Sample (adjusted): 2005M02 2021M11
Included observations: 202 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.139693	0.942684	-0.148187	0.8824
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.147354	0.053267	2.766337	0.0062
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.170942	0.051833	3.297905	0.0012
D(LIV_EX_100_BENCHMARK_FIN(-17))	-0.151559	0.049965	-3.033269	0.0028
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.163210	0.051074	3.195543	0.0016
D(FRANCE_CPI_WINE_FROM_GRA)	-6.717136	2.842698	-2.362944	0.0191
D(FRANCE_CPI_WINE_FROM_GRA(-36))	10.59854	3.618173	2.929253	0.0038
D(FRANCE_PPI_CORRUGATED_CA)	12.97450	1.610484	8.056274	0.0000
D(MANUFACTURE_AGRICULTURAL(-2))	0.031225	0.019795	1.577469	0.1163
D(MSCI_FRANCE_CONSUMER_STA)	0.199584	0.109829	1.817231	0.0707
D(NORTH_AMERICA_FERTILIZER)	0.065984	0.018648	3.538368	0.0005

R-squared	0.587683	Mean dependent var	1.602743
Adjusted R-squared	0.566096	S.D. dependent var	15.58993
S.E. of regression	10.26930	Akaike info criterion	7.549112
Sum squared resid	20142.59	Schwarz criterion	7.729265
Log likelihood	-751.4603	Hannan-Quinn criter.	7.622002
F-statistic	27.22362	Durbin-Watson stat	1.898592
Prob(F-statistic)	0.000000		

- We run a new regression with all the significant variables and lags 1, 2, 15, 16, 17, 35 and 36 (**A**). We then remove one by one the statistically non-significant variables and obtain a model which yields us an adjusted R-squared of 56.61 with 10 variables (**B**).

- The PACF for this new regression gives us lags for residuals (**C**) and squared residuals (**D**) that are much more within the boundaries that the “unlagged” regression.

C

Date: 03/28/22 Time: 21:54
Sample: 2002M01 2021M11
Included observations: 202
Q-statistic probabilities adjusted for 10 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.050	0.050	0.5059	0.477
		2	0.029	0.026	0.6741	0.714
		3	-0.015	-0.018	0.7233	0.868
		...				
		16	-0.141	-0.110	21.017	0.178
		17	-0.109	-0.065	23.639	0.130
		...				
		35	-0.020	-0.018	40.118	0.254
		36	0.021	0.057	40.227	0.288

D

Date: 03/25/22 Time: 10:42
Sample: 2002M01 2021M11
Included observations: 202

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.215	0.215	9.4996	0.002
		2	0.055	0.010	10.132	0.006
		3	0.182	0.177	17.027	0.001
		4	0.074	-0.001	18.164	0.001
		...				
		17	0.169	0.159	26.377	0.068
		18	0.178	0.140	33.488	0.015
		...				
		35	-0.022	-0.045	53.613	0.023
		36	0.028	0.047	53.815	0.028

E

Null Hypothesis: RESIDLINREG has a unit root
Exogenous: Constant
Lag Length: 0 (Fixed)

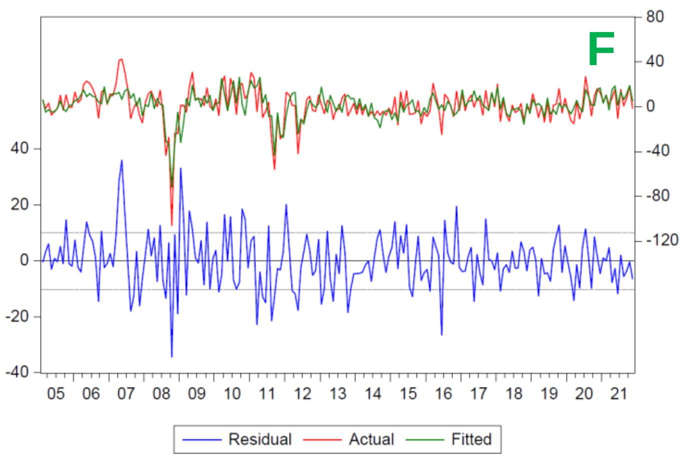
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.40738	0.0000
Test critical values:	1% level	-3.462901	
	5% level	-2.875752	
	10% level	-2.574423	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESIDLINREG)
Method: Least Squares
Date: 03/28/22 Time: 22:15
Sample (adjusted): 2005M03 2021M11
Included observations: 201 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDLINREG(-1)	-0.950225	0.070873	-13.40738	0.0000
C	0.000535	0.708754	0.000756	0.9994

R-squared	0.474598	Mean dependent var	-0.029863
Adjusted R-squared	0.471958	S.D. dependent var	13.82794
S.E. of regression	10.04828	Akaike info criterion	7.462580
Sum squared resid	20092.60	Schwarz criterion	7.495448
Log likelihood	-747.9892	Hannan-Quinn criter.	7.475880
F-statistic	179.7579	Durbin-Watson stat	1.999908
Prob(F-statistic)	0.000000		



- The ADF of the residuals (**E**) shows that they are stationary, as can be seen on the residuals charts (**F**).

B. Investigation for autoregressive properties

A

Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: Least Squares
Date: 03/29/22 Time: 08:59
Sample (adjusted): 2002M03 2021M11
Included observations: 237 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.968187	0.879270	1.101126	0.2720
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.377337	0.060415	6.245714	0.0000

R-squared	0.142364	Mean dependent var	1.564586
Adjusted R-squared	0.138714	S.D. dependent var	14.49927
S.E. of regression	13.45612	Akaike info criterion	8.045148
Sum squared resid	42550.79	Schwarz criterion	8.074415
Log likelihood	-951.3501	Hannan-Quinn criter.	8.056945
F-statistic	39.00895	Durbin-Watson stat	2.163808
Prob(F-statistic)	0.000000		

B

Null Hypothesis: RESIDAR1 has a unit root
Exogenous: Constant
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.61084	0.0000
Test critical values:	1% level	-3.457984	
	5% level	-2.873596	
	10% level	-2.573270	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESIDAR1)
Method: Least Squares
Date: 03/29/22 Time: 09:13
Sample (adjusted): 2002M04 2021M11
Included observations: 236 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDAR1(-1)	-1.083144	0.065207	-16.61084	0.0000
C	-0.007267	0.874695	-0.008308	0.9934

R-squared	0.541105	Mean dependent var	-0.049660
Adjusted R-squared	0.539143	S.D. dependent var	19.79374
S.E. of regression	13.43726	Akaike info criterion	8.042379
Sum squared resid	42251.04	Schwarz criterion	8.071733
Log likelihood	-947.0007	Hannan-Quinn criter.	8.054212
F-statistic	275.9201	Durbin-Watson stat	1.968413
Prob(F-statistic)	0.000000		

- Running an AR1 (**A**), we obtain an adjusted R-squared of 13.87 and stationary residuals (**B**). The PACF for residuals (**C**) and squared residuals (**D**) leads us to examine the lags 2 3 7 10 16 17 28 and 35 (highlighted in red) .

C

Date: 03/29/22 Time: 08:58
Sample: 2002M01 2021M11
Included observations: 237
Q-statistic probabilities adjusted for 1 dynamic regressor

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.083	-0.083	1.6526	0.199
		2	0.185	0.179	9.8628	0.007
		3	0.107	0.140	12.649	0.005
		4	-0.031	-0.047	12.889	0.012
		6	0.085	0.081	14.809	0.022
		7	-0.173	-0.138	22.209	0.002
		8	0.021	-0.029	22.318	0.004
		9	0.027	0.072	22.497	0.007
		10	0.086	0.152	24.341	0.007
		16	-0.090	-0.132	29.275	0.022
		17	-0.156	-0.136	35.550	0.005
		18	-0.144	-0.119	40.877	0.002
		28	-0.203	-0.196	59.772	0.000

D

Date: 03/29/22 Time: 08:58
Sample: 2002M01 2021M11
Included observations: 237

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.035	0.035	0.2916	0.589
		2	0.168	0.167	7.1105	0.029
		3	0.002	-0.009	7.1112	0.068
		34	0.060	0.068	15.952	0.996
		35	0.159	0.152	23.004	0.940
		36	0.008	-0.034	23.023	0.954

- Regressing with these lags and removing one by one the significant variables yields us an adjusted R-squared of 19.92 (**E**) and stationary residuals (**F** and **G**).

E

Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: Least Squares
Date: 03/29/22 Time: 09:15
Sample (adjusted): 2005M01 2021M11
Included observations: 203 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.322505	0.994429	1.329915	0.1851
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.286139	0.064256	4.453099	0.0000
D(LIV_EX_100_BENCHMARK_FIN(-17))	-0.191563	0.066868	-2.864773	0.0046
D(LIV_EX_100_BENCHMARK_FIN(-28))	-0.159406	0.066063	-2.412929	0.0167
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.143302	0.067851	2.111990	0.0359

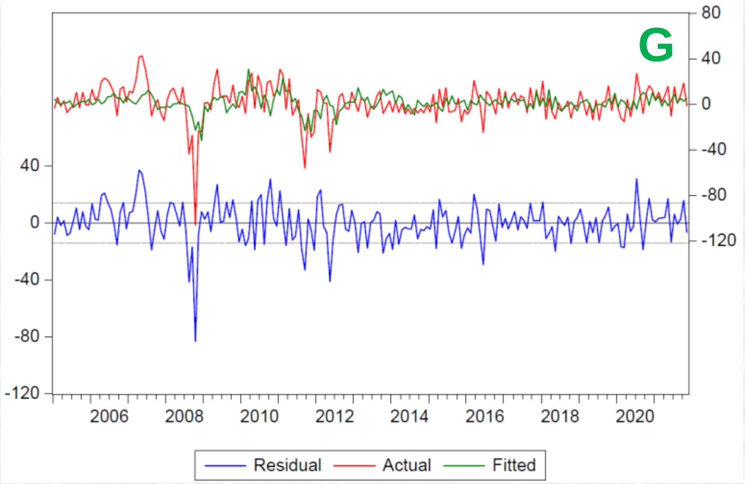
R-squared	0.215021	Mean dependent var	1.578892
Adjusted R-squared	0.199163	S.D. dependent var	15.55501
S.E. of regression	13.92010	Akaike info criterion	8.128867
Sum squared resid	38366.28	Schwarz criterion	8.210473
Log likelihood	-820.0800	Hannan-Quinn criter.	8.161881
F-statistic	13.55901	Durbin-Watson stat	1.582260
Prob(F-statistic)	0.000000		

F

Null Hypothesis: RESIDAUTOREGSIGLAG has a unit root
Exogenous: Constant
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.45689	0.0000
Test critical values:	1% level	-3.462737	
	5% level	-2.875680	
	10% level	-2.574385	

G



C. Investigation for conditional volatility properties

- Using a conditional volatility GARCH (1,1) (**A**) model and GARCH (1,1) model with a threshold (**E**) yield quite similar results.
- The PACF shows only one lag slightly outside the confidence interval (2) for squared residuals (**C** and **G**). The standardized results are stationary (**D** and **H**).

GARCH (1,1)

A

Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/29/22 Time: 09:23
Sample (adjusted): 2005M01 2021M11
Included observations: 203 after adjustments
Convergence achieved after 23 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(6) + C(7)*RESID(-1)^2 + C(8)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.948848	0.837933	1.132368	0.2575
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.246358	0.088860	2.772422	0.0056
D(LIV_EX_100_BENCHMARK_FIN(-17))	-0.038630	0.065083	-0.593546	0.5528
D(LIV_EX_100_BENCHMARK_FIN(-28))	-0.050842	0.063924	-0.795343	0.4264
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.142924	0.054038	2.644864	0.0082
Variance Equation				
C	20.22046	11.84853	1.706579	0.0879
RESID(-1)^2	0.253463	0.066325	3.821538	0.0001
GARCH(-1)	0.670148	0.087084	7.695447	0.0000

R-squared	0.174481	Mean dependent var	1.578892
Adjusted R-squared	0.157804	S.D. dependent var	15.55501
S.E. of regression	14.27502	Akaike info criterion	8.015020
Sum squared resid	40347.70	Schwarz criterion	8.145590
Log likelihood	-805.5245	Hannan-Quinn criter.	8.067843
Durbin-Watson stat	1.470769		

Correlogram of Standardized Residuals

B

Date: 03/30/22 Time: 11:21
Sample: 2002M01 2021M11
Included observations: 203
Q-statistic probabilities adjusted for 4 dynamic regressors

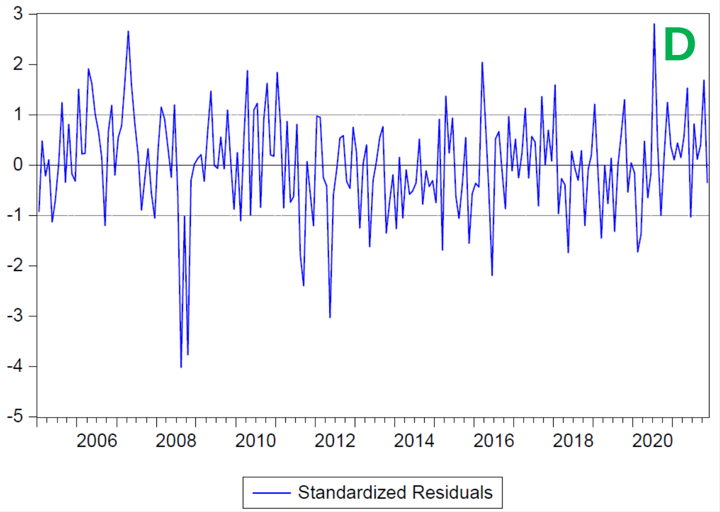
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.143	0.143	4.2345	0.040
		2	0.056	0.036	4.8856	0.087
		3	0.143	0.133	9.1475	0.027
		4	-0.040	-0.082	9.4793	0.050
		5	-0.011	-0.004	9.5043	0.091

Correlogram of Standardized Residuals Squared

C

Date: 03/30/22 Time: 11:22
Sample: 2002M01 2021M11
Included observations: 203

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.024	-0.024	0.1151	0.734
		2	0.210	0.209	9.2298	0.010
		3	-0.070	-0.064	10.251	0.017
		4	-0.022	-0.071	10.351	0.035
		5	-0.029	-0.002	10.526	0.062



GARCH (1,1) w. threshold

E

Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/29/22 Time: 09:24
Sample (adjusted): 2005M01 2021M11
Included observations: 203 after adjustments
Convergence achieved after 25 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(6) + C(7)*RESID(-1)^2 + C(8)*RESID(-1)^2*(RESID(-1)<0)
+ C(9)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.912839	0.881374	1.035701	0.3003
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.256062	0.090218	2.838272	0.0045
D(LIV_EX_100_BENCHMARK_FIN(-17))	-0.044969	0.065577	-0.685754	0.4929
D(LIV_EX_100_BENCHMARK_FIN(-28))	-0.044127	0.065275	-0.676024	0.4990
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.134987	0.051100	2.641614	0.0083
Variance Equation				
C	15.65852	10.44643	1.498936	0.1339
RESID(-1)^2	0.270600	0.129933	2.082609	0.0373
RESID(-1)^2*(RESID(-1)<0)	-0.053446	0.119564	-0.447009	0.6549
GARCH(-1)	0.706310	0.086255	8.188647	0.0000

R-squared	0.175200	Mean dependent var	1.578892
Adjusted R-squared	0.158538	S.D. dependent var	15.55501
S.E. of regression	14.26880	Akaike info criterion	8.024255
Sum squared resid	40312.55	Schwarz criterion	8.171145
Log likelihood	-805.4618	Hannan-Quinn criter.	8.083681
Durbin-Watson stat	1.479703		

Correlogram of Standardized Residuals

F

Date: 03/30/22 Time: 11:23
Sample: 2002M01 2021M11
Included observations: 203
Q-statistic probabilities adjusted for 4 dynamic regressors

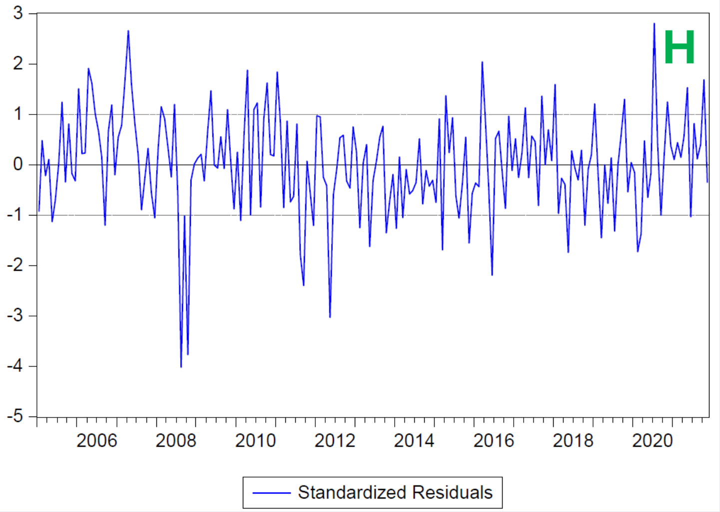
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.138	0.138	3.9473	0.047
		2	0.056	0.037	4.5850	0.101
		3	0.135	0.125	8.3928	0.039
		4	-0.042	-0.080	8.7552	0.068
		5	-0.012	-0.006	8.7859	0.118

Correlogram of Standardized Residuals Squared

G

Date: 03/30/22 Time: 11:25
Sample: 2002M01 2021M11
Included observations: 203

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.024	-0.024	0.1180	0.731
		2	0.215	0.215	9.6876	0.008
		3	-0.070	-0.064	10.721	0.013
		4	-0.019	-0.070	10.794	0.029
		5	-0.030	-0.002	10.978	0.052



D. Investigation for regime switching properties (1/2)

A

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Regime 1				
C	0.360537	2.175326	0.165739	0.8684
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.452726	0.125055	3.620205	0.0003
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.400425	0.082159	4.873798	0.0000
D(LIV_EX_100_BENCHMARK_FIN(-17))	0.092596	0.122219	0.757621	0.4487
D(LIV_EX_100_BENCHMARK_FIN(-35))	-0.083729	0.092313	-0.907009	0.3644
D(FRANCE_CPI_WINE_FROM_GRA)	-18.01750	7.266761	-2.479440	0.0132
D(FRANCE_CPI_WINE_FROM_GRA(-36))	12.80842	6.839906	1.872602	0.0611
D(FRANCE_PPI_CORRUGATED_CA)	21.86837	2.795311	7.823236	0.0000
D(MANUFACTURE_AGRICULTURAL(-2))	0.095483	0.039205	2.435465	0.0149
D(MSCI_FRANCE_CONSUMER_STA)	-0.104512	0.186155	-0.561424	0.5745
D(NORTH_AMERICA_FERTILIZER)	0.055572	0.033543	1.656758	0.0976
Regime 2				
C	0.046764	1.047543	0.044642	0.9644
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.081977	0.056564	1.449283	0.1473
D(LIV_EX_100_BENCHMARK_FIN(-2))	-0.039737	0.071379	-0.556709	0.5777
D(LIV_EX_100_BENCHMARK_FIN(-17))	-0.169210	0.055624	-3.042011	0.0024
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.284688	0.064355	4.423709	0.0000
D(FRANCE_CPI_WINE_FROM_GRA)	-5.104917	3.068627	-1.663583	0.0962
D(FRANCE_CPI_WINE_FROM_GRA(-36))	7.346420	4.446650	1.652125	0.0985
D(FRANCE_PPI_CORRUGATED_CA)	10.89906	2.143439	5.084845	0.0000
D(MANUFACTURE_AGRICULTURAL(-2))	-0.019183	0.023163	-0.828203	0.4076
D(MSCI_FRANCE_CONSUMER_STA)	0.196967	0.139586	1.411081	0.1582
D(NORTH_AMERICA_FERTILIZER)	0.039159	0.022963	1.705292	0.0881
Common				
LOG(SIGMA)	2.024020	0.069376	29.17459	0.0000
Probabilities Parameters				
P1-C	-0.725768	0.378091	-1.919560	0.0549

C

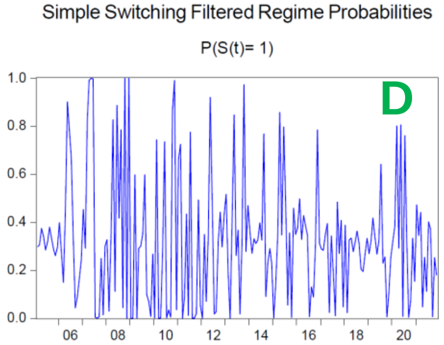
Constant transition probabilities:
P(i, k) = P(s(t) = k | s(t-1) = i)
(row = i / column = j)

	1	2
1	0.326124	0.673876
2	0.326124	0.673876

Constant expected durations:

1	2
1.483953	3.066318

D



B

Forecast: DLIVEXF	
Actual: DLIVEX	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	10.20662
Mean Absolute Error	7.519473
Mean Abs. Percent Error	230.2063
Theil Inequality Coefficient	0.375298
Bias Proportion	0.001443
Variance Proportion	0.157679
Covariance Proportion	0.840879
Theil U2 Coefficient	0.549543
Symmetric MAPE	104.5548

- Creating a Markov 2-regime switching model (**A**) yields a MAPE of 104. 55 (**B**) with significantly different probabilities (**C**). The second model's occurrence tends to increase as of 2014 (**D**).

- Putting as common variables (**E**) those whose difference is les than 0.3 (**F**) between the two models, we obtain quite similar MAPE (**I**) and switching probabilities (**G** and **H**).

E

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Regime 1				
C	-0.341382	1.120610	-0.304639	0.7606
D(LIV EX 100 BENCHMARK FIN(-1))	0.064444	0.060501	1.065179	0.2868
D(LIV EX 100 BENCHMARK FIN(-2))	-0.018140	0.075241	-0.241095	0.8095
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.302412	0.069107	4.376017	0.0000
D(FRANCE_CPI_WINE_FROM_GRA)	-5.506494	3.349549	-1.643951	0.1002
D(FRANCE CPI WINE FROM GRA(-36))	8.277120	4.344805	1.905061	0.0568
D(FRANCE PPI CORRUGATED CA)	9.746425	2.332080	4.179284	0.0000
D(MSCI FRANCE CONSUMER STA)	0.200348	0.147139	1.361625	0.1733
Regime 2				
C	1.006563	2.184226	0.460833	0.6449
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.466213	0.119445	3.903163	0.0001
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.360702	0.082620	4.365776	0.0000
D(LIV EX 100 BENCHMARK FIN(-35))	-0.099072	0.086139	-1.150142	0.2501
D(FRANCE CPI WINE FROM GRA)	-14.20757	6.924600	-2.051753	0.0402
D(FRANCE_CPI_WINE_FROM_GRA(-36))	12.71669	7.153194	1.777764	0.0754
D(FRANCE_PPI_CORRUGATED_CA)	21.76840	2.599639	8.373624	0.0000
D(MSCI FRANCE CONSUMER STA)	-0.007223	0.209069	-0.034550	0.9724
Common				
D(LIV EX 100 BENCHMARK FIN(-17))	-0.136352	0.054070	-2.521766	0.0117
D(MANUFACTURE AGRICULTURAL(-2))	0.014007	0.017991	0.778547	0.4362
D(NORTH AMERICA FERTILIZER)	0.051095	0.017469	2.924857	0.0034
LOG(SIGMA)	2.058647	0.068987	29.84105	0.0000
Probabilities Parameters				
P1-C	0.663070	0.420915	1.575305	0.1152

G

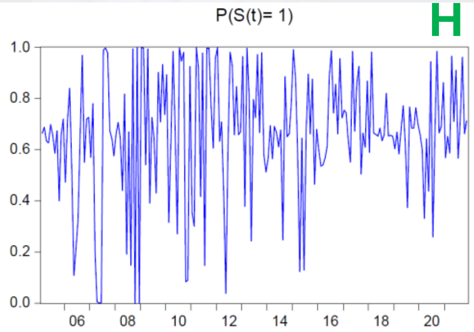
Constant transition probabilities:
P(i, k) = P(s(t) = k | s(t-1) = i)
(row = i / column = j)

	1	2
1	0.659950	0.340050
2	0.659950	0.340050

Constant expected durations:

1	2
2.940741	1.515267

H



F

Variable	T-Stat diff
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.371
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.440
D(LIV_EX_100_BENCHMARK_FIN(-17))	0.262
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.368
D(FRANCE_CPI_WINE_FROM_GRA)	12.913
D(FRANCE_CPI_WINE_FROM_GRA(-36))	5.462
D(FRANCE_PPI_CORRUGATED_CA)	10.969
D(MANUFACTURE_AGRICULTURAL(-2))	0.115
D(MSCI_FRANCE_CONSUMER_STA)	0.301
D(NORTH_AMERICA_FERTILIZER)	0.016

I

Forecast: DLIVEXF	
Actual: DLIVEX	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	10.09826
Mean Absolute Error	7.497863
Mean Abs. Percent Error	227.8954
Theil Inequality Coefficient	0.368179
Bias Proportion	0.000403
Variance Proportion	0.144661
Covariance Proportion	0.854936
Theil U2 Coefficient	0.534067
Symmetric MAPE	104.5880

D. Investigation for regime switching properties (2/2)

A

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Regime 1				
C	-0.071444	1.344218	-0.053149	0.9576
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.053554	0.071117	0.753045	0.4514
D(LIV_EX_100_BENCHMARK_FIN(-2))	-0.071774	0.107068	-0.670358	0.5026
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.353039	0.072422	4.874714	0.0000
D(FRANCE_CPI_WINE_FROM_GRA)	-5.804291	4.299119	-1.350112	0.1770
D(FRANCE_CPI_WINE_FROM_GRA(-36))	7.568328	5.491584	1.378168	0.1682
D(FRANCE_PPI_CORRUGATED_CA)	8.975073	2.628722	3.414235	0.0006
D(MSCI_FRANCE_CONSUMER_STA)	0.178352	0.188338	0.946980	0.3436
Regime 2				
C	0.236296	1.781789	0.132617	0.8945
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.402273	0.100588	3.999222	0.0001
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.307873	0.078643	3.914789	0.0001
D(LIV_EX_100_BENCHMARK_FIN(-35))	-0.049381	0.081229	-0.607922	0.5432
D(FRANCE_CPI_WINE_FROM_GRA)	-10.55269	5.373305	-1.963910	0.0495
D(FRANCE_CPI_WINE_FROM_GRA(-36))	12.33882	5.878135	2.099105	0.0358
D(FRANCE_PPI_CORRUGATED_CA)	19.57246	2.677975	7.308681	0.0000
D(MSCI_FRANCE_CONSUMER_STA)	0.079468	0.188623	0.421307	0.6735
Common				
D(LIV_EX_100_BENCHMARK_FIN(-17))	-0.147339	0.059164	-2.490327	0.0128
D(MANUFACTURE_AGRICULTURAL(-2))	0.015079	0.018327	0.822735	0.4107
D(NORTH_AMERICA_FERTILIZER)	0.055313	0.019281	2.868813	0.0041
LOG(SIGMA)	2.086926	0.072017	28.97826	0.0000
Probabilities Parameters				
P1-D(FRANCE_CPI_WINE_FROM_GRA)	-0.424749	1.247481	-0.340485	0.7335

C

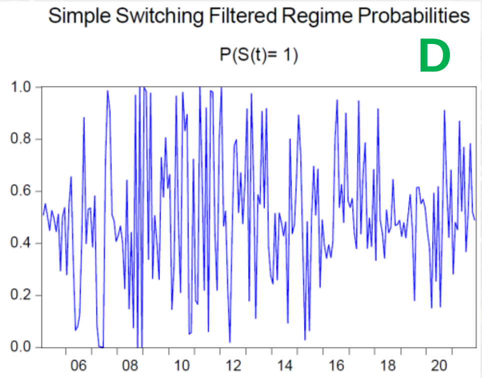
Time-varying transition probabilities:
P(i, k) = P(s(t) = k | s(t-1) = i)
(row = i / column = j)

		1	2
Mean	1	0.484932	0.515068
	2	0.484932	0.515068
Std. Dev.	1	0.028677	0.028677
	2	0.028677	0.028677

Time-varying expected durations:

	1	2
Mean	1.947651	2.069419
Std. Dev.	0.112294	0.124693

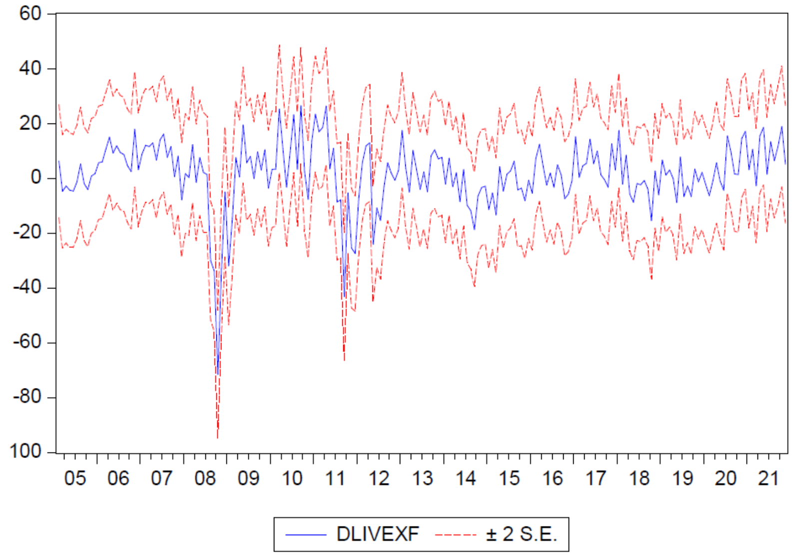
D



B

Forecast: DLIVEXF	
Actual: DLIVEX	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	10.09427
Mean Absolute Error	7.509201
Mean Abs. Percent Error	239.7340
Theil Inequality Coefficient	0.357998
Bias Proportion	0.000304
Variance Proportion	0.092485
Covariance Proportion	0.907211
Theil U2 Coefficient	0.495530
Symmetric MAPE	102.9426

E



Forecast: DLIVEXF	
Actual: DLIVEX	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	9.985779
Mean Absolute Error	7.547566
Mean Abs. Percent Error	242.0218
Theil Inequality Coefficient	0.360985
Bias Proportion	0.000000
Variance Proportion	0.132115
Covariance Proportion	0.867885
Theil U2 Coefficient	0.529111
Symmetric MAPE	103.9404

- Putting the CPI of wines from grapes as a regressor on top of the common variables (**A**), we obtain a slightly lower MAPE (**B**) but two models whose probabilities are very close (**C** and **D**).

- We see that the MAPEs we obtained with our variations of Markov 2-regime switching models are very close to the MAPE of 103.94 obtained with our linear regression with significant lags (**E**) we obtained in slide 4 – B.

- Hence, we do not think that using a regime switching model to forecast the evolution of the Liv-ex index is the most relevant approach.

E. Specification and testing of a one step ahead predictive model for the mean

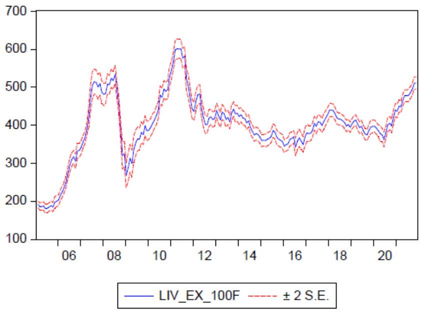
A

Dependent Variable: D(LIV_EX_100_BENCHMARK_FIN)
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 03/30/22 Time: 21:07
Sample (adjusted): 2005M02 2021M11
Included observations: 202 after adjustments
Convergence achieved after 30 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(12) + C(13)*RESID(-1)^2 + C(14)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.307823	1.003073	0.306880	0.7589
D(LIV_EX_100_BENCHMARK_FIN(-1))	0.112906	0.062333	1.811324	0.0701
D(LIV_EX_100_BENCHMARK_FIN(-2))	0.148168	0.053897	2.749116	0.0060
D(LIV_EX_100_BENCHMARK_FIN(-17))	-0.095149	0.059366	-1.602757	0.1090
D(LIV_EX_100_BENCHMARK_FIN(-35))	0.149116	0.051624	2.888509	0.0039
D(FRANCE_CPI_WINE_FROM_GRA)	-7.109180	3.481997	-2.041696	0.0412
D(FRANCE_CPI_WINE_FROM_GRA(-36))	7.256436	3.790631	1.914308	0.0556
D(FRANCE_PPI_CORRUGATED_CA)	13.33275	1.748102	7.626987	0.0000
D(MANUFACTURE_AGRICULTURAL(-2))	0.017304	0.020438	0.846679	0.3972
D(MSCI_FRANCE_CONSUMER_STA)	0.219565	0.102551	2.141033	0.0323
D(NORTH_AMERICA_FERTILIZER)	0.069412	0.018732	3.705586	0.0002
Variance Equation				
C	4.851903	3.013484	1.610065	0.1074
RESID(-1)^2	0.114190	0.044073	2.590928	0.0096
GARCH(-1)	0.842523	0.060872	13.84082	0.0000

R-squared	0.577451	Mean dependent var	1.602743
Adjusted R-squared	0.555328	S.D. dependent var	15.58993
S.E. of regression	10.39595	Akaike info criterion	7.455220
Sum squared resid	20642.48	Schwarz criterion	7.684506
Log likelihood	-738.9772	Hannan-Quinn criter.	7.547989
Durbin-Watson stat	1.822023		

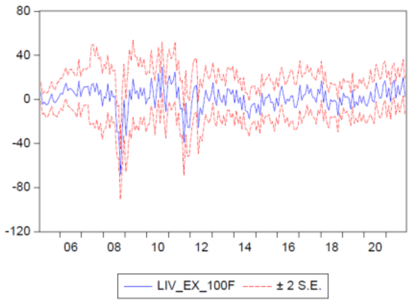
B



Forecast: LIV_EX_100F
Actual: LIV_EX_100_BENCHMARK_FIN
Forecast sample: 2002M01 2021M11
Adjusted sample: 2005M02 2021M11
Included observations: 202

Root Mean Squared Error	10.10893
Mean Absolute Error	7.505657
Mean Abs. Percent Error	1.918200
Theil Inequality Coefficient	0.012364
Bias Proportion	0.000130
Variance Proportion	0.030337
Covariance Proportion	0.969533
Theil U2 Coefficient	0.686660
Symmetric MAPE	1.923751

C



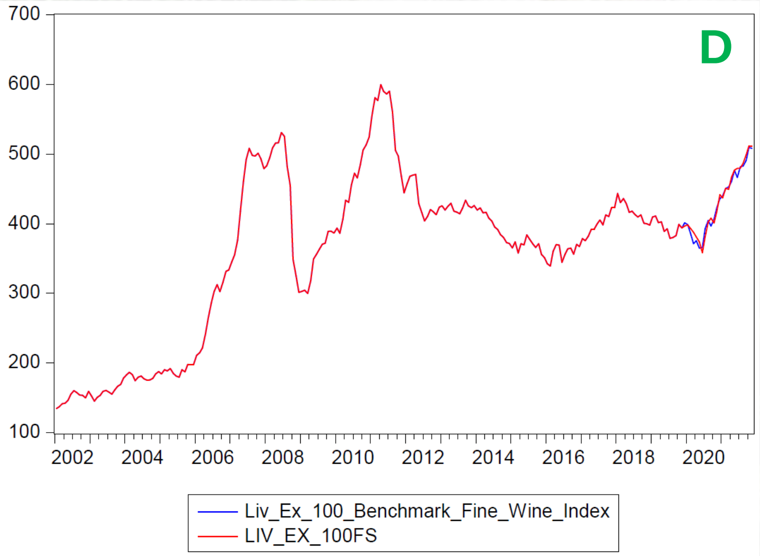
Forecast: LIV_EX_100F
Actual: D(LIV_EX_100_BENCHMARK_FIN)
Forecast sample: 2002M01 2021M11
Adjusted sample: 2005M02 2021M11
Included observations: 202

Root Mean Squared Error	10.10893
Mean Absolute Error	7.505657
Mean Abs. Percent Error	246.5529
Theil Inequality Coefficient	0.372862
Bias Proportion	0.000130
Variance Proportion	0.170166
Covariance Proportion	0.829704
Theil U2 Coefficient	0.538073
Symmetric MAPE	104.2417

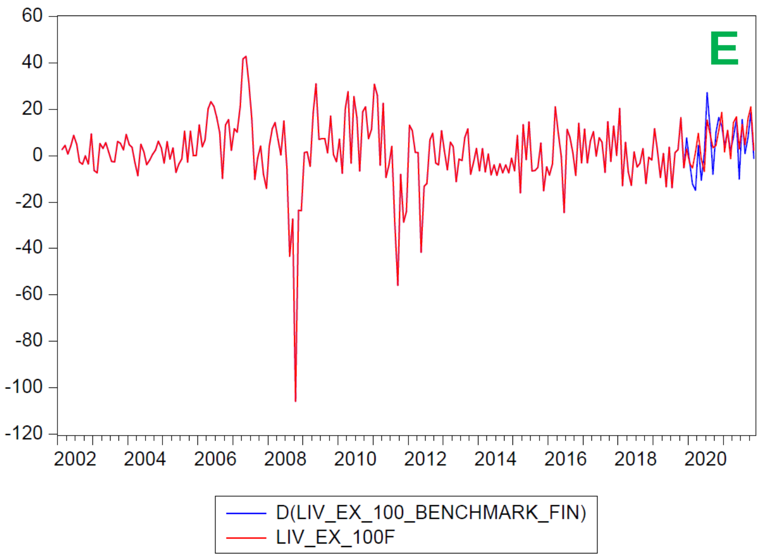
- Using the linear regression model we obtained in slide 4 – B and using a GARCH (1,1) model to better take into account the changing volatility (**A**), we obtain MAPE of 1.92 (**B**) and 104.24 (**C**) for respectively the index and the differences.

- Back testing with 90% of the data to forecast the remaining 10%, the model's accuracy seems fair for both the index (**D**) and the differences (**E**).

D

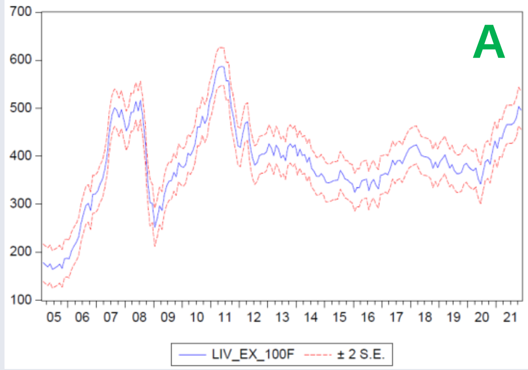


E

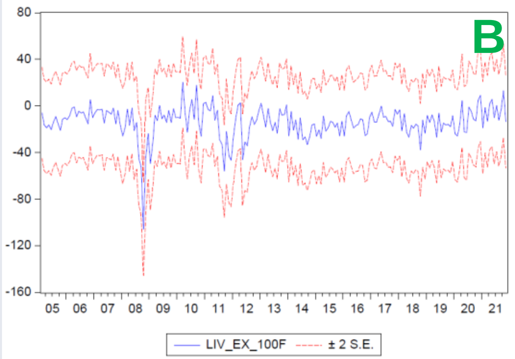


F. Specification and testing of a one step ahead predictive model for the P5 and P95 quantiles

5th quantile

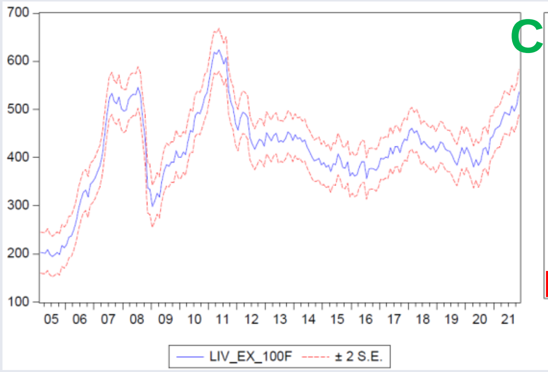


Forecast: LIV_EX_100F	
Actual: LIV_EX_100_BENCHMARK_FIN	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	18.93896
Mean Absolute Error	15.77278
Mean Abs. Percent Error	4.223858
Theil Inequality Coefficient	0.023602
Bias Proportion	0.678451
Variance Proportion	0.005666
Covariance Proportion	0.315883
Theil U2 Coefficient	1.391803
Symmetric MAPE	4.364469



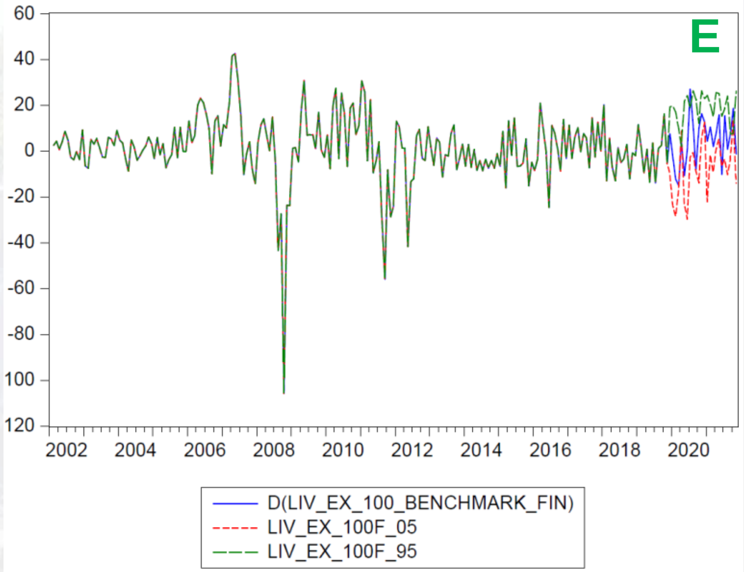
Forecast: LIV_EX_100F	
Actual: D(LIV_EX_100_BENCHMARK_FIN)	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	18.93896
Mean Absolute Error	15.77278
Mean Abs. Percent Error	609.3364
Theil Inequality Coefficient	0.538857
Bias Proportion	0.678451
Variance Proportion	0.010664
Covariance Proportion	0.310885
Theil U2 Coefficient	1.817919
Symmetric MAPE	138.7135

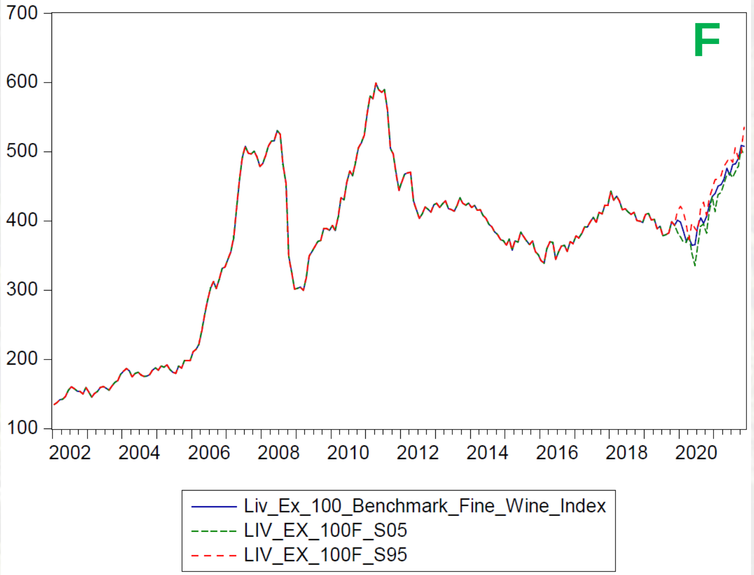
95th quantile



Forecast: LIV_EX_100F	
Actual: LIV_EX_100_BENCHMARK_FIN	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	20.51129
Mean Absolute Error	16.97557
Mean Abs. Percent Error	4.418227
Theil Inequality Coefficient	0.024592
Bias Proportion	0.660035
Variance Proportion	0.008010
Covariance Proportion	0.331956
Theil U2 Coefficient	1.348486
Symmetric MAPE	4.279323

Forecast: LIV_EX_100F	
Actual: D(LIV_EX_100_BENCHMARK_FIN)	
Forecast sample: 2002M01 2021M11	
Adjusted sample: 2005M02 2021M11	
Included observations: 202	
Root Mean Squared Error	20.51129
Mean Absolute Error	16.97557
Mean Abs. Percent Error	954.5873
Theil Inequality Coefficient	0.573938
Bias Proportion	0.660035
Variance Proportion	0.121663
Covariance Proportion	0.218303
Theil U2 Coefficient	0.900491
Symmetric MAPE	130.5948





- Still using the linear regression model we obtained in slide 4 – B , we obtain MAPEs of 4.36 (**A**) and 138.71 (**B**) for respectively the index and the index's differences for the 5th quantile regression, and MAPEs of 4.28 (**C**) and 130.60 (**D**) for respectively the index and the index's differences for the 95th quantile regression.

- Back testing in the same fashion for the quantiles, we see that the actual data fits well between the boundaries of the 5th and 95th quantiles for both the differences (**E**) and the index (**F**).