Model validation task.

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The task

You are provided time-series of 3 equity underlyings for this task: Bank of America, Microsoft, Apple.

1. The Historical Simulation approach relies on the assumption that the distribution of returns is stationary, i.e. does not change very fast. Run two-sample Kolmogorov-Smirnov test to assess stationary of returns.
2. As a high-level check of the methodology you are required to run backtesting: see how many times the actual PnL would be less than VaR during the last year (i.e. the drop in portfolio price was more significant than VaR, for example VaR = -1250 USD, Actual PnL = -1400 USD). For this task assume that all pricing parameters except the equity spot price are fixed.
   The portfolio of the company is made up of the following holdings:
   - 100 Call options on Bank of America with maturity=2March 2015 and K=16
   - 30 Put options on Microsoft with maturity=2March 2015 and K=40
   - 3 Call options on Apple with maturity=2March 2015 and K=600

   The company's portfolio has been without changes during the past year.

The objective is to perform the two tasks. Data are received in a MS Excel file.

To carry out these tasks, the following tools are used:

- MS Excel
- Python
    - Spyder 2.3.8

Spyder 2.3.8 has been used to write the code. There are two python files (see ***Table 1: Name and content of the files***):

Table 1: Name and content of the files

File Name	File Content
model_validation_task_1.py	This file contains the code developed to perform the task 1 (Two sample Kolmogorov Smirnov Test).
model_validation_task.py	This file contains the code developed to perform the task 2 (Backtesting).

Several Python modules used are:

- xlrd: this modules enables extracting data from excel files,https://pypi.python.org/pypi/xlrd
- datetime: This module enables to acquire dates from MS Excel float data, https://pypi.python.org/pypi/DateTime
- scipy: it is used to perform Kolmogorov Smirnov test, https://pypi.python.org/pypi/scipy

Task 1:

The Historical Simulation approach relies on the assumption that the distribution of returns is stationary, i.e. does not change very fast. Run two-sample Kolmogorov-Smirnov test to assess stationary of returns.

The Python file used for carry out this activity was **model_validation_task_1.py**

This task was performed as follows:

The data contained in the MS Excel file '**TimeSeries**' was stored in the matrix **values**. From this information, the historical equity returns were calculated as

$$r_{t,i} = \frac{S_{t+1,i} - S_{t,i}}{S_{t,i}}$$

where S represents the equity spot price. The next step was to keep the equity returns In different lists with the following names: bac, msft , aaple. Therefore, the composition of the tables is shown in the ***Table 2***: Structure of values table and

Table 3: Structure of bac, msft and aaple tables. The field Date_return is one day less than Dates, because we do not consider 01.05.2014 as a current historical date.

Table 2: Structure of values table.

values							
Dates	BAC	MSFT	AAPLE	Eq_return_BAC	Eq_return_MSFT	Eq_return_AAPLE	Date_return

Table 3: Structure of bac, msft and aaple tables

bac	msft	aaple
Eq_return_BAC	Eq_return_MSFT	Eq_return_AAPLE

From the returns, three two-sample Kolmogorov Smirnov test, henceforth KM, have been performed. The idea is to compare the first two years from the equity returns of one of the equities (e.g. bac) with the last two years equity returns of the same equity (e.g. bac_1). In the first test, the time-series of Bank of America equity returns were compared. For the second test, the compared values were between Microsoft. Finally, the comparison took place between first and last two years of Apple.

The details and results of the three tests are shown in the following ***Table*** 4: KM test details

Table 4: KM test details

KM test (name of the variable)	Equity Returns Samples	Sample Size	p-value
KM1	bac vs bac_1	503 - 503	1.257778e-05
KM2	msft vs msft_1	503 – 503	0.406883
KM3	aaple vs aaple_1	503 – 503	0.193417

Task 2:

As a high-level check of the methodology you are required to run backtesting: see how many times the actualPnL would be less than VaR during the last year.

The Python file used for carry out this activity was **model_validation_task.py**

The portfolio of the company consisted of the following holdings (***Table 5***: Portfolio of the company:

Table 5: Portfolio of the company

Option Number	Underlying Equity	Option Type	Maturity Date	K Value
100	Bank of America (BAC)	Call	2 March 2015	16
30	Microsoft (MSFT)	Put	2 March 2015	40
3	Apple (AAPLE)	Call	2 March 2015	600

For this task, the matrix **values** was also used. A capture of the matrix is shown in the ***Figure 1***: values matrix. There, it is possible to observe the data and the historical prices of the three equities for the whole period (four years contained in the MS Excel file) and the equity returns of the three equities for a period of three years (the number of trading days is assumed as 250). Thus, the matrix contains 1007 values of historical dates and there are 750 values of equity returns as the task requires it.

values - Lista (1008 elementos)

Índice	Tipo	Tamaño	Valor
0	list	8	['Date', 'BAC', 'MSFT', 'AAPLE', 'Eq_return_BAC', 'Eq_return_MSFT', 'Eq_return_AAPLE', 'Date_return']
1	list	8	[datetime... 1, 0, 0), 15.09, 40.0, 591.48, -0.00330...075297696, -0.00990...099009866, 0.002355...787133935, datetime...30, 0, 0)]
2	list	8	[datetime...30, 0, 0), 15.14, 40.4, 590.09, -0.00656...790026223, -0.00271...187854714, -0.00378167575506898, datetime...29, 0, 0)]
3	list	8	[datetime...29, 0, 0), 15.24, 40.51, 592.33, 0.01939799331103685, -0.00880...931734755, -0.00296...097190646, datetime...28, 0, 0)]
4	list	8	[datetime...28, 0, 0), 14.95, 40.87, 594.09, -0.06269592476489029, 0.024054121773991504, 0.03872783858446686, datetime...25, 0, 0)]
5	list	8	[datetime...25, 0, 0), 15.95, 39.91, 571.94, -0.02386...057527573, 0.001254...662819156, 0.007344523310495576, datetime...24, 0, 0)]
6	list	8	[datetime...24, 0, 0), 16.34, 39.86, 567.77, -0.00183...475260314, 0.004283194759385279, 0.0819818961410195, datetime...23, 0, 0)]
7	list	8	[datetime...23, 0, 0), 16.37, 39.69, 524.75, 0.0049109883364028l5, -0.00750...468867323, -0.01307128079744225, datetime...22, 0, 0)]
8	list	8	[datetime...22, 0, 0), 16.29, 39.99, 531.7, 0.012430080795525126, 0.001251...167251944, 0.000997...153605935, datetime...21, 0, 0)]
9	list	8	[datetime...21, 0, 0), 16.09, 39.94, 531.17, -0.00371...278637692, -0.00174...093476703, 0.011868023012153587, datetime...17, 0, 0)]
10	list	8	[datetime...17, 0, 0), 16.15, 40.01, 524.94, 0.001239...044637059, -0.00965...346534667, 0.011425598736055306, datetime...16, 0, 0)]
11	list	8	[datetime...16, 0, 0), 16.13, 40.4, 519.01, -0.01586...299573007, 0.0163522012578616, 0.002027183566298468, datetime...15, 0, 0)]
12	list	8	[datetime...15, 0, 0), 16.39, 39.75, 517.96, 0.024375000000000036, 0.014548238897396638, -0.00713...158257771, datetime...14, 0, 0)]
13	list	8	[datetime...14, 0, 0), 16.0, 39.18, 521.68, 0.01458465440710212, -0.00076...410864865, 0.003983757048555525, datetime...11, 0, 0)]
14	list	8	[datetime...11, 0, 0), 15.77, 39.21, 519.61, -0.021712158808933l0, -0.00381...097560615, -0.00739...819515636, datetime...10, 0, 0)]
15	list	8	[datetime...10, 0, 0), 16.12, 39.36, 523.48, -0.03008...860409144, -0.02742...240177895, -0.01289...982350338, datetime... 9, 0, 0)]

Figure 1: values matrix

Then, with the 750 equity returns, 3 matrices were created with the following names: **bac_tomorrow, msft_tomorrow** and **aaple_tomorrow,** each of them containing 750

hypothetical equity prices for each historical date. The hypothetical equity prices were calculated using the following formula:

$$HypotheticalS_{t+1,j} = S_t \cdot (1 + r_{t,j})$$

where

$HypotheticalS_{t+1,j}$ is the hypothetical tomorrow's equity price.

S_t is the equity price of today.

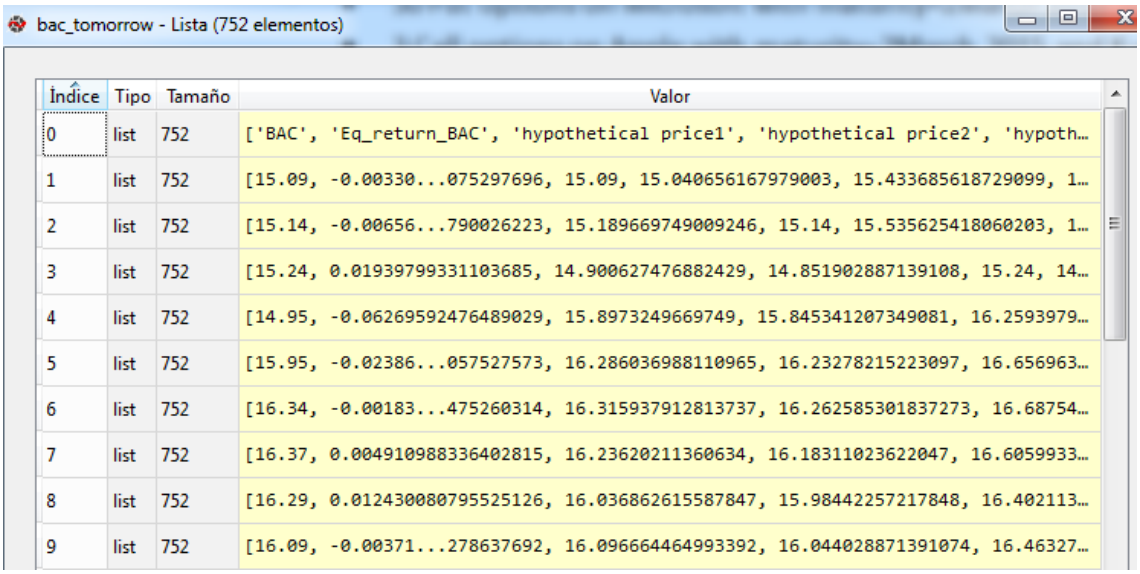
$r_{t,j}$ is the equity return previously calculated.

Therefore, there are 750 $r_{t,j}$ for each type of equity underlying (BAC, MSFT, and AAPLE) as they were calculated in the matrix values. Thus, each historical date of a specific equity (BAC, for example) has 750 possible tomorrow's equity prices. This is better appreciated in the following ***Table*** 6: bac_tomorrow matrix:

Table 6: bac_tomorrow matrix

BAC Today's Equity Price	Tomorrow's Equity $Price_1$	Tomorrow's Equity $Price_2$	…	Tomorrow's Equity $Price_i$	…	Tomorrow's Equity $Price_{749}$	Tomorrow's Equity $Price_{750}$
30/04/2014							
29/04/2014							
…							
09/05/2011							
06/05/2011							

As an example, a capture of the bac_tomorrow matrix is shown in the following ***Figure*** 2: bac_tomorrow table. It is posible to observe the 750 hypothetical prices.:


bac_tomorrow - Lista (752 elementos)

Índice	Tipo	Tamaño	Valor
0	list	752	['BAC', 'Eq_return_BAC', 'hypothetical price1', 'hypothetical price2', 'hypoth…
1	list	752	[15.09, -0.00330...075297696, 15.09, 15.040656167979003, 15.433685618729099, 1…
2	list	752	[15.14, -0.00656...790026223, 15.189669749009246, 15.14, 15.535625418060203, 1…
3	list	752	[15.24, 0.01939799331103685, 14.900627476882429, 14.851902887139108, 15.24, 14…
4	list	752	[14.95, -0.06269592476489029, 15.8973249669749, 15.845341207349081, 16.2593979…
5	list	752	[15.95, -0.02386...057527573, 16.286036988110965, 16.23278215223097, 16.656963…
6	list	752	[16.34, -0.00183...475260314, 16.315937912813737, 16.262585301837273, 16.68754…
7	list	752	[16.37, 0.004910988336402815, 16.23620211360634, 16.18311023622047, 16.6059933…
8	list	752	[16.29, 0.012430080795525126, 16.036862615587847, 15.98442257217848, 16.402113…
9	list	752	[16.09, -0.00371...278637692, 16.096664464993392, 16.044028871391074, 16.46327…

Figure 2: bac_tomorrow table. It is posible to observe the 750 hypothetical prices.

The next step was to calculate the current and hypothetical portfolio values. The price of each historical portfolio was estimated once the options were priced. The following formulas were used for pricing the options of our portfolio:

$$P_{Call}(K,T) = e^{-rT} \cdot [F \cdot N(d_1) - K \cdot N(d_2)]$$

$$P_{Put}(K,T) = e^{-rT} \cdot [K \cdot N(-d_2) - F \cdot N(-d_1)]$$

The following table (***Table 7***: Current average, maximum and minimum prices for the different options of our portfolio) shows current average, maximum and minimum option price values for the three option types:

Table 7: Current average, maximum and minimum prices for the different options of our portfolio

	BAC	MSFT	AAPLE
Average Price	0.517945	8.744284	37.884564
Maximum Price	2.676944	13.583038	157.025321
Minimum Price	0.000863	2.101627	3.590179

With the current and hypothetical tomorrow equity prices, current and 750 future portfolio prices were calculated for each historical date as follows:

$$Pprice_0^t = 100 \cdot P_{0\,Call-BAC}^t(KT) + 30 \cdot P_{0\,Put-MSFT}^t(K,T) + 3 \cdot P_{0\,Call-AAPLE}^t(KT)$$

$$Pprice_i^t = 100 \cdot P_{i\,Call-BAC}^t(KT) + 30 \cdot P_{i\,Put-MSFT}^t(K,T) + 3 \cdot P_{i\,Call-AAPLE}^t(KT)$$

Where

$Pprice_0^t$ is the current portfolio price for a given historical date.

$Pprice_i^t$ is a hypothetical portfolio price for a given historical date.

P_i^0 is the current equity option price for a given historical date.

P_i^t is a hypothetical equity option price for a given historical date.

The ***Table 8: Portfolio prices***, presents maximum, minimum and average portfolio prices for the 750 dates:

Table 8: Portfolio prices

	BAC	MSFT	AAPLE	portfolio price
Average Price	0.517945	8.744284	37.884564	427.776819
Maximum Price	2.676944	13.583038	157.025321	734.265198
Minimum Price	0.000863	2.101627	3.590179	244.012580

The following capture (***Figure 3: current portfolio prices***) illustrates the different values of the portfolio (from 6 May 2011 until 30 April 2014). The maximum value (734.265198) was reached on 19 Sep 2012:

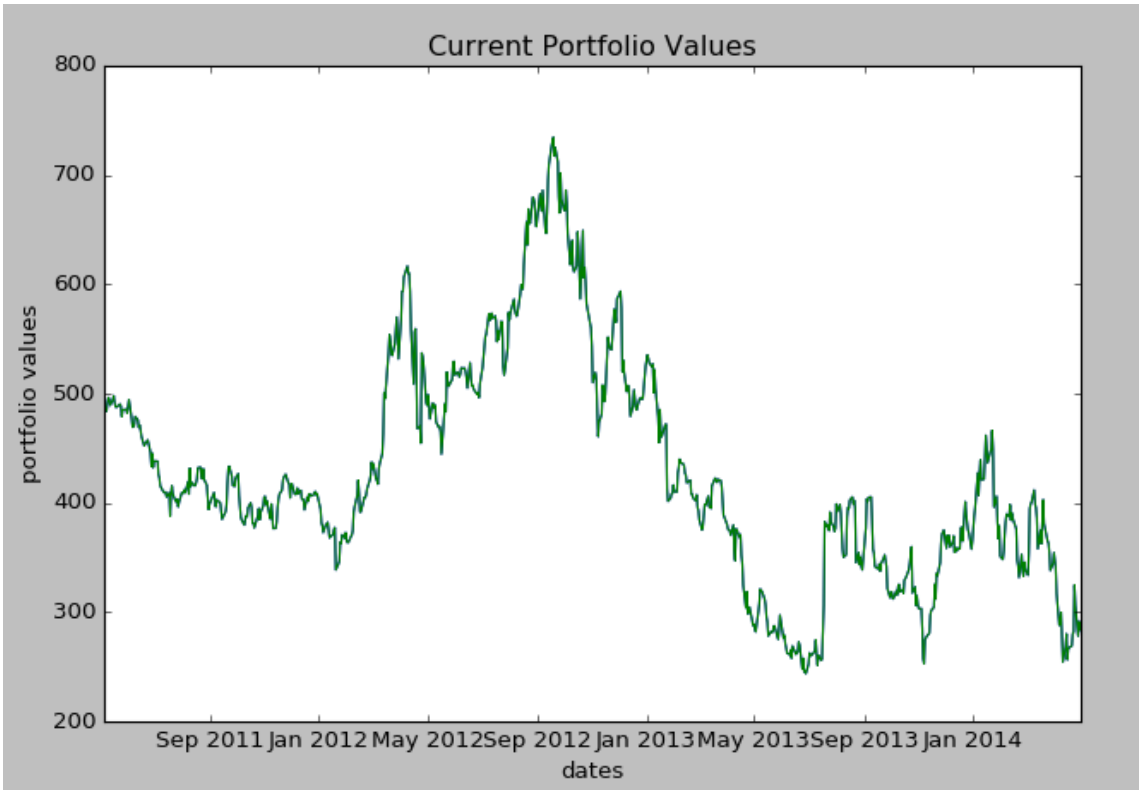


Figure 3: current portfolio prices

Once the portfolio prices were calculated, the final steps were the calculation of the portfolio price changes (PNL) and its comparison with the corresponding VAR. Portfolio price changes were calculated for each historical date using the next formula

$$PNL^t = Pprice(\hat{S}_{1,1}^{(t)}, \hat{S}_{1,2}^{(t)}, \ldots, \hat{S}_{1,N}^{(t)}, today) - Pprice(S_{0,1}, S_{0,2}, \ldots, S_{0,N}, today)$$

where 750 portfolio price changes arise from the respective differences between the 750 hypothetical portfolio prices and the current portfolio price for each historical date.

Finally, the estimation of the VAR was needed to be compared with the PNL. According with the information provided, VAR is calculated as the 1% interpolated percentile of those 750 samples for each historical date. Thus, the 750 PNL values for each historical date were ordered from lowest to highest value and the value corresponding to the 1% percentile was considered the VAR.

According with the description, the comparison between VAR and PNL was performed for the last year.

The matrix **actual_pnl_vs_var** shows PNL values and VAR for each date (see ***Figure 4: actual_pnl_vs_var matrix***).

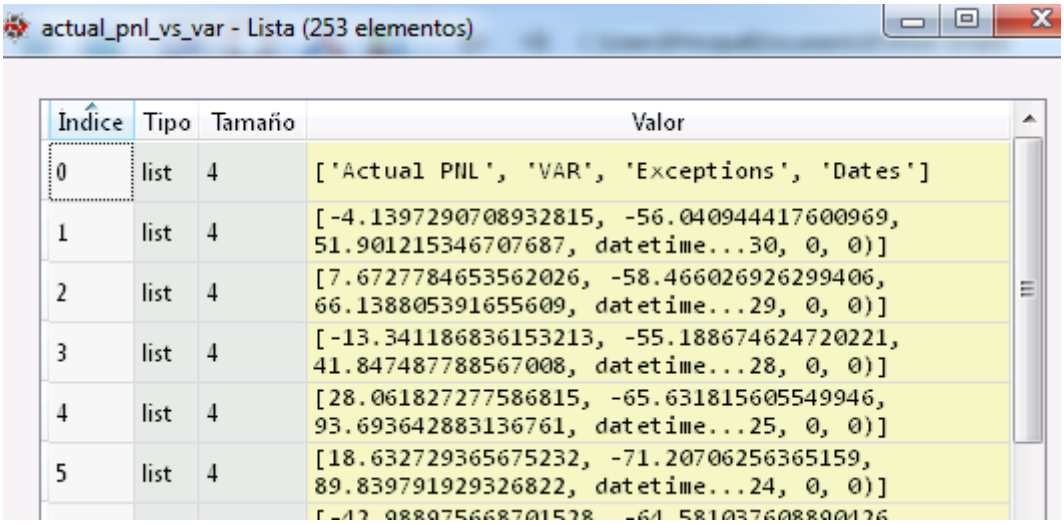


Figure 4: actual_pnl_vs_var matrix

The following table (***Table 9: Resume of steps***) shows a resume of the steps:

Table 9: Resume of steps

Steps	Table/Matrix names	Additional Information
Estimate historical equity	**values**	

returns		
Calculate 750 hypothetical equity prices for each historical date	**bac_tomorrow** **msft_tomorrow** **aaple_tomorrow**	
Estimate current portfolio values	**portfolio_price**	**fut_portfolio_price** – **portfolio_price** results in **hyp_pnl** matrix
Calculate 750 hypothetical portfolio prices for each historical date	**fut_portfolio_price**	
Sort the 750 portfolio values to find the 1% percentile	**hyp_pnl_sorted**	Once the values are sorted, the VAR corresponds for each historical fate to the 8th element of the list/array
Comparison between actual PNL and VAR	**actual_pnl_vs_var**	

Below are presented the results which are contained in the **actual_pnl_vs_var** matrix (see ***Table 10***: Results: comparison between PNL and VAR during the last year):

Table 10: Results: comparison between PNL and VAR during the last year

Actual PNL	VAR	Exceptions	Dates
-4.1397290708932815	-56.040944417600969	51.901215346707687	30/04/2014 0:00
7.6727784653562026	-58.466026926299406	66.138805391655609	29/04/2014 0:00
-13.341186836153213	-55.188674624720221	41.847487788567008	28/04/2014 0:00
28.061827277586815	-65.631815605549946	93.693642883136761	25/04/2014 0:00
18.632729365675232	-71.20706256365159	89.839791929326822	24/04/2014 0:00
-42.988975668701528	-64.581037608890426	21.592061940188898	23/04/2014 0:00
-1.6581567347109285	-63.704969100509629	62.046812365798701	22/04/2014 0:00
-10.977278669424436	-60.760603749954498	49.783325080530062	21/04/2014 0:00
-2.3531606338841584	-60.562565645333763	58.209405011449604	17/04/2014 0:00
-10.331095192131784	-60.051456733720869	49.720361541589085	16/04/2014 0:00
23.678681970230116	-64.773485683904937	88.452167654135053	15/04/2014 0:00
-11.638207869467919	-57.08237229443273	45.444164424964811	14/04/2014 0:00
-14.209155041115878	-52.734779091071232	38.525624049955354	11/04/2014 0:00
21.662995997978555	-59.811983107098911	81.474979105077466	10/04/2014 0:00
23.626318469969078	-70.562914797657527	94.189233267626605	09/04/2014 0:00
-8.9553658475085172	-66.334573515623106	57.379207668114589	08/04/2014 0:00
-2.7143265515500161	-65.199401517642315	62.485074966092299	07/04/2014 0:00
29.289760803791523	-72.399810099630571	101.68957090342209	04/04/2014 0:00
23.472331666358002	-82.054970087253764	105.52730175361177	03/04/2014 0:00
6.7614659964997372	-84.514861029988765	91.276327026488502	02/04/2014 0:00

6.9247112104943653	-86.177720369992414	93.10243158048678	01/04/2014 0:00
-9.8281855341762707	-82.601229428433498	72.773043894257228	31/03/2014 0:00
-6.4394770958203935	-78.068356379551915	71.628879283731521	28/03/2014 0:00
15.51142354499558	-78.250202780338896	93.761626325334475	27/03/2014 0:00
9.3664718819455288	-81.864571602124158	91.231043484069687	26/03/2014 0:00
1.7473364554761019	-83.93304584096694	85.680382296443042	25/03/2014 0:00
3.9146667463328981	-85.783707576277038	89.698374322609936	24/03/2014 0:00
12.212368651078691	-88.739893957678419	100.95226260875711	21/03/2014 0:00
21.833903540005053	-93.12245733752394	114.95636087752899	20/03/2014 0:00
-19.287014831883994	-85.992297454857692	66.705282622973698	19/03/2014 0:00
-20.879144588354734	-81.462696486279867	60.583551897925133	18/03/2014 0:00
12.132039563687613	-78.990088916984405	91.122128480672018	17/03/2014 0:00
-16.833932528420235	-72.878645298555625	56.044712770135391	14/03/2014 0:00
28.034721273719754	-80.136343814509416	108.17106508822917	13/03/2014 0:00
9.4387551282025015	-82.943232394661891	92.381987522864392	12/03/2014 0:00
3.2845474249979816	-82.6236399259368	85.908187350934782	11/03/2014 0:00
12.982268642133704	-85.911305824387	98.893574466520704	10/03/2014 0:00
-11.2143229709514	-83.342069187030916	72.127746216079515	07/03/2014 0:00
-1.4398937731992305	-83.850335462981775	82.410441689782544	06/03/2014 0:00
-4.2205744528852733	-82.099147912296473	77.8785734594112	05/03/2014 0:00
-40.578993972938747	-72.498705860123152	31.919711887184405	04/03/2014 0:00
-20.322813091795979	-64.638448358508697	44.315635266712718	03/03/2014 0:00
5.3361871045063936	-68.469101938453832	73.805289042960226	28/02/2014 0:00
6.4617729675384226	-67.651813112665934	74.113586080204357	27/02/2014 0:00
-12.631021334414584	-63.608363165795254	50.97734183138067	26/02/2014 0:00
4.3961010200921464	-64.464701746918763	68.86080276701091	25/02/2014 0:00
15.383647370224651	-68.415515580477177	83.799162950701827	24/02/2014 0:00
-21.044975356152634	-64.180641778372603	43.13566642221997	21/02/2014 0:00
10.75497709970432	-66.036331244370047	76.791308344074366	20/02/2014 0:00
5.0665547910960527	-64.054939207434927	69.12149399853098	19/02/2014 0:00
28.505117093803165	-69.231805485467078	97.736922579270242	18/02/2014 0:00
9.877394287712832	-73.753913762888658	83.63130805060149	14/02/2014 0:00
4.6513277332578582	-74.733882905482744	79.385210638740602	13/02/2014 0:00
-6.6247595666886809	-73.277774964196112	66.653015397507431	12/02/2014 0:00
14.301337854363396	-75.395318216633427	89.696656070996823	11/02/2014 0:00
-11.008836614317431	-71.912164871651669	60.903328257334238	10/02/2014 0:00
2.4033839368185568	-72.732026948523583	75.135410885342139	07/02/2014 0:00
-7.5468764238966628	-68.498928216803506	60.952051792906843	06/02/2014 0:00
-11.168025181976986	-64.014932465730794	52.846907283753808	05/02/2014 0:00
-15.343527737597185	-62.848619149256763	47.505091411659578	04/02/2014 0:00
-7.4433387691729536	-62.667416844692696	55.224078075519742	03/02/2014 0:00
2.8623636416089084	-68.849478009350264	71.711841650959173	31/01/2014 0:00
27.962727623319495	-70.856002380316397	98.818730003635892	30/01/2014 0:00
-11.842832422192544	-66.615160748052347	54.772328325859803	29/01/2014 0:00
15.242740735906239	-68.40939319729091	83.652133933197149	28/01/2014 0:00

23.505092282677992	-66.34938508583258	89.854477368510572	27/01/2014 0:00
-9.831985708142895	-69.144322893455126	59.312337185312231	24/01/2014 0:00
53.135891527237277	-76.774162111979592	129.91005363921687	23/01/2014 0:00
16.876998740694887	-82.278989803660465	99.155988544355353	22/01/2014 0:00
-16.409676676052356	-79.694334636927977	63.28465796087562	21/01/2014 0:00
-13.119507040887697	-78.535214678900729	65.415707638013032	17/01/2014 0:00
13.296953750705086	-81.061645767106711	94.358599517811797	16/01/2014 0:00
11.802977797043638	-82.846910335456812	94.64988813250045	15/01/2014 0:00
-21.667522892716192	-75.203174545042486	53.535651652326294	14/01/2014 0:00
-18.374573762413945	-68.84219032249564	50.467616560081694	13/01/2014 0:00
-0.55529108184566667	-73.487738417847538	72.932447336001871	10/01/2014 0:00
17.959415757371232	-75.298395916849529	93.257811674220761	09/01/2014 0:00
-11.954636648058795	-71.728561290563732	59.773924642504937	08/01/2014 0:00
-20.134836682804291	-70.346857886927978	50.212021204123687	07/01/2014 0:00
20.432997354922122	-73.291349415193906	93.724346770116028	06/01/2014 0:00
-32.226075310054057	-68.76127745880251	36.535202148748454	03/01/2014 0:00
-7.3041281822290216	-64.365941499511962	57.06181331728294	02/01/2014 0:00
-22.533348996709094	-62.118525828180339	39.585176831471244	31/12/2013 0:00
-7.6959784677239327	-59.460023085037164	51.764044617313232	30/12/2013 0:00
15.041742272970112	-62.702049757898749	77.74379203086886	27/12/2013 0:00
2.457146787632837	-64.022119135626781	66.479265923259618	26/12/2013 0:00
14.537839176752414	-65.799191547627061	80.337030724379474	24/12/2013 0:00
11.317627392218753	-65.871057766416868	77.188685158635622	23/12/2013 0:00
-35.915365343937253	-56.329070371443834	20.41370502750658	20/12/2013 0:00
12.571214624019603	-57.792025843201884	70.363240467221488	19/12/2013 0:00
-0.48542534082082511	-57.85722093855577	57.371795597734945	18/12/2013 0:00
-19.139160765870429	-54.802557573962872	35.663396808092443	17/12/2013 0:00
0.68662931149458473	-56.462613582008998	57.149242893503583	16/12/2013 0:00
-3.0440323422695883	-54.968062271836857	51.924029929567268	13/12/2013 0:00
3.5796256719174835	-57.334742370678384	60.914368042595868	12/12/2013 0:00
-4.3777032318689635	-57.726817948510245	53.349114716641282	11/12/2013 0:00
14.884921157759152	-64.268079806646199	79.153000964405351	10/12/2013 0:00
-5.6300667023337496	-65.16699355879382	59.53692685646007	09/12/2013 0:00
-4.4425461504320083	-62.802926497410056	58.360380346978047	06/12/2013 0:00
10.270512109170681	-62.278163052142531	72.548675161313213	05/12/2013 0:00
-6.3450355963397556	-65.431681659260164	59.086646062920408	04/12/2013 0:00
6.5907357849466734	-64.402159672128903	70.992895457075576	03/12/2013 0:00
-11.715789803328505	-61.331526238031756	49.615736434703251	02/12/2013 0:00
16.688989757917682	-63.744259986350301	80.433249744267982	29/11/2013 0:00
-3.9076590946636429	-60.25709580722048	56.349436712556837	27/11/2013 0:00
-7.5855130082479718	-59.929097708245308	52.343584699997336	26/11/2013 0:00
-18.345245486937017	-58.823019822369076	40.477774335432059	25/11/2013 0:00
-11.729375222457804	-55.080262733607583	43.350887511149779	22/11/2013 0:00
1.903591841031357	-53.96185014725927	55.865441988290627	21/11/2013 0:00
-23.444461732552895	-47.402634503464583	23.958172770911688	20/11/2013 0:00

13.560721554098052	-48.38775720177631	61.948478755874362	19/11/2013 0:00
-21.186534230109771	-44.747106244982035	23.560572014872264	18/11/2013 0:00
-2.7629557142301451	-45.822481776735629	43.059526062505483	15/11/2013 0:00
-4.134880218890828	-46.24057043542993	42.105690216539102	14/11/2013 0:00
-16.458586850895244	-42.635314579630716	26.176727728735472	13/11/2013 0:00
-1.1320170402395888	-39.643251414166798	38.511234373927209	12/11/2013 0:00
-0.80602968377928619	-39.966832486678413	39.160802802899127	11/11/2013 0:00
-3.9734140833198808	-39.239216152841209	35.265802069521328	08/11/2013 0:00
-22.086156542199916	-34.368605181682625	12.282448639482709	07/11/2013 0:00
4.223994229154215	-36.199513523370371	40.423507752524586	06/11/2013 0:00
28.207322335535423	-37.482216997955845	65.689539333491268	05/11/2013 0:00
17.814086069652376	-39.16095118495997	56.975037254612346	04/11/2013 0:00
-0.005966659387638628	-38.121468324816419	38.115501665428781	01/11/2013 0:00
3.6906270442539153	-38.303410953072728	41.994037997326643	31/10/2013 0:00
7.842965555394585	-40.775017371725539	48.617982927120124	30/10/2013 0:00
-8.4217588048365997	-38.784941928298053	30.363183123461454	29/10/2013 0:00
16.718943862081801	-41.389339083495486	58.108282945577287	28/10/2013 0:00
-5.5071570659954432	-41.529295315879835	36.022138249884392	25/10/2013 0:00
42.19299837522567	-41.699850698727914	83.892849073953585	24/10/2013 0:00
-6.5331035435032163	-41.658188713427421	35.125085169924205	23/10/2013 0:00
-8.6868125795935498	-42.539452345896677	33.852639766303128	22/10/2013 0:00
-5.722595219941411	-43.129291355351256	37.406696135409845	21/10/2013 0:00
-6.6579767860547463	-40.914618271840368	34.256641485785622	18/10/2013 0:00
-1.4904070724853113	-40.862327572627748	39.371920500142437	17/10/2013 0:00
-1.5354338493226578	-39.33217856955622	37.796744720233562	16/10/2013 0:00
-11.831589776912608	-35.509287337684441	23.677697560771833	15/10/2013 0:00
3.3852982535748311	-36.914404894521965	40.299703148096796	14/10/2013 0:00
-2.2435774617561606	-34.645906259878871	32.40232879812271	11/10/2013 0:00
6.8980179438556206	-34.646876727239146	41.544894671094767	10/10/2013 0:00
-2.0240166919882654	-32.682114197269243	30.658097505280978	09/10/2013 0:00
-7.5846488703331261	-30.797469562790866	23.21282069245774	08/10/2013 0:00
3.4365826012801222	-32.536691768280377	35.9732743695605	07/10/2013 0:00
-6.3956666315671669	-33.358317265265441	26.962650633698274	04/10/2013 0:00
-0.73785383144502248	-33.554041740607829	32.816187909162807	03/10/2013 0:00
6.1737643532511015	-33.764996886653648	39.93876123990475	02/10/2013 0:00
0.19392793271651954	-34.432694169395745	34.626622102112265	01/10/2013 0:00
-5.1705123561042683	-31.915447204335237	26.744934848230969	30/09/2013 0:00
8.4319770566351053	-34.077399710165935	42.50937676680104	27/09/2013 0:00
20.21642619385085	-35.010245891892794	55.226672085743644	26/09/2013 0:00
4.7815675046633714	-34.764572870850429	39.546140375513801	25/09/2013 0:00
5.6045886251775414	-35.585177088357511	41.189765713535053	24/09/2013 0:00
-2.6861402516894941	-35.15653206635443	32.470391814664936	23/09/2013 0:00
-5.257402589257083	-37.238431881661199	31.981029292404116	20/09/2013 0:00
-6.7808263760938985	-39.14591077335092	32.365084397257021	19/09/2013 0:00
6.542402229639606	-40.712892506144613	47.255294735784219	18/09/2013 0:00

-3.9201305819474328	-37.668200133296921	33.748069551349488	17/09/2013 0:00
-0.45638886224014641	-37.537361789629017	37.080972927388871	16/09/2013 0:00
2.1116350088192917	-37.85891975369492	39.970554762514212	13/09/2013 0:00
12.207198460563916	-38.253634737167204	50.46083319773112	12/09/2013 0:00
3.4717396894872081	-39.740333032036517	43.212072721523725	11/09/2013 0:00
26.311334915541579	-41.015871059466122	67.327205975007701	10/09/2013 0:00
21.430918462539978	-40.810078810008804	62.240997272548782	09/09/2013 0:00
-0.32034526003764086	-38.172339685126531	37.85199442508889	06/09/2013 0:00
-3.6142243586309633	-38.142093800095552	34.527869441464588	05/09/2013 0:00
2.0608211454368757	-37.784710105654824	39.8455312510917	04/09/2013 0:00
-26.504345975040735	-35.993135530205166	9.4887895551644306	03/09/2013 0:00
-38.220673279243613	-34.656425207035056	-3.564248072208556	30/08/2013 0:00
3.0512563237473955	-35.684831054180961	38.736087377928357	29/08/2013 0:00
8.6410227853390325	-35.28548838460307	43.926511169942103	28/08/2013 0:00
-6.8353253397946787	-34.896897783479517	28.061572443684838	27/08/2013 0:00
11.00874325699732	-40.446035076075816	51.454778333073136	26/08/2013 0:00
-9.2200231268187167	-41.277439954402325	32.057416827583609	23/08/2013 0:00
49.571734242582068	-41.339783202676131	90.911517445258198	22/08/2013 0:00
7.1658231706969104	-39.089412916767401	46.255236087464311	21/08/2013 0:00
-3.0767984184790294	-38.278924626024889	35.202126207545859	20/08/2013 0:00
6.3685373742781621	-41.151192675760683	47.519730050038845	19/08/2013 0:00
-2.9103337437767891	-40.55510374301906	37.644769999242271	16/08/2013 0:00
-7.6559724748341864	-38.682655629368355	31.026683154534169	15/08/2013 0:00
0.79634787550060082	-41.623287266678176	42.419635142178777	14/08/2013 0:00
-8.803378851454795	-40.373569153672918	31.570190302218123	13/08/2013 0:00
-34.224105770983385	-37.905597096170538	3.6814913251871531	12/08/2013 0:00
-2.3527637242088417	-37.705579875094372	35.352816150885531	09/08/2013 0:00
7.3678108514926635	-40.213865957969745	47.581676809462408	08/08/2013 0:00
17.017803694085728	-38.979214432957747	55.997018127043475	07/08/2013 0:00
16.037972388926619	-40.447634167212016	56.485606556138634	06/08/2013 0:00
7.9131196026124826	-42.133372132008731	50.046491734621213	05/08/2013 0:00
-6.5082274587714437	-43.204650421771817	36.696422963000373	02/08/2013 0:00
6.8758080952162572	-45.612886764773862	52.488694859990119	01/08/2013 0:00
-22.139993591925133	-40.126458400275737	17.986464808350604	31/07/2013 0:00
-2.9573768753678564	-38.999256606687197	36.041879731319341	30/07/2013 0:00
4.1219629974829672	-38.629617744566929	42.751580742049896	29/07/2013 0:00
4.5488491650170317	-41.572121088166284	46.120970253183316	26/07/2013 0:00
8.9449762834197486	-43.025601366279318	51.970577649699067	25/07/2013 0:00
-16.865830054424748	-41.423619123577168	24.55778906915242	24/07/2013 0:00
5.102467600276384	-43.957721793075677	49.060189393352061	23/07/2013 0:00
-1.9530437777507359	-44.101609827671098	42.148566049920362	22/07/2013 0:00
5.1215150844330992	-41.24114583519281	46.36266091962591	19/07/2013 0:00
-76.597913818011648	-41.273899553902709	-35.32401426410893	18/07/2013 0:00
-25.38953302601135	-36.289889499422543	10.900356473411193	17/07/2013 0:00
-24.08370733051413	-30.889478997106494	6.8057716665923635	16/07/2013 0:00

-0.69657146779707091	-30.992637211856334	30.296065744059263	15/07/2013 0:00
4.6006696024147686	-31.660987925908387	36.261657528323155	12/07/2013 0:00
-9.163276337097102	-28.23796769075841	19.074691353661308	11/07/2013 0:00
10.460790350183913	-26.805206800183527	37.26599715036744	10/07/2013 0:00
12.709434824005541	-29.025290070653909	41.73472489465945	09/07/2013 0:00
-10.2446421179406	-26.682456004084173	16.437813886143573	08/07/2013 0:00
-3.2886040611947465	-26.164368734871118	22.875764673676372	05/07/2013 0:00
-1.1273778536370855	-25.972210651001774	24.844832797364688	03/07/2013 0:00
2.6536552366932256	-26.243293410460495	28.896948647153721	02/07/2013 0:00
-10.048113488296877	-25.823189460121995	15.775075971825117	01/07/2013 0:00
-8.7453383272666372	-25.385926982157798	16.640588654891161	28/06/2013 0:00
2.3293844059814717	-25.182855044885002	27.512239450866474	27/06/2013 0:00
-0.58564777235895349	-25.632108619661864	25.04646084730291	26/06/2013 0:00
12.097697880283135	-26.23599537778577	38.333693258068905	25/06/2013 0:00
-9.6192452331104903	-24.479816809477228	14.860571576366738	24/06/2013 0:00
22.053572512898569	-26.373920768039795	48.427493280938364	21/06/2013 0:00
2.5672551060367255	-26.567828419869358	29.135083525906083	20/06/2013 0:00
-9.1551636940810681	-26.156339934436289	17.001176240355221	19/06/2013 0:00
-0.27551460991764998	-27.085698331018648	26.810183721100998	18/06/2013 0:00
-1.8150325166623702	-26.329330943298771	24.514298426636401	17/06/2013 0:00
5.9207887745392327	-26.088418993212485	32.009207767751718	14/06/2013 0:00
1.6466212155243056	-26.586847630801515	28.23346884632582	13/06/2013 0:00
-11.102731523248281	-25.45013237801939	14.347400854771109	12/06/2013 0:00
7.6546554256773902	-25.753123315268283	33.407778740945673	11/06/2013 0:00
-4.2797029150314074	-27.774105186828649	23.494402271797242	10/06/2013 0:00
1.1637579692738882	-28.006868047150078	29.170626016423967	07/06/2013 0:00
4.9168680636838644	-27.019625404256146	31.936493467940011	06/06/2013 0:00
3.7467367147552295	-26.010696957902894	29.757433672658124	05/06/2013 0:00
7.6826103370003693	-28.748453959213265	36.431064296213634	04/06/2013 0:00
-2.5916245090705274	-29.829453429063449	27.237828919992921	03/06/2013 0:00
15.585647140175979	-31.217566178769403	46.803213318945382	31/05/2013 0:00
5.5525871768381876	-33.04772079094289	38.600307967781077	30/05/2013 0:00
-13.69054043221206	-29.076649529392881	15.386109097180821	29/05/2013 0:00
-8.5015942958584105	-28.219712894473076	19.718118598614666	28/05/2013 0:00
12.270277799065695	-27.34578263044483	39.616060429510526	24/05/2013 0:00
-0.12994133800054897	-27.298624373864641	27.168683035864092	23/05/2013 0:00
-5.2395073488223716	-28.106831382528753	22.867324033706382	22/05/2013 0:00
-0.47714150933927613	-28.823981852187956	28.346840342848679	21/05/2013 0:00
0.57732867405991328	-29.569713325405473	30.147041999465387	20/05/2013 0:00
-3.9569614621219102	-28.780989620298385	24.824028158176475	17/05/2013 0:00
12.890330746198686	-29.708580275160102	42.598911021358788	16/05/2013 0:00
4.4938997176138855	-29.612013522300458	34.105913239914344	15/05/2013 0:00
10.936202299110789	-28.667102730003819	39.603305029114608	14/05/2013 0:00
5.3544078894016707	-27.663381239830073	33.017789129231744	13/05/2013 0:00
7.1646288455206104	-27.655520381675387	34.820149227195998	10/05/2013 0:00

0.1409836006431533	-27.657881251967297	27.79886485261045	09/05/2013 0:00
1.977990657754674	-28.521747440555885	30.499738098310559	08/05/2013 0:00
-13.201456516999997	-27.814303983718844	14.612847466718847	07/05/2013 0:00
-7.234847737492089	-27.451175277095047	20.216327539602958	06/05/2013 0:00
-18.663206191464894	-23.900267129972462	5.2370609385075682	03/05/2013 0:00
2.7735046418607112	-24.183928760427023	26.957433402287734	02/05/2013 0:00
4.2376567270993064	-23.836279736360837	28.073936463460143	01/05/2013 0:00

In the following capture (***Figure 5***: Comparison between VAR and PNL for the last year) is possible to appreciate better a comparison between the PNL and the VAR for the last year:

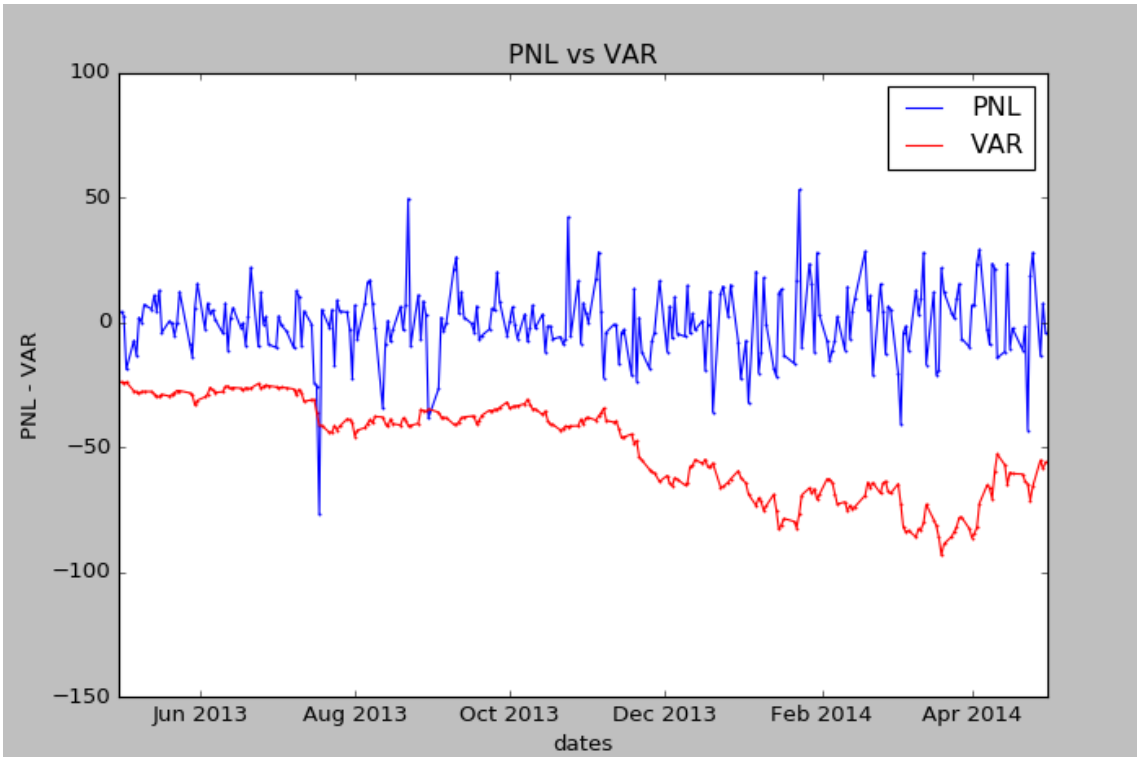


Figure 5: Comparison between VAR and PNL for the last year

The results (exceptions) are shown in the ***Table 11: Results***:

Table 11: Results

Exceptions	2
Dates	2013-08-30 00:00:00
	2013-07-18 00:00:00

Conclusions

Task 1:

Regarding the first task, three two-sample Kolmogorov Smirnov test were performed. The null hypothesis of KM test says that two samples are drawn from the same continuous distribution.

For the first test, the comparison between bac and bac_1 (comparison between first two years and last two years of the returns) has as a result a p-value of 1.2577e-05.

The results of the second and third tests show p-values of 0.406 and 0.193 (comparison between msft and msft_1 values for the second test and aaple and aaple_1 for the third).

Thus, the null hypothesis of KM is rejected for the bac historical series and accepted for the msft and aaple historical series.

Other possible verification could be the comparison between these standardized historical series with a standard normal distribution. Additionally, the Shapiro-Wilk test would be also recommendable.

Task 2:

Considering the second task, the objective was to measure the exceptions quantified by the Backtesting.

For these test, I considered the last year of our portfolio. 252 days were analyzed and the model failed two times. For a VAR at 99% confidence level, we could expect 2.5 exceptions to occur in 252 trading days. Therefore, the model is considered accurate.

Also, taking into account the Basel Traffic Light Approach, a model with less than 5 exceptions in 252 trading days is considered precise. Following this approach, the model is within the green zone.

However, one of the two exceptions exceeded the VAR by far (the one occurred on 18 July 2013). According with the ***Figure 5***: Comparison between VAR and PNL for the last yearthe VAR fluctuates approximately between 25 and 80 negative points. This fact is interesting if we look at the following ***Table*** 12: Comparison between VAR and portfolio price:

Table 12: Comparison between VAR and portfolio price

Actual PNL	VAR	Dates	Portfolio Price
-4.1397290708932815	-56.040944417600969	30/04/2014 0:00	283,95
7.6727784653562026	-58.466026926299406	29/04/2014 0:00	291,63
-13.341186836153213	-55.188674624720221	28/04/2014 0:00	278,28
28.061827277586815	-65.631815605549946	25/04/2014 0:00	306,35
18.632729365675232	-71.20706256365159	24/04/2014 0:00	324,97
-42.988975668701528	-64.581037608890426	23/04/2014 0:00	281,99
-1.6581567347109285	-63.704969100509629	22/04/2014 0:00	280,33
-10.977278669424436	-60.760603749954498	21/04/2014 0:00	269,35

Comparing the VAR with the portfolio price, the highlighted VAR represents a loss of 22.90% of the portfolio. This fact happens for many dates. Therefore, my conclusion is that the model must be revised.

Considerations:

The use of other versions of Spyder can cause the execution of the scripts to fail.

I have considered 250 days in a year instead 252. Regarding the time to maturity, I did not assume it constant.