Portfolios construction with Canadian TSX-60
Financial Market Analytics Project

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Abstract

This project is about the construction of different portfolios starting from the Canadian **S&P/TSX-60** index, which includes the top-60 assets in Canada. Considering a time period of five years, we created a various number of portfolios on the basis of the parameters of the regression "ex-post" equation for the Security Market Line $r_i - r_f = \alpha_i + \beta_i(R_M - r_f) + e_i$ (e.g. with respect to beta coefficient, alpha coefficient or R-squared) and even for some combination of them. Each portfolio has been rebalanced weekly, depending on the parameter considered and the result of the rolling regression (with a time window of 180 days). Then, we analyzed each portfolio created in terms of efficiency.

Contents

1 Introduction

In this work we built and analyzed the performances of 11 different portfolios, with respect to the yields of the assets in the S&P/TSX-60 index [1] over the previous 5 years. We got the data from FactSet [2] and we manually changed the composition of the index, by means of the various news we found on the web ([3][4]). Then, we applied a rolling regression for each asset's log-returns (adjusted for the risk-free rate), using a sample of 180 days. The portfolios were weekly rebalanced and equally weighted. In the end, we computed the returns and the volatility (i.e. the risk) for each portfolio, comparing the results with the index portfolio through tables and charts.

2 Data acquisition

We got the daily asset prices of the Canadian index S&P/TSX-60, which includes the top-60 assets in Canada. The initial data, related to the 12th of July 2022, were taken from FactSet. Then, we researched the various changes in the composition of the index over the previous 5 years. In particular, we found specific documents on the websites [4] and [3]. Finally, we manually checked the various stocks added and removed from the index via [5], whose values have been inserted into the dataset. Moreover, in order to compute the risk-free parameter, we took the daily government bonds rate from [6]. We'll explain this further in the analysis (section 3.2).

3 Data preparation

3.1 Data exploration

The index has a fixed dimension, consequently there are 60 stocks for each day considered. In total, 73 companies have been in the index through the 5 years and 50 assets never left the TSX-60. With regard to the daily prices of the index over the years:

- Mean: 1031.934.
- Median: 979.94.
- Standard Deviation: 134.71.

The stacked-bar chart in Figure 1 shows the actual composition of the index with respect to the various sectors.

3.2 Risk-free rate

At this point, we started to enrich the dataset. Firstly, we added a new column containing the risk-free rate, i.e. the daily government bond rate (5 years), which we retrieved from

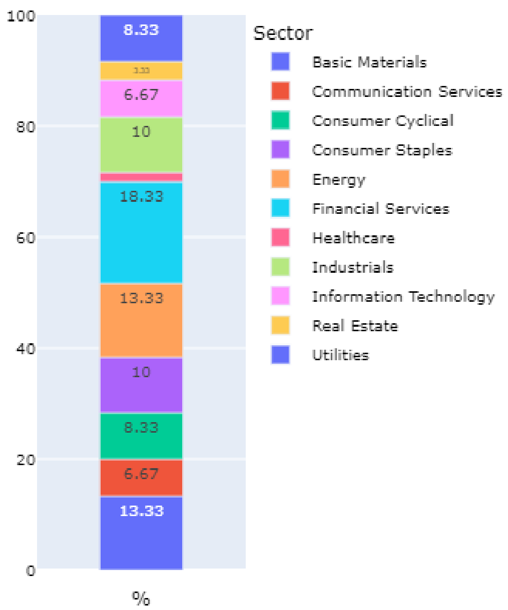

Figure 1: *Sectors proportion (%).*

[6]. However, looking at the time series of the risk-free rate, we noticed that there were a few missing days of data, due to some national Canadian holiday, during which the bonds (and not the stocks) are closed. So, we decided to delete the six rows (out of 1255) corresponding to these days.

3.3 Log-returns

We computed the daily log-returns for each asset, according to the formula $ln(P_{t+1}) - ln(P_t)$. Thus, the resulting dataset has one row less, i.e. 1248. We used these values, adjusted for the risk-free rate, in the rolling regression, explained in the next section.

4 Rolling regression

We performed the rolling regression on our dataset according to the formula $r_i - r_f = \alpha_i + \beta_i(R_M - r_f) + e_i$. We used 180 days as sample, losing the first 180 days of the dataset and deleting those assets with an insufficient number of daily observations (Intact Financial

Corporation (IFC-CA), Hydro One Limited (H-CA), Agrium Inc. (AGU), Potash Corporation of Saskatchewan Inc. (POT)).

We applied the regression over all the assets, storing the resulting data (objects of type OLSResults [7]) in a dictionary, from which we obtained the values of R^2, α and β through the various methods of the related library *StatsModels* [8]. Moreover, the values in the dictionary are already filtered weekly, in order to simplify the subsequent rebalancing operation based on the regression parameters.

5 Parameters selection

We selected various parameters for the construction of the portfolios. In particular, we created a dictionary containing as many keys as the number of parameters to be tested. Each key is associated with the weekly values of the related variable:

- R^2: the ratio between systematic and specific risk, obtained from the regression.
- α: the excess returns, obtained as the intercept of the regression.
- β: the sensitivity of each security to the movements in the overall market, obtained as the coefficient of the regression.
- r_i: the returns of each asset, obtained from the log-returns.
- $\beta^2\sigma_M^2$: the systematic risk, computed as the beta squared times the weekly variance of the market.
- σ_{ei}^2: the specific risk, computed as the weekly variance of each asset contained in the index.
- σ_i^2: the total risk, the sum between the systematic and the specific risk.

Moreover, we combined some of these parameters and added a portfolio with a momentum strategy. We'll explain this further in the following section.

6 Portfolios creation

We composed each portfolio by means of the top-20-percentile of a specific tested parameter. Each portfolio has been rebalanced weekly, with an equally weighted scheme, until the 7th July 2022.

In conclusion, we obtained 11 different portfolios: one for each of the previous 7 parameters, one for the market index itself (also useful as comparison for the other portfolios) and the remaining three have been built on the basis of the following combinations:

- R^2 without the risk-free adjustment: the previous R^2 but without considering the risk-free in the rolling regression equation, which becomes $r_i = \alpha_i + \beta_i R_M + e_i$.
- $\frac{\alpha}{r}$: the ratio between the excess returns and the total returns.
- $R^2\beta$: this product is an adjustment of the R^2 for the beta coefficient, in order to explore the aggressive assets strongly correlated with the market.

Through the selection of the top-20-percentile assets of the returns dictionary, we performed a top-20% momentum strategy.

7 Portfolios evaluation

In order to evaluate the performance of the portfolios, comparing each with the market portfolio, we used the following measures:

- graph of weekly returns;
- estimation of annual returns;
- graph of annual volatility;
- estimation of annual volatility;
- portfolio efficiency.

In the rest of the paper, with *market portfolio* we will refer to the portfolio that invested every week in the market index **S&P/TSX 60**.

7.1 Portfolios returns

In Figure 2 we can see how all the portfolios, except the momentum based one, have a similar main trend in terms of historical returns, that is the same of the market portfolio, with individual variations due to the particular composition of each portfolio. In particular, all portfolios values have a strong decrease in correspondence of firsts months of 2020 and 2022, probably related to the pandemic period and the war in Ukraine respectively. The portfolios built on systematic risk and β have the same values for the returns, but this is a consequence of the fact that the β coefficient itself is an indicator of systematic risk.

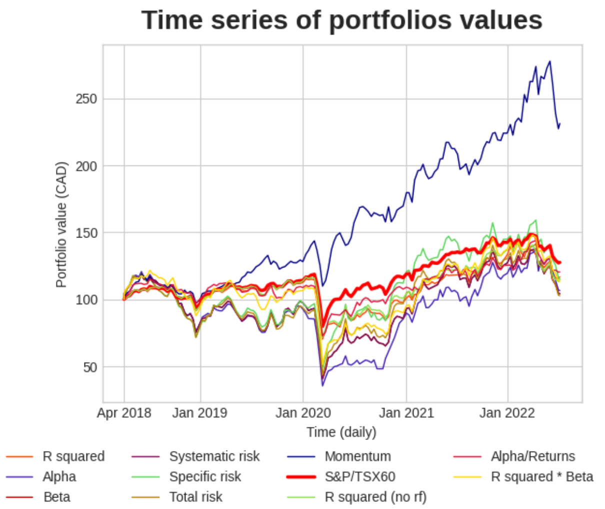

Figure 2: *Time series (returns) of all the portfolios. Notice that the red, bold curve refers to the market portfolio and the colors are the same for every chart.*

We also observe that, as expected, the momentum strategy shows the best performances, while the strategy which performs worse is the one based on the alpha value.

In order to have a clearer understanding of the difference in performances among the various portfolios, we include more graphs, referring to the following parameters categories:

- **regression**: alpha, beta, r-squared, r-squared (not risk-free adjusted):
- **returns**: momentum (top-20% returns);
- **risk**: systematic risk, specific risk, total risk;
- **combinations**: $\dfrac{\alpha}{returns}$, $R^2\beta$.

7.1.1 Regression parameters graph

In Figure 3 it is possible to see how all the portfolios based on the regression parameters perform worse than the market portfolio. In addition, we observe that:

- the portfolio based on the assets with the highest betas amplifies the market portfolio movements (as expected). Also, the one based on the assets with the highest alpha values behaves similarly;
- the portfolio based on the R^2s values behaves very similarly to the market portfolio, especially in the pre-pandemic period;

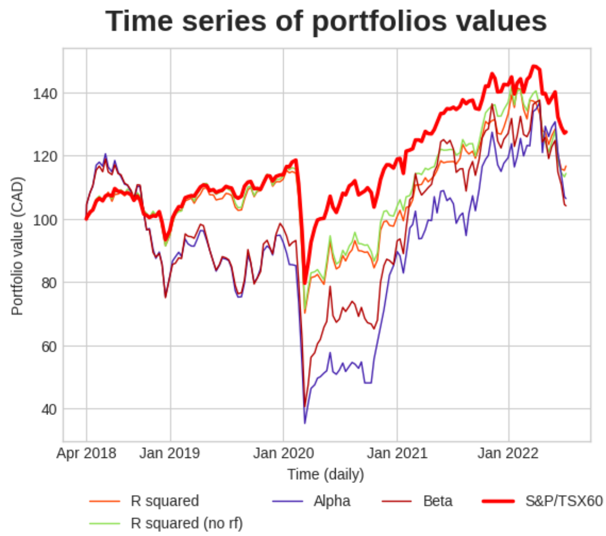

Figure 3: *Time series (returns) of portfolios built on the basis of regression parameters.*

7.1.2 Returns parameters graph

Figure 4 shows a broad superiority of the momentum strategy, compared to the market portfolio. However, the momentum strategy applied in this work is purely theoretical. In fact, as for all the others portfolios, we are considering a weekly rebalancing without transaction costs.

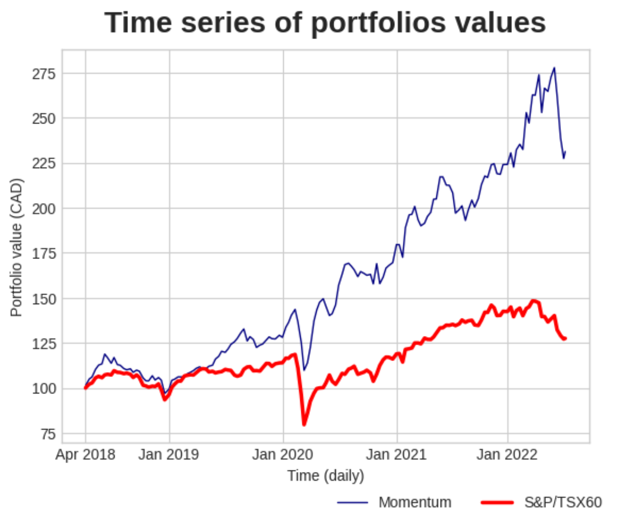

Figure 4: *Time series (returns) of portfolios built on the basis of stocks returns.*

7.1.3 Risk parameters graph

In Figure 5 we observe that the portfolio based on specific risk has better returns than those based on systematic and total risk, especially in the last months.

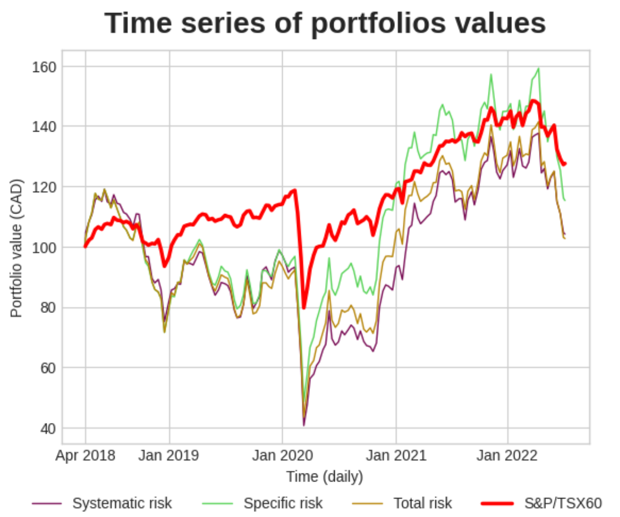

Figure 5: *Time series (returns) of portfolios built on the basis of stocks risk.*

7.1.4 Parameters combinations graph

In Figure 6 we see that the portfolios based on the parameters combinations have a lower value than the one obtained considering the market portfolio. Moreover, we can observe that:

- the portfolio based on the product between the beta coefficient and the R^2 value amplifies the market portfolio movements less than the one based on the only beta, but more than the one based on the only R^2. At the same time it performs better, in the last period, than both the previous two portfolios in terms of return;
- also the portfolio based on the ratio $\alpha/returns$ became less susceptible to market movements than the one based on the only α parameter.

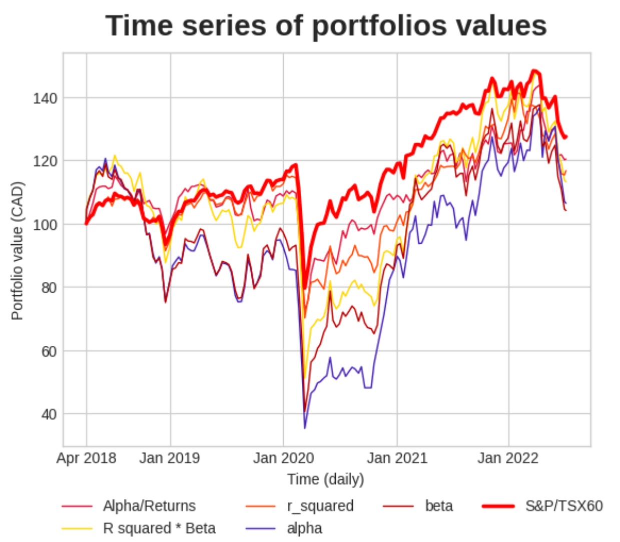

Figure 6: *Time series (returns) of portfolios built on the basis of the parameters combinations.*

7.2 Portfolios volatility

Subsequently, we compared the volatility of the portfolios using the weekly annual estimation graphs.

We report a graph for each category of parameters.

7.2.1 Regression parameters graph

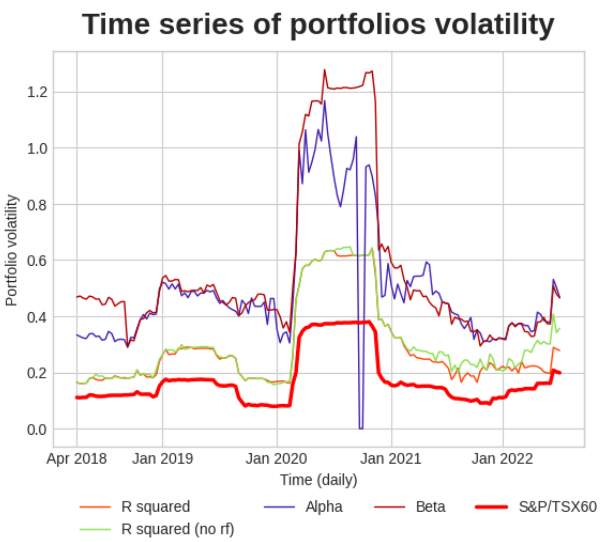

Figure 7: *Time series (volatility) of portfolios built on the basis of regression parameters.*

7.2.2 Returns parameters graph

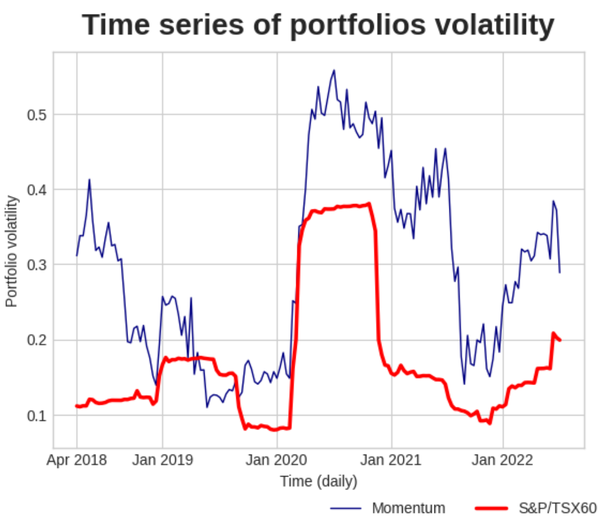

Figure 8: *Time series (volatility) of portfolios built on the basis of stocks returns.*

7.2.3 Risk parameters graph

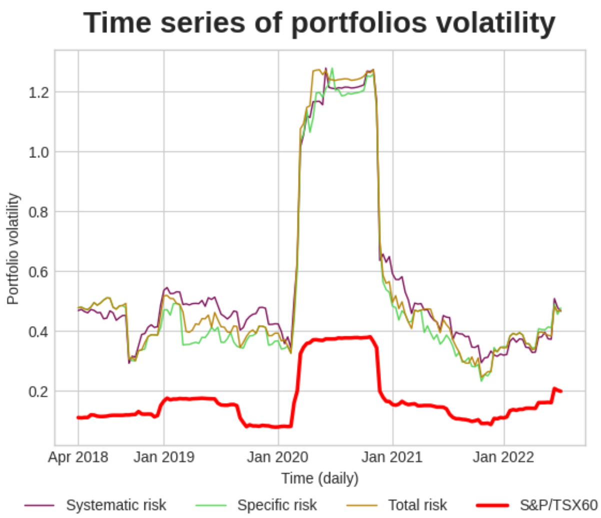

Figure 9: *Time series (volatility) of portfolios built on the basis of stocks risk.*

7.2.4 Combine parameters graph

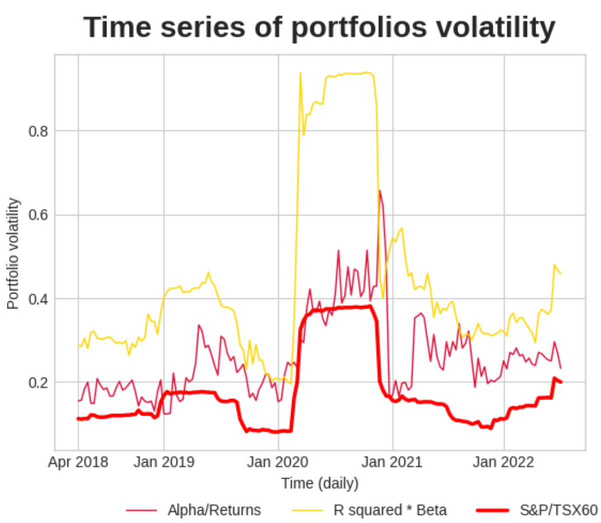

Figure 10: *Time series (volatility) of portfolios built on the basis of the parameters combinations.*

7.2.5 General observations

From the previous graphs we can observe similar properties about the volatility time series of the various portfolios:

1. the volatility of all the portfolios is greater than the volatility of the market portfolio for almost every date. This

agrees with the fact that the market portfolio is the most diversified;
2. as in the returns case, the portfolios respectively built on systematic risk and β coefficient have the same values for the volatility, as we expected;
3. in Figure 7 we can observe a different trend than the previous graphs for what concern the alpha based portfolio. In particular, we see that the value of the volatility occasionally goes to zero. This is a consequence of the fact that only assets with significant and positive alpha values belong to this portfolio. Therefore, in those weeks where the volatility is zero, no investments were made because there was no portfolio with these characteristics. Effectively, we could also observe that in almost all the weeks in which the volatility is different from zero, its value is greater than the value of volatility for the market portfolio.
4. also in the volatility graphs is possible to observe the effects of the COVID-19 pandemic and the Ukrainian war. In particular, we can observe how the volatility of each portfolio increases in the first months of 2020 and 2022.
5. the portfolios with the higher values of volatility, especially during the pandemic period, are those based on: specific risk, total risk, systematic risk and alpha, while the ones with the smaller values of volatility are those based on the values of: R^2, $R^2 norf$ and $\alpha/returns$.

7.3 Portfolio annual estimation and efficiency

The Table 1 below shows the final results for each previously built portfolio. Specifically, the reported values include the annual returns, the annual volatility and the efficiency.

Starting from the weekly return of each portfolio and assuming IID observations, we approximated the annual return (R_A) as:

$$R_A = R_W \times 52. \tag{1}$$

with R_W the average weekly return.
In the same way, we approximated the annual volatility from weekly values through the following formula:

$$\sigma_A = \sigma_W \times \sqrt{52}. \tag{2}$$

Finally, we computed the efficiency of each portfolio by simply dividing the annual return by the annual volatility.

$$Efficiency = \frac{R_A}{\sigma_A}. \tag{3}$$

Thus, the value of the efficiency of each portfolio represents the trade-off between return and risk in the event of an investment in that specific portfolio. The goal is to maximize this value, so, theoretically, we should invest in the portfolio with the highest efficiency.

	1-yr estimations		
Portfolios	Ret.	Vol.	Eff.
TSX-60	**0.083**	**0.172**	**0.479**
α	0.021	0.494	0.043
$Syst.\ risk\ \beta$	0.014	0.563	0.025
R^2	0.053	**0.230**	0.181
$R^2\ not\ adj.$	0.046	0.304	0.150
$Momentum$	**0.285**	0.296	**0.962**
$Spec.\ risk$	0.048	0.528	0.091
$Total\ risk$	0.009	0.549	0.016
$R^2\beta$	0.042	0.445	0.095
$\alpha/Returns$	**0.063**	**0.259**	**0.244**

Table 1: *Portfolios annual estimations (returns and volatility) and efficiency.*

Beyond the considerations regarding return and volatility already expressed in the previous sections, let's point out the values regarding the efficiency of the portfolios through the following observations:

1. as we expected, the best performing portfolio is the one for which we applied the momentum strategy. However, as already stated in section 7.1.2, this does not take into account the transaction costs.

Nonetheless, it is demonstrated that a momentum strategy can overperform the market, so these results (maybe too optimistic) still don't surprise us that much.

2. the momentum strategy outperforms all the other portfolios except for volatility, for which the TSX-60 itself reaches the best performance. Anyway, this result is due to the inherent diversification of the market index.

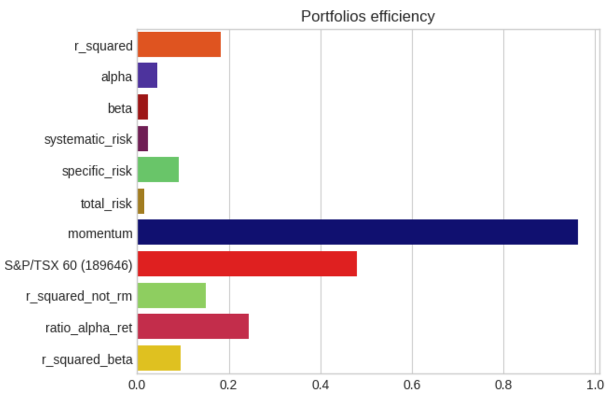

Figure 11

3. the efficiency of the specific risk portfolio is greater than the one regarding the total risk and the systematic risk portfolios;
4. the results regarding the combination between the R^2 with the β and those concerning the α results reach a higher efficiency than the portfolio based on the singular values of the same parameters. In particular, the portfolio based on the ratio $\alpha/returns$ has also an efficiency greater than the one based on the R^2 value.

8 Conclusions

In summary, through the 5-years historical time series regarding the Canadian S&P/TSX-60 market index, we performed a rolling regression on log-returns and analyzed different portfolios, built on the basis of various parameters. Analyzing the final results in the summary table (Table 1), we discovered that the top-3 efficient portfolios are those constructed using as parameters, in descending order, momentum, the index TSX-60 itself and the ratio between excess returns (α) and total returns. These results, as explained in the previous section, seem to make sense. Furthermore, looking at the previous graphs, it is also possible to notice the impact of real events on the market.

Bibliography

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