COLEGIO UNIVERSITARIO DE ESTUDIOS FINANCIEROS

BUSINESS ADMINISTRATION DEGREE

FINAL WORK OF DEGREE

"ECONOMETRICS MODELS FOR THE WEEKLY HIGH AND LOW PRICES FORECAST OF EUROPEAN FIRMS"

Bankinter

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SUMMARY

This article studies the possible predictability of Bankinter stock prices based on their past performance. It tries to expand, as far as possible, the study made by Caporin et al (2013) on the predictability of daily high and low prices. In order to do so, stock market data from Bankinter company is collected and analysed in order to make forecasts used for elaborating a trading strategy that can outperform the simple "buy and hold" strategy.

Key words:

- Market efficiency
- Predictability
- Co-integration
- VEC model
- High, low and closing prices
- "Buy and hold" strategy

1. INTRODUCTION

The purpose of this article is studying the possible predictability of Bankinter stock prices based on their past performance. To carry this out, it tries to extend, as far as possible, the study made by Caporin et al (2013) on the predictability of daily high and low prices. In this study, the authors support the idea that, having co-integration between variables and using a VEC model, prices are largely predictable. And with these predictions they elaborate an investment strategy that can outperform the simple "buy and hold" strategy.

It is possible to extend this study from two perspectives: one, by adding more variables, such as the closing prices, as they can give relevant information for their close relation with high and lows; and including as well a fourth series of values that form the NYSE Composite Index. And another one, by changing the data frequency, collecting data on a weekly basis instead of daily, that despite of gathering less information it provides with less volatility.

Therefore, this article is intended to give answer to the following questions: To what extent are Bankinter stock returns predictable? Can weak and semi-strong efficiencies be accepted? And, is it possible to elaborate with these predictions a trading strategy that outperforms the simple "buy and hold" strategy?

It is structured in the following way: in section 2 it makes a general overview to the literature concerning the predictability of stock prices and the efficiency of the markets; in section 3 it explains what co-integration and VEC models are; in section 4 it displays the empirical analysis and the building-up of the VEC model; and in section 5 it makes a conclusion of the study.

2. PREDICTABILITY OF STOCK RETURNS

The question of predictability of stock returns has important and broad economic implications. Predictability relates directly to the efficiency of the capital markets in allocating resources to their highest valued uses. However, the evidence of its existence as well as the possibility to interpret it constitutes a controversial topic nowadays.

Numerous studies have been made with the aim of explaining this phenomenon and more still have tried to use these theories in order to predict future changes in prices. However, there is no universally accepted theory explaining what is behind these daily price changes.

Before starting with the elaboration of the model, it will be studied the research made by Caporin et al (2013) in which this project is based on. And then, it will be illustrated the theories of two great authors in this field, E. Fama and R. Shiller. Yet defending opposite theories, they both were awarded with the Nobel Prize of Economics in 2013 for their empirical studies on predicting stock prices.

2.1. STUDY MADE BY CAPORIN, RANALDO AND DE MAGISTRIS

The study made by Caporin, Ranaldo and de Magistris (2013) has served as a basis for the survey and empirical analysis of this project. They show that, having co-integration between variables and using a VEC model, high and low prices are largely predictable. For which they build a better strategy in terms of profitability than that of the simple “buy and hold”.

However, the authors were surprised by the lack of attention that high and low prices are given, as they are indeed very important for various reasons: there is a large amount of available historic data about them; many trading techniques are based on support and resistance levels, which are closely related to high and low prices; and they give us a lot of information about transaction costs, market liquidity and information asymmetries.

Their study addresses three questions: Are high and low prices of equity shares predictable? How can we model them? Do forecasts of high and low prices provide useful information to improve TA trading rules?

To answer the first question, they analysed the high and low prices that form the Dow Jones Industrial Average Index over a sample period of 8 years. They find out that high and low prices were co-integrated, which means they tend to go in parallel in the long run even though they sometimes diverge from each other. Therefore, the answer is affirmative; there is evidence of the predictability of high and low prices.

To answer the second question, they use a fractional vector autoregressive model with error correction (FVECM) between high and low prices. They implemented this model because it incorporates the co-integrating relationship between variables, and it captures the range of the data set in the long run, which serves to measure volatility and gives a lot of information. Hence, the answer is affirmative; we can apply a model that captures the fractional co-integration between high and low prices.

To answer the third and last question, they found evidence that the FVECM has a strong forecasting ability, outperforming in this way the benchmark models. They use high and low forecasts to implement a simple trading strategy in order to determine entry and exit signals, obtaining better results in terms of return and riskiness than that of the simple "buy and hold". Therefore, the answer is affirmative; high and low forecasts do improve TA trading rules.

It seems that it exists a period of efficiency, but this efficiency is not total. For this reason, we cannot reject the possibility of forecasting stock returns. As many authors have demonstrated, neither the efficiency is total nor the irrationality.

2.2. MAIN AUTHORS

2.2.1. Eugene Fama

Fama (1965) is most often thought as the father of the efficient-market hypothesis (EMH). An efficient market means that the stock prices reflect all the available information, besides its risk and expectative, so that the stock price matches with its intrinsic value. In an efficient market, price variations are not correlated with each other, that is to say, the past does not give any information about the present or the future.

He popularized the idea that the stock performance in the short run was very difficult to predict, as prices tend to follow a "random walk" or similar processes. This means that:

$$P_t = P_{t-1} + a_t$$

Where P_t is the neperian logarithm of the stock price in period "t", and a_t is the "white noise". Therefore, the best forecast that can be make for the stock price in period "t+1", conditioned to everything known until "t" (Ω_t), is precisely the price in "t":

$$E\,(P_{t+1}/\Omega_t) = P_t$$

According to Fama:

- When the forecast error (a_{t+1}) is not auto-correlated, it is said that there is "weak informational efficiency". This implies that the market immediately incorporates all historic information of the price; so this information provides no added value to the investor.
- When it is in-correlated with all the public information in "t", it is said that there is "semi-strong informational efficiency". The market immediately incorporates the historic and public information of the price; so both types of information do not provide any added value to the investor.
- When it is in-correlated with all type of information, public or private in "t", it is said that there is "strong informational efficiency". The market immediately incorporates all historic, public or private information of the price; so no type of information provides added value to the investor.

Each of these cases imply a certain level of lack of predictability of stock returns. Therefore, if it is unpredictable, it is understood that the market works efficiently. Any

relevant information known today about the future price is immediately incorporated to the price today, thus preventing speculation. See Fama (1988).

However, the fact that the market incorporates information to the prices very quickly does not mean they cannot be predicted. Efficiency and predictability are not incompatibles, especially in the long run. This opportunity of predicting stock prices opens due to the search of information and to a possible incorporation of risk to the price. The higher the risk, the higher the profitability, which can lead to ways of extracting correlations that can help in predicting stock returns.

See Flores (2014).

2.2.2. Robert Shiller

On the other side, Robert Shiller (1980) published an article where he found out that stock prices do not correspond with the actual value of the future dividends discounted to a constant rate. This means that dividends do not change so much as for explaining the great fluctuations and volatility of the stock prices, contradicting what was previously said by Fama.

Like his counterpart Fama, Shiller tried to explain the predictability of stock returns in the long run, but from a very different position. He was one of the inspirations of the theory called "Behavioural Economics", which states that investors occasionally act influenced by social and psychological factors, leading to actions they would not perform if they were rational. This means that investors sometimes behave irrationally when measuring risk, choosing the moments of purchase and sale and predicting returns.

A clear example of this theory are speculative bubbles, which different authors have exposed as one of the reasons of the inefficiency of the market. Malkiel (2016) supports the idea that the existence of bubbles does not mean the market is not efficient, but they are errors that end up being corrected. That is to say, the market always corrects any irrationality, but on his calm and inexorable way.

Shiller also identified and analysed different ratios to explain and predict annual returns such as "dividends/price" or "price/average profit"; using this last as a leading indicator of the formation of speculative bubbles. He warns that the real danger is given when the

price is very high compared with the historic average profits of the stock. See Campbell and Shiller (1988).

However, it is not the idea of predictability of stock returns what concerns Fama and Shiller, but the reason behind it. In fact, there is some consensus between them about predictability, especially in periods of one year or larger; as the bigger the forecast horizon, the better it can be predicted. This may seem unusual because it is well known that as we increase the forecast horizon the error dispersion increases. However, Shiller affirms the existence of reversion to the mean, which means that in the long run prices tend to their mean making them to some extent predictable.

Therefore, the predictability of stock returns exists, but with very little precision. And this precision reduces as we drift away into the future, which shows how difficult is to predict stock returns. However, and taking into account what was previously said, we can conclude that no total rationality nor exuberance exists in the market. See Flores (2014).

2.2.3. Other authors' contributions

According to this point, it is going to be exposed the principle ideas of various researchers that supported both of the authors mentioned above.

On the one side, we have the supporters of Fama and his efficient market hypothesis. Authors such like Mandelbrot (1963) and Samuelson (1965) defended the impossibility of predicting stock prices, and support the idea that in general the market has an efficient behaviour. Fama supporters claimed that rationality, which is what characterizes human beings, make us unconsciously create an efficient market, because everyone acts in a rational way.

In addition, Leroy (1979) and Lucas (1978) showed that the impossibility to forecast stock returns is not a sufficient nor necessary condition for the market to have an efficient behaviour. Therefore, a market can be efficient without the prices following a "random walk".

On the other side, we have the supporters of Shiller and the non-efficiency of the market. Disagreeing with Fama, Grossman and Stiglitz (1980) claimed the impossibility of the existence of a market with strong informational efficiency. Precisely, this is the incentive

for those investors who search that information not assimilated by the market and use it for making operations.

Later on, Black (1986) showed that each investor has its particular characteristics and sometimes goes to the market due to unexpected liquidity needs or to the search of information that can be used to generate profits. Although their behaviour is rational in any of both cases, it could be that the same agent acts in one way at a time and in another way at another time.

It can be concluded that, to some extent, all the opinions are correct, since none of them is universally accepted. Although the market can have an efficient behaviour, some mismatches or inefficiencies may also occur. Therefore, using the appropriate methodology, investors can detect these errors and take advantage of them in order to forecast prices and elaborate trading strategies.

2.3. METHODS FOR FORECASTING PRICES AND TRENDS

Following the hypothesis that the market is not entirely efficient and that stock prices do not follow a "random walk", some methods can be followed by investors to anticipate, with more or less precision, changes in the value of stocks and therefore, "beat the market".

The most common methods when it comes to approaching the stock market are fundamental analysis and technical analysis, but quantitative analysis will be mentioned as well. The objective of these techniques is not about forecasting stock prices but their future trends.

2.3.1. Fundamental analysis

Fundamental consists on evaluating securities by attempting to measure the intrinsic value of a stock. This value is compared to the current market price to determine if it is worth buying because the stock is undervalued, or if it is worth selling because it is overvalued; as the price always tends to its real value. Fundamental analysts study everything that can affect the price, from the overall economy and industry conditions to the financial condition and management of the companies.

2.3.2. Technical analysis

Technical analysis consists on evaluating securities through statistics, using data on market activity such as historical returns, stock prices and volume of trades. Its main assumptions are that: all known fundamentals are factored into the price, thus there is no need to pay close attention to them; prices move following a trend; and the market has memory since prices make movements that will be repeated in the future. Technical analysts use stock charts to identify patterns and trends that suggests what a stock will do in the future. The most popular forms are simple moving averages, support and resistance levels, trend lines, and momentum-based indicators.

Technical analysis uses data from short periods of time, while fundamental analysis relies on information that spans years. Although technical analysis is more common in short-term trading due to its short duration of data collection, it can be a beneficial tool to evaluate long-term investments when combined with fundamental analysis.

2.3.3. Quantitative analysis

Quantitative analysis consists on the evaluation of the historical performance of a company through simple financial ratio calculations, such as earnings per share (EPS) or the discounted cash flow (DCF). The results provide insight into the valuation or historic performance of the stocks, with the aim of finding a statistical advantage in outperforming the market average. But this analysis is not often used as an independent method for evaluating long-term investments, so it is used in conjunction with fundamental and technical analysis instead.

As said before, fundamental analysis is most often used for determining quality of long-term investments; technical analysis is most often used for short-term investment decisions; and quantitative analysis is normally used to evaluate the financial stability of a company. Even though some may prefer one over another to evaluate long-term investments, a combination of all of them is the most appropriate and accurate option.

3. CO-INTEGRATION AND VEC MODELS

3.1. CO-INTEGRATION

Co-integration between two variables X and Y means they have a strong relationship with each other in the long run. This implies that they evolve over time in a synchronized way, and when this happens, more reliable predictive models can be developed.

3.2. VEC MODELS

A VEC (Vector Error Correction) model is a tool used for forecasting series with more than one variable when co-integration exists between each other. It is simply a VAR model in which co-integration relationships have been detected. These multivariate models enable to improve predictability versus univariate models as they use more information, more variables.

VEC model refines the VAR model as it includes variable dynamics adjustment in the short run towards an equilibrium in the long run determined by an unexpected "shock". Therefore, we can affirm that VEC model gives more information than VAR model, especially regarding the information of the adjustment speed. (Fernandez-Corugedo, 2003).

If x_t and y_t are integrated of first order I (1) and they are not co-integrated, a dynamic model in first differences can be estimate, such as:

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta y_{t-1} + y_0 \Delta x_t + y_1 \Delta x_{t-1} + u_t$$

…where u_t has zero mean, given Δx_t, Δy_{t-1}, Δx_{t-1} and additional delays.

Instead, if x_t and y_t are co-integrated with ß parameter, then we obtain additional zero-order integrated I(0) variables that can be added to the previous equation. Being $S_t = y_t - ßx_t$, hence S_t would be I(0) and it is supposed to have zero mean. Thereby, S_t delays can be added to the equation. If it is only included one delay, the equation would be like this:

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta y_{t-1} + y_0 \Delta x_t + y_1 \Delta x_{t-1} + \delta S_{t-1} + u_t$$

…where there is information on all the past values of x and y. Besides, it can also be included a correction error term, $\delta(y_{t-1} - ßx_{t-1})$, leaving the equation like this:

$$\Delta y_t = \alpha_0 + \alpha_1 \Delta y_{t-1} + y_0 \Delta x_t + y_1 \Delta x_{t-1} + \delta(y_{t-1} - ßx_{t-1}) + u_t$$

These type of models are able to study the evolution of the short term relationship between variables x and y. The lag-free model of Δx_t and Δy is considered to be:

$$\Delta y_t = \alpha_0 + y_0 \Delta x_t + \delta(y_{t-1} - ßx_{t-1}) + u_t$$

…where $\delta<0$. If $y_{t-1} > ßx_{t-1}$, the previous period exceeds the equilibrium; because $\delta<0$, the corrector error term works to return and balance. Likewise, if $y_{t-1} < ßx_{t-1}$, the corrector error term induces a positive change and returns it to equilibrium.

To estimate the parameters of a VEC model of this equation we would have to know ß, and the regression of Δy_t on Δx_t and S_{t-1} will be performed, where $S_{t-1} = (y_{t-1} - ßx_{t-1})$.

See Wooldridge (2000).

4. EMPIRICAL ANALYSIS

4.1. DATA

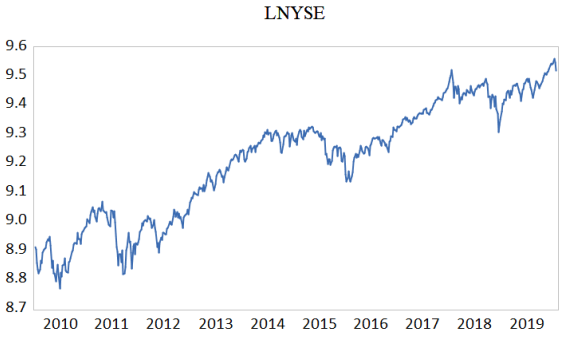
In order to elaborate the VEC model and perform the study of the possible predictability of Bankinter stock returns, past data of the company is collected from 4 January 2010 to 27 January 2020. It is composed of 4 temporary series that correspond to the high, low and closing stock prices of the company, and the last one are values that form the NYSE Composite Index. The data has been obtained from Investing (2020) and it is arranged on a weekly basis.

First of all, raw data is transformed into neperian logarithms, as they induce normality and it is more adequate for stock returns. As it can be seen in the graphs below, the four series (HIGH, LOW, CLOSE and NYSE) are non-stationary, as they show a clear trend.[1]

Graph 1 - Neperian logarithm of the High prices

Graph 2 - Neperian logarithm of the Low prices

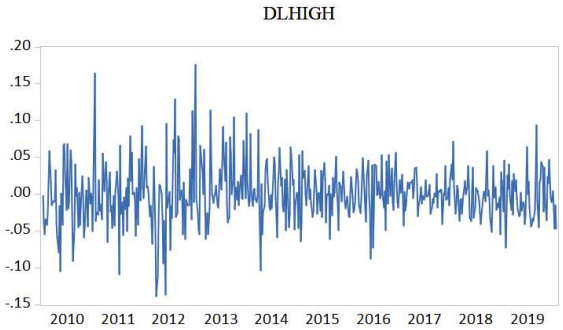
Graph 3 - Neperian logarithm of the Closing prices



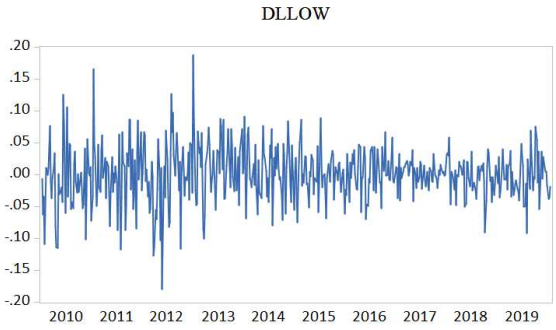
Graph 4 - Neperian logarithm of the NYSE values

[1] All the graphs and tables used in this project are own elaboration by means of Eviews and Excel.

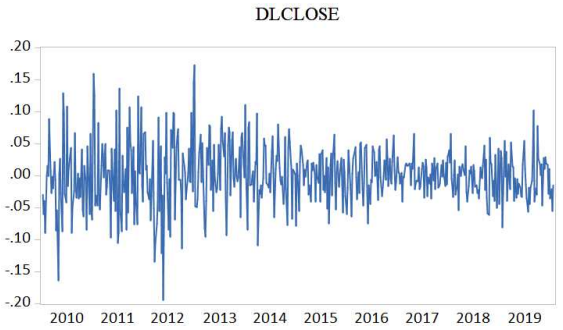
After that, first differences are applied to all the series, turning them into stationary, that is to say, to fluctuate around a mean with constant variance. They can be seen in the graphs below:



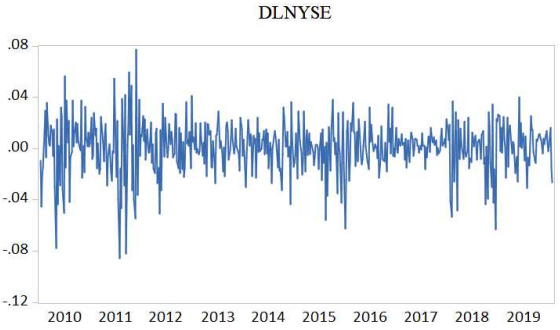
Graph 5 - High prices after 1st difference applied



Graph 6 - Low prices after 1st difference applied



Graph 7 - Closing prices after 1st difference applied



Graph 8 - NYSE values after 1st difference applied

4.2. ARMA MODEL (Weak efficiency)

Now all series are stationary, univariate ARMA models can be used in order to analyse the "weak efficiency", that it to say, to see if the past of each of the series provides information about the present or future of the same series.

According to the ARMA model estimations, the following outcomes come out:

ARMA Model Estimations				
Parameters	∇LHIGH	∇LLOW	∇LCLOSE	∇LNYSE
δ	-	-	-	-
φ_1	0.1498	0.1735	-	-0.0782
φ_2	-	-0.1142	-0.0859	-
φ_3	-	-	-	-0.0597
φ_4	-	-0.0789	-	-

φ_5	-	-	-	-0.0765
R^2	0.0222	0.0415	0.0072	0.0123
P-value (Q_6)	0.914	0.692	0.794	0.708

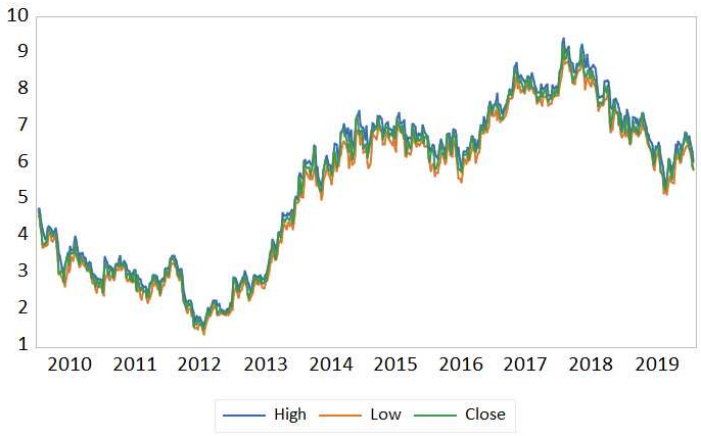
Table 1 - ARMA model estimation made on Eviews

As we can see in the table, the high price in first differences follows an AR (1) with an R^2 of 2.22%. The low price follows an AR (4) with R^2 of 4.15%. The closing price follows an AR (2) with R^2 of 0.72%. And the NYSE values follow and AR (5) with R^2 of 1.23%.

All the R^2 values are below 5%, which means that prices practically follow a random walk, especially for the high and closing prices. The past does not provide information about the present or future, it is "white noise". Therefore, "weak efficiency" cannot be rejected for any of these variables.

However, studying the weak efficiency is not enough, as the series could also depend on the past of other variables, apart from their own past; so "semi-strong efficiency" will be studied as well.

As it can be seen in the graph below, high, low and closing prices move following the same path:



Graph 9 – High, Low and Closing prices of Bankinter company

This similarity indicates the possible existence of one or more co-integrating relations between these 3 variables, which will be studied next.

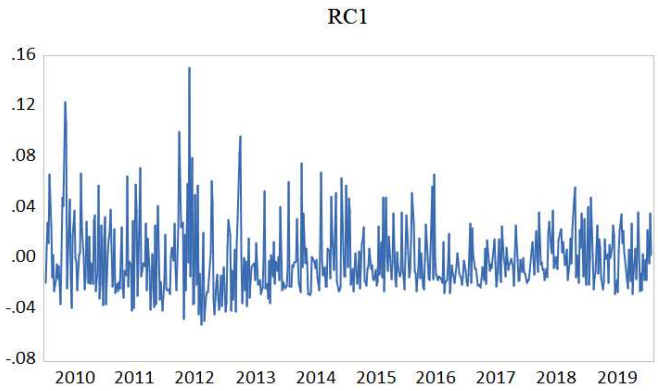
4.3. CO-INTEGRATING ANALYSIS

In order to study the possible co-integration relationships between the high, low and closing prices of Bankinter, the Johansen Test has been performed by means of Eviews.

The resulting co-integrating equations from Johansen Test are the following:

The first co-integrating equation (RC1) is:

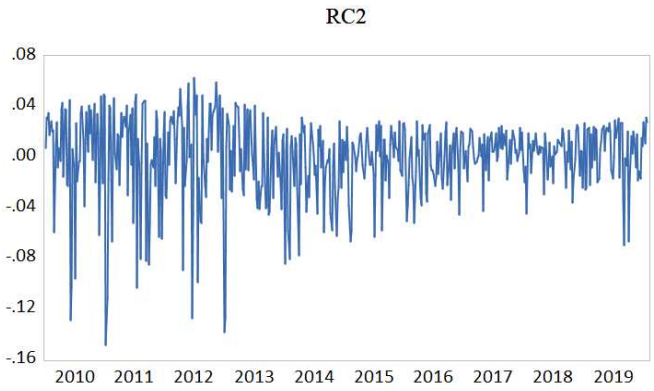
$$RC1 = LHigh - 0.980524*LClose - 0.062891$$



Graph 10 - 1st co-integrating relation

The second co-integrating equation (RC2) is:

$$RC2 = LLow - 1.023911*LClose + 0.074099$$



Graph 11 - 2nd co-integrating relation

This analysis has shown the existence of two co-integrating equations; one between the high and the closing prices, and another one between the low and the closing prices. Now that they both are known, VEC models can be used in order to study the "semi-strong efficiency".

4.4. VEC MODEL (Semi-strong efficiency)

The general VEC model has the form:

$$\Delta y_t = Bz_{t-1} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \ldots + \Gamma_{p-1} \Delta y_{t-(p-1)} + a_t$$

…where Δy_t is a 4x1 vector made up of the 4 stationary variables; z_{t-1} is a 2x1 vector made up of the co-integrating relations; B is a 4x2 matrix of coefficients associated to the co-integrating relations; and Γ is a 4x4 matrix of coefficients associated to the lags of the stationary variables.

In this case, the VECM order is 1, as the VAR order in levels is 2. Therefore, only one lag from each variable will be used for the elaboration of the VEC model.

The results of the model are the following:

VEC MODEL ESTIMATIONS				
	∇LHIGH	∇LLOW	∇LCLOSE	∇LNYSE
C	-	-	-	0.001152
RC1(-1)	-0.840065	-0.291605	-	-
RC2(-1)	-	-0.770007	-	0.051318
∇LHIGH (-1)	-	0.158432	0.210930	-
∇LLOW (-1)	-0.173696	-0.165804	-0.235791	-
∇LCLOSE (-1)	0.128931	-	-	-
∇LNYSE (-1)	-	-	-	-
R^2	**0.401741**	**0.512735**	**0.027991**	**0.006763**
Q-stat (Q6)	3.7698	5.6289	5.9285	7.8533
P-value (Q6)	0.708	0.466	0.431	0.249
S.E. of regression	0.029690	0.029723	0.046290	0.019707
S.D. of dependent variable	0.038312	0.042458	0.046907	0.019755

Table 2 - VEC model estimation made on Eviews

The R^2 from the VEC model indicates the predictability of a variable; how much the past of the variables in the data set explain the present of that variable.

As it can be seen in the table, the R^2 corresponding to high and low variables are pretty high, being around 40% and 50% respectively. This means that the past does affect the present or future of these variables, and therefore, "semi-strong efficiency" cannot be accepted for these two variables.

In the case of closing prices and the NYSE values, both R^2 are very close to zero, indicating they basically follow a "random walk", and therefore, "semi-strong efficiency" cannot be rejected for these other two variables.

Finally, looking at the residuals of each of the series, it can be seen that all of them are "white noise", as the p-values are higher than 5%.

5. CONCLUSION

As it has been shown, this research has answered the issues approached in the introduction as well as the questions raised by Caporin et al (2013).

According to the question of how predictable are Bankinter prices, it can be said that high and low prices are largely predictable, with around 40% and 50% of significance, respectively. While closing prices and NYSE values are not predictable at all.

The weak efficiency cannot be rejected for any of the variables, as it has been shown that all of them seem to follow a "random walk". But, on the other side, semi-strong efficiency cannot be rejected only for the high and low prices, as the past of the data set does affect to some extent the present or future of these two variables, once the risk is depurated.

However, this model has not been able to provide us with suitable predictions in order to elaborate a trading strategy that outperforms the simple "buy and hold" strategy.

The continuation and optimization of this research would consist of simply adding more variables (such as the mean price) that could give additional information.

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