FORECASTING EXCHANGE RATE RETURN BASED ON ECONOMIC VARIABLES

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Abstract
Many studies have proven that exchange rate return is not predictable using random walk tests. In other words, the return is not predictable based on historical returns. But, in this article, we try to forecast the return using publicly available information, and test whether or not it is predictable using a nonparametric test of predictive performance which has been proposed by Pesaran and Timmermann in 1992. For forecasting the return, we used a recursive estimation method in which the parameter estimates were updated recursively in light of new weekly observations, and its regressors were chosen recursively based on the R^2 criterion regarding the statistical significance of all coefficients. The results indicated that the returns of weekly exchange rates of the Canadian dollar, the euro, and the British pound against the US dollar are predictable. Moreover, it was assessed which economic variables are most important in forecasting the returns by counting the number of times that each variable was inserted into the forecasting model.
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1. Introduction

The question of whether asset price changes are predictable has long been the subject of many studies. There is an old joke among economists, about an economist walking the street with his mate. They saw a $100 bill on the ground, and as the mate reaches down to pick it up, the economist says, 'Don't bother, if it was a genuine $100 bill, someone would have already picked it up'. This funny example of economic logic conveys the concept of efficient markets hypothesis (EMH). A market is said to be informationally efficient, if prices in the market completely reflect all the available and relevant information. From this perspective, in an efficient market, price changes only because of the arrival of new information. But, because future information cannot be predicted, it is also impossible to forecast future price changes according to the information set available, so it is not possible to make economic profit using the available information (see Malkiel, 1992). Therefore, EMH can be tested by testing whether price changes are predictable or not.

The origins of the EMH can be found in the works of Fama and Samuelson and Roberts who had been working independently on the issue in the 1960s. It is generally accepted that there are three forms of efficiency depending on the information set Ω_t: *Weak form*: No investor can earn excess returns using historical prices. *Semi-strong form:* No investor can earn excess returns using historical prices and all publicly available information. *Strong form:* No investor can earn excess returns using any information, including historical prices, publicly available information, and private or insider information.

In this article, we first show that the exchange rates returns of the Canadian dollar, the Euro, and the British Pound against the US dollar are predictable using publicly available information; that is, the two

last forms of the EMH are rejected. Then it will be shown which Economic variables contribute most to the prediction of the returns.

The starting point of our samples is around 2007, because the recent global financial crisis, whose initial effects emerged in 2007, has changed international economic relations, and has severely affected financial markets. Therefore, we decided to focus on the foreign exchange market after the crisis.

The remainder of this paper is organized as follows: section 2 describes the methodology which was used for forecasting the returns. Section 3 presents the empirical results. And Section 4 summarizes the article.

2. Methodology

2.1 Proposed method for forecasting

Many articles estimate their forecasting model on the basis of the entire sample of available observations or on subsamples of the data, while in fact, traders can only have access to historical data, that is, they cannot estimate parameters based on the entire sample. In addition, the articles ignore the problem of "model uncertainty", because they use a particular model for forecasting over time, while as time passes, more new information emerge, and the added information may help the trader to improve the forecasting model, so it is not reasonable to use a particular forecasting model with certainty over time. To deal with these two problems, at each point in time, we use only historical data to choose a model according to a model selection criterion, which in this article the criterion is R^2; then one-step-ahead forecasts are computed using the model. This method is done in three step as follows (see Pesaran and Timmermann, 1995, 2000; Amemiya, 1980; Bossaerts and Hillion, 1999):

1) In the first step, the forecasting model is determined: first, there is no additional regressor in the model, then the regressor that maximizes R^2 is added; then the regressor that leads to the largest increase in R^2 is inserted into the model; next each of the two regressors is compared individually with all the variables that are outside the model, and it is checked whether it is possible to increase R^2 by swapping each of the inserted variables with an "outside" variable or not, if it is possible, the "inside" variable is replaced by the "outside" variable; among all of the possible swaps, the swap that result in the largest increase in R^2 is done. After that, if it is possible to increase R^2 by inserting a third variable, the variable that leads to the largest increase in R^2 will be inserted into the model, and so on. This process continues until either it is not possible to increase R^2 more or there would not be any variable left to be inserted into the model, in addition it is necessary to mention that we decided to insert only the regressors which are all statistically significant at the 10% level.

2) After finding the forecasting model in the first step, one-step-ahead is forecasted by the model.

3) The next observation is added to the data set, and again steps 1 and 2 are repeated.

It is obvious that this method requires so many estimations, and we cannot supply the reader the results of the estimations; however, some of the main results are displayed graphically. The results are as follows: 1) The recursively computed values of the correlation between the actual returns and the forecasted returns. 2) The recursively computed values of the root mean square prediction error (*RMSPE*). 3) The directional accuracy of the forecasts (we made a series that takes the value of unity if the direction of change in the log price is forecasted correctly, and zero otherwise. 4) The importance of each regressor, which is identified by the number of times that the lags of the regressor are inserted in the selected model. The more the regressor is inserted, the more important it is in forecasting.

2.2 Statistical tests

2.2.a Non-parametric test of predictive performance

In this subsection and the next one, we explain two statistical tests which are used for assessing predictability. Pesaran and timmermann (1992) proposed a test statistic whose focus is on the correct forecast of the direction of change in the variable under consideration. This test is based on the portion of times that the direction of change in the variable is correctly forecasted Let $\hat{y}$ be the predictor of y, $p_y = \Pr(y_t > 0)$, $p_{\hat{y}} = \Pr(\hat{y}_t > 0)$, and $\hat{p}$ the

portion of times that the sign of y_t is correctly forecasted. The test statistic is

$$PT = \frac{\hat{p} - \hat{p}_*}{(\hat{v}(\hat{p}) - \hat{v}(\hat{p}_*))^{\frac{1}{2}}} \sim N(0,1)$$

Where $\hat{p} = \frac{1}{n}\sum_{t=1}^{n} Sign(\hat{y}_t y_t)$, and $\hat{p}_* = \hat{p}_y \hat{p}_{\hat{y}} + \left(1 - \hat{p}_y\right)(1 - \hat{p}_{\hat{y}})$, and $\hat{v}(\hat{p}) = \frac{1}{n}\hat{p}_*(1 - \hat{p}_*)$, and

$$\hat{v}(\hat{p}_*) = \frac{1}{n}\left(2\hat{p}_y - 1\right)^2 \hat{p}_{\hat{y}}\left(1 - \hat{p}_{\hat{y}}\right) + \frac{1}{n}\left(2\hat{p}_{\hat{y}} - 1\right)^2 \hat{p}_y\left(1 - \hat{p}_y\right) + 4\frac{1}{n^2}\hat{p}_y \hat{p}_{\hat{y}}\left(1 - \hat{p}_{\hat{y}}\right)\left(1 - \hat{p}_y\right)$$

The null hypothesis of the test is that y_t and $\hat{y}_t$ are distributed independently, in other words, $\hat{y}_t$ has no power in forecasting y_t.the 95% and 99% critical values are 1.64 and 2.33 respectively.

2.2.b Testing for zero correlation between the forecasted values and the actual values

In fact, correlation coefficient between the actual returns *r* and the forecasted returns $\hat{r}$ shows the fit of the forecasting model. To test whether the correlation coefficient is statistically zero or not, the following statistics is used:

$$t = \frac{\hat{\rho}}{\sqrt{\frac{1 - r^2}{n - 2}}}$$

Where $\hat{\rho}$ is the correlation coefficient between *r* and $\hat{r}$. Under the null hypothesis of $\rho = 0$, t has a student's distribution with *n-2* degrees of freedom (see chiang, 2003: 291-292).

3. Empirical Results

To see whether the exchange rates returns are predictable using publicly available information or not, we used weekly observations on USD/CAD and EUR/USD and their associated economic variables from December 15, 2006 to July 22, 2011 (a total of 241 weeks). But, for forecasting GBP/USD and its associated economic variables, we used weekly observations from March 9, 2007 to July 22, 2011(a total of 229 weeks). The first forecast of each return was computed in April 3, 2009, and the observations before this date were used as a preliminary "training" period for estimation. It may be useful to mention that the starting point of GBP/USD was decided to be different from the others, because it leaded to a larger *PT* test statistic. Perhaps it is because different countries have reacted to the recent financial crisis at different points in time. The economic variables which are in Table 1 were first transformed, and then they were used for computing one-step-ahead forecasts of the returns of the exchange rates (see Chen & Chen, 2007; Ehrmann & Fratzscher, 2005; Lien, 2009: 165-207). All variables except Libor rates were transformed like $X_1 = \log$(six-week Moving average of *x* at *t*)-log(six-week Moving average of *x* at *t-4*), and Libor rates were transformed like $X_2 = (\mathrm{LiborY_t} - \mathrm{LiborY_{t-4}}) - (\mathrm{LiborX_t} - \mathrm{LiborX_{t-4}})$. For example, when we want to forecast the USD/CAD returns, LiborX=Libor of CAD, and LiborY= Libor of USD, GBP, CHF, etc.

Table1. Regressors

Exchange rate	Regressors
USD/CAD	Initial jobless claims(-1 to -5), Gold(-1 to -4), Oil(-1 to -4), Copper(-1 to -4), Dow Jones industrial(-1 to -4), S&P_TSX(-1 to -4), USD Libor(-1 to -5), Frank Libor(-1 to -5), JPY Libor(-1 to -5), GBP Libor(-1 to -5)
GBP/USD	Initial jobless claims (-1 to -5), Gold(-1 to -4), CCI(-1 to -4), COPPER(-1 to-4), Dow Jones industrial (-1 to -4), FTSE(-1 to -4), USD Libor (-1 to -5), CAD Libor (-1 to -5), Frank Libor (-1 to -5), JPY Libor (-1 to -5)
EUR/USD	Initial jobless claims(-1 to -5), CCI(-1 to -5), Oil(-1 to -5), Gold(-1 to -5), Copper(-1 to -5), Dax(-1 to -5), Cac(-1 To -5), Dow Jones industrial (-1 to -5), USD Libor (-1 to -5), CAD Libor(-1 to -5) Frank Libor (-1 to -5), GBP Libor (-1 to -5), JPY Libor(-1 to -5)

Notes: Dow Jones industrial, FTSE, S&P TSX, CAC, DAX are respectively the national stock indices of the USA, the UK, the Canada, the France, the Germany; Libor is the 12-month London Interbank Offer Rate; CCI is Continuous Commodity Index; Initial jobless claims is a leading indicator of Unemployment in the USA. Oil is Brent Crude Oil Spot Price; Gold is gold spot price; and Copper is copper spot price.

As it can be seen in Table 2, all Pesaran-Timmermann (PT) test statistics are well above 2.33, the 99% critical value for a one sided test. In other words, the returns are predictable at all conventional levels. In addition, all sample correlation coefficients between r and $\hat{r}$ are statistically significant at all conventional levels. The last column shows the proportion of times the sign of the returns is correctly predicted.

Table2. Non-parametric Statistic of Pessaran-Timmermann (PT)

Exchange rate	PT	p-value of the PT test statistic	Correlation coefficient	p-value for the null of zero correlation	proportion of correct signs %
USD/CAD	3.304	0.000	0.356	0.000	66.1%
EUR/USD	2.922	0.002	0.274	0.002	63.63%
GBP/USD	2.426	0.008	0.296	0.001	61.16%

See Figures 1 and 2 for a graphical representation of the forecasting accuracy of the model from the perspectives of direction and magnitude respectively, as it can be seen in Figure 1, the directional accuracy of the model for all currencies is approximately uniform over time, but the recursively computed values of the RMSPEs have tendency to decrease. Therefore, the magnitude of the one-step-ahead forecasts gets closer to the actual values over time; in other words, the forecasting model gets better from the perspective of the magnitude of forecast as time passes.

Figure 3 shows the recursively computed values of the correlation coefficients between the actual returns and the forecasted returns. As it can be seen from panel a, which is for the USD/CAD returns, the correlation stabilizes approximately after the 56th forecast, and it takes a value of 0.356 at the end of the sample. Panel b which is for the EUR/USD returns shows that the correlation stabilizes approximately after the 92th forecast, and it takes a value of 0.274 at the end of the sample. And finally Panel b which is for the GBP/USD returns shows that the correlation does not seems to tend to stabilize, it seems that it tend to increase slowly.

Figure 4 shows how many times the lags of a variable were inserted in the model, the more the variable is inserted, the more important it is in forecasting. Panel a of Figure 4 shows that the most important variables in forecasting the USD/CAD returns are respectively GBP Libor, Copper, USD Libor, Oil, CHF Libor, S&P TSX, JPY Libor, Initial jobless claims, Gold, and Dow Jones Ind. Panel b shows that the most important variables in forecasting the EUR/USD returns are respectively USD Libor, Copper, CHF Libor, CAC, Dow Jones Ind., Oil, JPY Libor, Initial jobless claims, GBP Libor, CCI, Gold, DAX, CAD Libor. And finally panel c shows that the most important variables in forecasting the GBP/USD returns are respectively CHF Libor, Copper, CAD Libor, USD Libor, CCI, Gold, Dow Jones Ind., JPY Libor, FTSE, Initial jobless claims. Therefore, the influence of each variable is different on each exchange rate. For example, the most important variable in forecasting the USD/CAD returns is “GBP Libor”, while the most important variable in forecasting the EUR/USD returns is “USD Libor”.

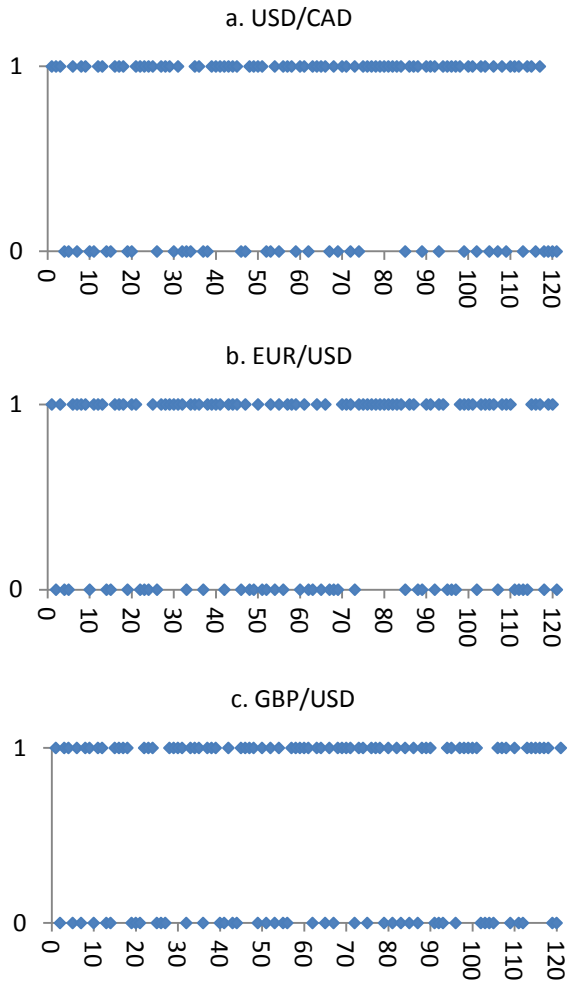

Figure1. Frequency of Correctly Predicted Signs of Returns

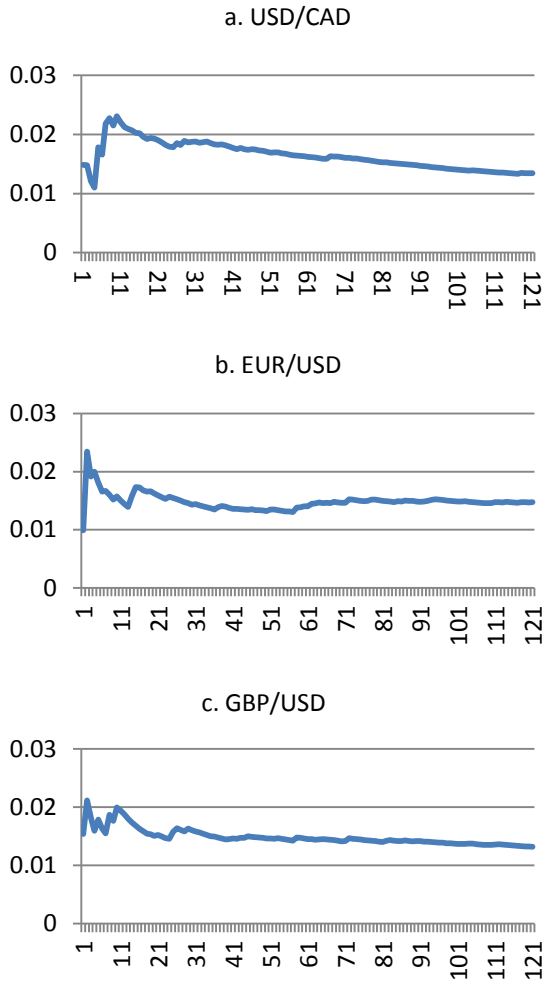

Figure2. Root Mean Square Prediction Errors

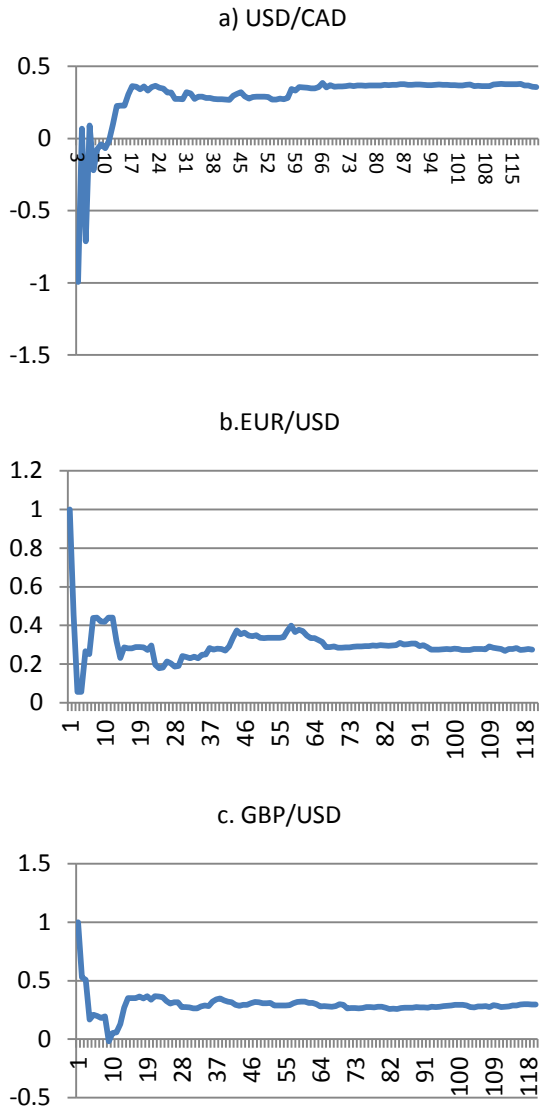

Figure3. Correlation coefficients between the actual returns and the forecasted returns

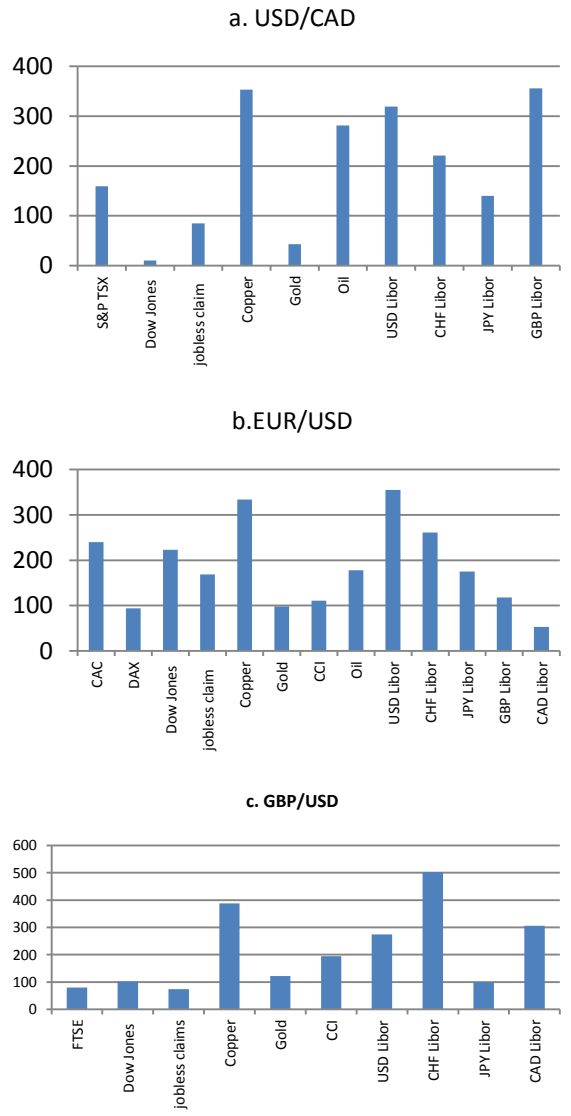

Figure4. Number of times where regressors are included in the forecasting model.

4. Conclusion

In this article, we examined predictability of weekly exchange rates of the Canadian dollar, the euro, and the British pound against the US dollar using publicly available information after the recent global financial crisis in 2007. The one-step-ahead forecasts of the returns of the exchange rates were computed using publicly available information by a recursive estimation method in which the parameter estimates were updated recursively in light of new weekly observations, and also its regressors were changed recursively according to the R^2 criterion. Then predictability was tested using a nonparametric test of predictive performance which has been proposed by Pesaran and Timmermann in 1992. The results showed that the returns are predictable. Moreover, the most important variables in forecasting the returns were determined and it was shown that the influence of each regressor is different on each exchange rate.

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