QUANTITATIVE METHODS IN ECONOMICS
Vol. XV, No. 2, 2014, pp. 252 – 260

THE APPLICATION OF DISCRIMINANT ANALYSIS IN FORECASTING OF INVESTORS' REACTION TO MACROECONOMIC NEWS ANNOUNCEMENTS

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Abstract: Macroeconomic news announcements, particularly concerning the U.S. economy, have a significant impact on stock markets. Recent studies show that stock prices react significantly as soon as macroeconomic news is announced. However, the strength of the reaction and its duration depends on the market and on the news announced. In this paper, we study the applicability of discriminant analysis in the prediction of direction of changes of the main indices of stock exchanges in Warsaw and Vienna after release of the Employment Report by the U.S. Bureau of Labor Statistics.

Keywords: macroeconomic news announcements, intraday data, discriminant analysis, nonfarm payrolls

INTRODUCTION

Every day, stock markets are deluged by a variety of news. Among them, announcements of macroeconomic news describing the state of economies seem to be most important because they impact whole stock markets. European stock markets are mainly influenced by news announcements from European economies and from the U.S. economy. However, only U.S. macroeconomic news announcements are released during trading hours of European stock markets. News from European economies are mainly released before opening of stock markets or after their closure. This fact and the place of the U.S. in the global economic

[1] Financial support for this paper from the National Science Centre of Poland (Research Grant DEC-2012/05/B/HS4/00810) is gratefully acknowledged.

system is the main reason of the importance of U.S. macroeconomic news announcements for investors on European stock markets. It is also a source of strong and immediate impact of U.S. macroeconomic data on stock prices on European stock markets.

The impact of U.S. macroeconomic news announcements on European stock markets was first studied (and confirmed) on developed European markets. Nikkinen and Sahlström [Nikkinen and Sahlström 2004] study the impact of monthly announcements of CPI, PPI and Unemployment Rate on German and Finnish stock markets. On the basis of daily data from January 1996 to December 1999 they show that both markets react only on announcements of U.S. data while they remain unaffected by domestic macroeconomic news announcements. The strongest reaction on the both markets is observed when UR or PPI is announced.

Nikkinen et al. [Nikkinen et al. 2006] extend the above results and show differences in reaction to U.S. macroeconomic data announcements between emerging and developed markets in various parts of the world. Among others, Nikkinen et al. conclude that European developed markets strongly react to news about the American economy, particularly to announcements about inflation and employment situation. On the other hand, the reaction of European emerging markets, including Poland is insignificant.

Quite different result is presented by Gurgul et al. [Gurgul et al. 2012] who examine the effect of U.S. macroeconomic data announcements solely on the Warsaw Stock Exchange. They show that information about CPI and Industrial Production significantly affects daily returns of the WIG20 (the main index of the WSE), but there is no visible reaction to Unemployment Rate announcements. The insignificant impact of UR announcements on the WSE is probably due to different interpretation of unemployment rate during expansion and contraction periods (see for example [Andersen et al. 2007]).

The abovementioned paper deal with daily data, however, application of intraday data allows to more detailed description of stock market reaction to U.S. macroeconomic data announcements. For example, Andersen et al. [Andersen et al. 2007] show significant impact of unexpected news on high-frequency stock, bond and exchange rate data in U.S., Germany and UK. Significant reaction of intraday returns on European stock markets is also confirmed by Harju and Hussain [Harju and Hussain 2011] who examine five-minute returns of the CAC40, DAX, SMI and FTSE 100. One of the conclusion of Harju and Hussain is that the impact of U.S. macroeconomic data is immediate. Significant changes in returns are observed in the first five minutes after news announcements. The strongest impact is implied by Unemployment Rate and Durable Goods Orders announcements. Similar results for five-minute returns are presented by Będowska-Sójka [Będowska-Sójka 2009] who examines reaction of the CAC40, DAX and WIG20. Also Gurgul et al. [Gurgul et al. 2013] show strong and immediate reaction of the WIG20 in the first five minutes after U.S. macroeconomic data

announcements. However, they indicate that the strongest reaction is observed after Nonfarm Payrolls announcements.

Analysis of more frequent data, i.e. 1-minute returns of the DAX index, allows Dimpfl [Dimpfl 2011] to prove that investors on the FSE react to U.S. data in the first minute after a news release and the significant reaction is observed in the first 10 minutes. Similar conclusion for the Polish stock market is presented by Gurgul and Wójtowicz [Gurgul and Wójtowicz 2014].

All the abovementioned papers prove significant impact of U.S. macroeconomic news announcements on European stock markets. In fact, investors react as soon as news is released. This significant reaction is observed after announcements of variety of macroeconomic indicators describing the U.S. economy. However, Andersen et al. [Andersen et al. 2007] underlines the importance of Nonfarm Payrolls announcements. This is also confirmed by the results for the Warsaw Stock Exchange [Suliga and Wójtowicz 2013, Gurgul et al. 2013, Gurgul and Wójtowicz 2014].

It is natural to ask if stock prices reaction to U.S. macroeconomic data announcements (its direction or strength) can be predicted and what variables should be applied to ensure correctness of such prediction. In this paper we examine whether investors' reaction on the Warsaw Stock Exchange and on the Vienna Stock Exchange can be forecasted on the basis of announced news about the U.S. labor market. More precisely, we apply discriminant analysis to predict the direction of changes in stock market indices implied by announcements of the Employment Report. This study will show whether such prediction is feasible and what is its effectiveness. The analysis of both stock markets, the WSE and the VSE, also allows us to compare results for emerging market and small developed market.

The structure of this paper is as follows. Next section describes the data under study. Empirical results are presented and discussed in the third section. Short summary concludes the paper.

DATA

Nonfarm Payrolls (NFP) is one of the macroeconomic indicators included in the Employment Report published monthly by the U.S. Bureau of Labor Statistics. The other important indicators in the report are: Unemployment Rate (UR), Average Hourly Earnings (AHE) and Average Workweek (AW). The Employment Report is usually released on first Friday of the month at 8:30 EST (Eastern Standard Time) i.e. at 14:30 CET (Central European Time). However, due to differences in introduction of the Daylight Saving Time in the U.S. and Europe some of the announcements (in November) are released at 13:30 CET.

The Report describes the U.S. labor market in the month prior to release date. Thus, its importance comes from the fact that it is released at the beginning of the month and its publication precedes other macroeconomic data

announcements. It is usually first official publication in the month that describe such important aspect of economic situation in U.S. Thus, values of other macroeconomic indices (e.g. about inflation of production) can be partially forecasted on the basis of information contained in the Employment Report.

The Employment Report contains four main macroeconomic indicators. Each of them describes different aspect of the U.S. labor market and its changes can be differently interpreted by investors depending on the situation of the U.S. and global economy. However, as indicated by [Suliga and Wójtowicz 2013] on the example of the Warsaw Stock Exchange, investors' reaction is in line with unexpected news about NFP. The other indicators in the Report (AW, AHE and UR) play less important role in determining stock prices changes.

Unexpected news is the difference between announced value of an indicator and its expected value approximated by consensus forecast published by news agencies few days before the announcement. Released value of NFP greater than consensus is good news and in general it implies positive reaction of investors and increase in stock prices. On the other hand, NFP smaller than expected is bad news and is followed by negative returns.

The analysis in this paper is based on the Employment Report announcements released between January 2009 and December 2013. The whole sample contains 56 announcements released on trading days on the WSE and 57 announcements released on trading days on the VSE. We also consider consensus published by Bloomberg a few days before an announcement. Bloomberg publications contain consensus value of each indicator together with consensus range (minimum and maximum). In the whole dataset for the WSE good news was released 27 times and bad news was also released 27 times. In two cases announced value of NFP was identical with consensus. In the case of the VSE there are 28 good and 27 bad news announcements.

In order to study the predictability of investors' reaction to NFP announcements on the WSE and the VSE we apply intraday data. The ATX, the main index of the VSE, is quoted every second, but the WIG20 is quoted every 15 seconds. Hence, to make results for both markets comparable, the analysis in the paper is based on 15-sec log-returns of the ATX and WIG20. This also allows us to take into account the fact that stock markets react immediately to U.S. macroeconomic news announcements.

The Employment Report is usually announced at 14:30 CET and thus the first return when new information can be observed is computed at 14:30:15 on the basis of index prices at 14:30:00 and 14:30:15. To shortly characterize the impact of unexpected news about NFP on the WIG20 Figure 1 presents means of cumulative returns of the WIG20. To simplify the description we restrict our attention only to news announced at 14:30. Cumulative returns R_t are calculated every 15 seconds between 14:30 to 16:00 according to the formula:

$$R_t = 100(lnP_t - lnP_0),$$

where P_0 is the value of the WIG20 at 14:30 and P_t is the value of the WIG20 at time t. These cumulative returns describe the behavior of the WIG20 relative to the moment of news release. Means presented in Figure 1 are computed in two clusters: "good news" when announced the value of NFP was greater than consensus and "bad news" when the value of NFP was smaller than expected.

Figure 1. Means of cumulative returns of the WIG20 implied by good and bad news about NFP in the period January 2009 - December 2013.

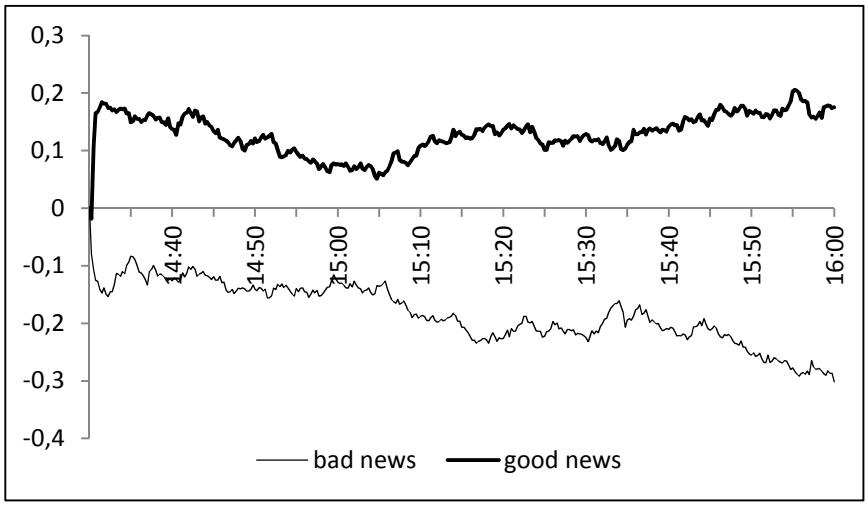

Figure 1 confirms the immediate reaction of the WIG20 to NFP announcements. The change in means of cumulative returns is observed as soon as news is released. Means of cumulative returns implied by good news quickly increases to reach 0.18% at 14:32. Then the impact of good news seems to disappear. After about 40 minutes cumulative returns stabilize. Similarly, very fast and strong reaction of the WIG20 is also observed after bad news announcements.

EMPIRICAL RESULTS

In order to describe more precisely the reaction of the WIG20 and ATX to NFP announcements and to make it more readable we restrict our attention to cumulative returns computed in the following horizons after news release: 15 seconds, 30 seconds, 1 minute, 5 minutes, 10 minutes, 20 minutes. When an announcement is released at 14:30 these cumulative returns are computed at: 14:30:15, 14:30:30, 14:31, 14:35, 14:40 and at 14:50. Additionally, we consider cumulative returns from the moment of news release to the end of a trading session. Reaction to news announcement is positive when cumulative return at given time horizon is greater than zero. Otherwise, the reaction is seen as negative.

There is no need to consider separate class of neutral reaction, because only one cumulative return under study is equal to 0.

NFP is the most informative indicator included in the Employment Report. Hence, forecast investors' reaction after the Report release only on the basis of value and consensus of NFP. Each announcement is described by four variables. First of them is the actual value of NFP published by the Bureau of Labor Statistics. The other three are values published by Bloomberg before news release: consensus value, consensus minimum and consensus maximum. The difference between the last two values describes the accuracy of the estimation of NFP made by market experts. It is also a measure of a discrepancy between investors' expectations about the future value of NFP.

In order to evaluate predictability of investors' reaction we apply discriminant analysis to construct appropriate classification functions and then validate them. We describe the analysis procedure in detail in the case of the WSE. For each time horizon under study the procedure is as follows. From the whole sample of 56 4-dimensional vectors containing described above data associated with the announcements we randomly generate the subsample of length 46. This is a training set. In the case of the VSE, the training set contains 47 elements. Remaining 10 data will be applied later. On the training set we perform linear discriminant analysis and construct linear classification functions. Independent variables are: value of NFP, consensus, consensus minimum and consensus maximum. The grouping factor is a reaction of investors (positive or negative) described by the sign of cumulative returns computed on given time horizon. Then, on the basis of 10 remaining data that were not used to estimate classification functions we compute classification matrix. It contains numbers of correctly and incorrectly classified data from testing set and it describes the predictive validity of the classification functions. Because we have very limited dataset we repeat the whole above procedure 200 times. It means that for each time horizon we perform 200 discriminant analyzes and verify them on the basis of 2000 randomly chosen data. This allows us to compute posterior probabilities of correct classification to each group. They describe what is the probability that announcement classified as implicating positive (negative) investors' reaction really implies positive (negative) cumulative returns at given time horizon.

Table 1 presents the results of discriminant analysis performed accordingly to described above procedure. For each market index under study and each time horizon we report two probabilities that forecast of negative (positive) investors' reaction is correct. As a comparison we report also percentage of correct naive forecast that good (bad) news implies positive (negative) cumulative returns. Comparison of corresponding probabilities indicates that in the case of the WSE the applications of discriminant analysis to forecast the WIG20 changes impied by release of the Employment Report gives, in general, more adequate results than naive forecasts based only on the comparison of announced NFP value with its

consensus. In the case of the ATX, similar results hold true only when negative changes are forecasted.

Application of discriminant analysis is the most efficient when changes in the WIG20 in the first 15 seconds after news release are forecasted. The estimated posterior probability of a correct forecast is equal to 0.92 and 0.898 for negative and positive investors' reaction, respectively. The probability of correct prediction decreases when its horizon increases. In general, prediction about closing prices is more certain when the naive method is applied. However, prediction of changes in market indices under study even in a 20-minute period after news announcements is correct in about 75% of cases.

Table 1. Posterior probabilities of correct classification when cumulative returns are calculated on the basis of index prices at the time of announcement.

time horizon	discriminant analysis				naive prediction			
	WIG20		ATX		WIG20		ATX	
	negative reaction	positive reaction	negative reaction	positive reaction	negative reaction	positive reaction	negative reaction	positive reaction
15 sec	0.920	0.898	0.813	0.759	0.815	0.741	0.704	0.750
30 sec	0.875	0.845	0.868	0.825	0.778	0.778	0.741	0.821
1 min.	0.837	0.787	0.892	0.777	0.741	0.815	0.778	0.821
5 min.	0.847	0.785	0.722	0.743	0.667	0.704	0.630	0.750
10 min.	0.813	0.827	0.709	0.708	0.593	0.815	0.667	0.750
20 min.	0.747	0.690	0.754	0.742	0.667	0.667	0.667	0.750
close	0.642	0.598	0.606	0.617	0.704	0.593	0.741	0.679

Practical applications of the results from Table 1 may be questioned because prediction is made at exactly the same moment as U.S. data are published and all the information may not yet be available. To resolve these doubts we also perform classification 15 seconds after news announcements. In this case cumulative returns are computed relative to index prices at 14:30:15 (at 13:30:15 when news is released at 13:30). Results of this analysis are presented in Table 2 together with naive classification. When analyzing the posterior probabilities in Table 2 we must take into account that stock markets reacts immediately to U.S. macroeconomic data announcements. It is very well visible in Figure 1. The average of WIG20 returns in the first 15 seconds after good news announcements is about 0.11%. In the same period after bad news announcements the WIG20 decreases about 0.08%. These are the large portions of the total changes implied by the announcements under study. Hence, after 15 seconds from an announcement changes in stock market indices are much slower and cumulative returns stabilize.

In general, the probabilities of correct predictions in Table 2 are smaller than the corresponding probabilities in Table 1. However, there is still over 70% chance that the forecast of the WIG20 behavior made in 10-minute horizon will come true.

It is particularly important when we take into account that significant impact of U.S. macroeconomic news announcements is observed only in few minutes after news release. Similarly to results in Table 1, the quality of predictions decreases when time horizon increases. However, in the case of the WIG20, application of discriminant analysis in short horizon gives better results than naive prediction. When the behavior of the ATX is predicted, discriminant analysis outperforms naive method only when negative reaction is forecasted. When positive changes of the ATX are predicted it is still better to simply compare NFP value with its consensus.

It is worth noting here that the posterior probabilities of correct classification presented in Tables 1 and 2 for the WIG20 and the ATX are quite close. Predictions of cumulative returns computed on the basis of index prices at the moment of the announcements are more certain in the case of the WIG20. On the other hand, better results for the ATX are observed when the analysis starts 15 seconds later. This difference is mainly due to slower and weaker reaction of investors on the Vienna Stock Exchange.

Table 2. Posterior probabilities of correct classification when cumulative returns are calculated on the basis of index prices 15 seconds after news release.

time horizon	discriminant analysis				naive prediction			
	WIG20		ATX		WIG20		ATX	
	negative reaction	positive reaction	negative reaction	positive reaction	negative reaction	positive reaction	negative reaction	positive reaction
1 min.	0.758	0.708	0.795	0.789	0.667	0.704	0.667	0.786
5 min.	0.645	0.677	0.673	0.710	0.593	0.556	0.593	0.786
10 min.	0.699	0.744	0.677	0.722	0.593	0.741	0.593	0.750
20 min.	0.643	0.582	0.700	0.657	0.630	0.593	0.667	0.679
close	0.514	0.473	0.591	0.581	0.630	0.593	0.704	0.679

In order to verify that NFP is the best explanatory variable among macroeconomic indicators published in the Employment Report we repeat the above analysis also for consensus and announced values of AW, AHE and UR. None of them, however, give better results than NFP. In majority, posterior probabilities of correct forecast are even smaller than naive prediction.

CONCLUSIONS

This paper analyses applicability of discriminant analysis to predict the behavior of investors after announcements of the Employment Report. The Report is one of the earliest publications of the month that describe the U.S. economy. Hence investors around the world pay special attention on it. As indicated by empirical studies announcements of the Report implies immediate and very strong

reaction of stock markets. This reaction is mainly in line with unexpected news about Nonfarm Payrolls contained in the Report.

On the basis of data from January 2009 to December 2013 we show that reaction of investors on the Warsaw Stock Exchange and on the Vienna Stock Exchange can be successfully predicted on the basis of consensus published by news agencies and on the basis of released value of Nonfarm Payrolls. The best results are obtained when prediction is performed in the moment of news release. Significant reaction to U.S. macroeconomic news announcements is observed in first few minutes after news release. Hence, we study the performance of forecast on very short horizon. From the analysis presented in the paper it follows that the probability of a correct forecast of investors' behavior up to 20 minutes after the Employment Report announcements is greater than 0.7 on each of the market under study.

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