UNIVERSITA' DEGLI STUDI DI PADOVA

DIPARTIMENTO DI SCIENZE ECONOMICHE ED AZIENDALI "M.FANNO"

CORSO DI LAUREA IN ECONOMIA

PROVA FINALE

"RESPONSE OF U.S. BUSINESS CYCLE INDICATOR TO FINANCIAL UNCERTAINTY SHOCKS "

RELATORE:

CH.MO PROF. EFREM CASTELNUOVO

LAUREANDO: RICCARDO CALABRETTA

MATRICOLA N. 1160881

ANNO ACCADEMICO 2019 – 2020

Index

Abstract

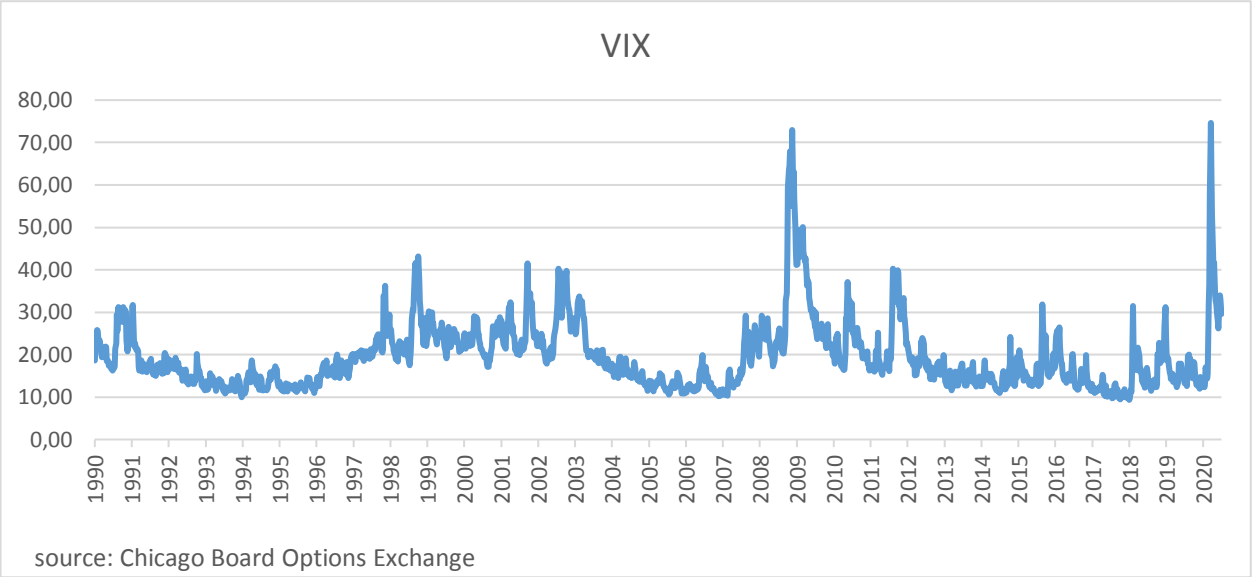
Il presente lavoro intende fornire, attraverso un'analisi empirica, un modello che metta in luce la possibile relazione tra la volatilità finanziaria (utilizzata qui come approssimazione del grado di incertezza nell'economia) e un indice di attività economica americano, il Weekly Economic Index, e, nel caso tale relazione sussista, costruire un modello autoregressivo che sia il più preciso possibile in modo da prevedere, anche attraverso la volatilità finanziaria, il presente valore del suddetto indice. Innanzitutto l'elaborato, dopo aver adeguatamente spiegato in cosa consiste e come si ricava il Weekly Economic Index, si concentra nello studiare, attraverso un modello autoregressivo, la relazione che sussiste tra il suddetto indice e un altro indice della volatilità finanziaria (VIX, fornito dal Chicago Board Options Exchange). In seguito ai risultati ottenuti, l'analisi prende in considerazione due ipotesi riguardo a possibili problematiche che potrebbero minare la validità del modello econometrico: una distorsione dovuta al campione di dati preso in considerazione (cioè quello che include anche il periodo della pandemia) e una distorsione da variabili omesse. Per verificare la seconda ipotesi l'analisi si inoltra nel trovare modelli più precisi e meglio specificati attraverso l'inserimento sequenziale di altre variabili indipendenti all'interno della regressione (come il tasso di interesse nominale, l'inflazione ecc.), valutando caso per caso se la nuova variabile inserita modifichi in maniera significativa il modello, aumentandone la capacità predittiva; mentre per verificare la prima ipotesi la medesima analisi viene ripetuta in una maniera del tutto analoga considerando un campione più ristretto che esclude i dati raccolti durante il periodo della pandemia. E' infatti necessario considerare che questo lavoro viene svolto e scritto in un momento di profonda instabilità globale e incertezza non solo economica, ma anche politica. Alla fine dell'analisi ivi riassunta, l'elaborato giunge alle conclusioni per le quali sia una distorsione dovuta al campione preso in considerazione, sia una distorsione da variabili omesse, influenzavano il modello di partenza, e quindi viene costruito un modello che elimina le distorsioni menzionate e permette non solo di evidenziare chiaramente quale sia la relazione tra VIX e WEI, ma anche di prevedere il valore corrente del Weekly Economic Index, attraverso VIX ed eventualmente altre variabili, con un'ottima precisione. Per costruire e analizzare i modelli di regressione si è utilizzato il software statistico R.

1. The aim of this essay

The recent covid-19 pandemic has forcefully posed policymakers in front of a difficult issue: taking decisions (e.g. about monetary and fiscal policy) in real time without having a clear picture of where the economy was. This issue is due to lags in the release of data on GDP, consumption, unemployment and so forth, which make real time decisions aimed at stabilizing the business cycle complicated. A recent paper[1] proposes a weekly indicator of the US business cycle (Weekly Economic Index) with the intent of rendering timely information on the US business cycle more promptly available to policymakers. Not much is known, however, on the possible predictors of the Weekly Economic Index (WEI). The aim of this essay is to evaluate the response of WEI to financial uncertainty shocks, and to do so it is necessary to verify whether the value of the WEI is caused or at least correlated with financial volatility[2]. In fact, given that financial volatility is one of the first economic indicators that change when there is an economic shock, it might be useful to study in deep how strong it affects the real economic activity in real time or in a short period, since, as we said, the main (and actual) problem for policymakers is to react as quickly as possible in response to shocks and in absence of complete data. If such relation between financial volatility and WEI is found, then the former could be useful to detect and react to drops in economic growth more rapidly. Eventually, we may add further variables that could help to forecast the value of the WEI together with financial volatility even more precisely.

To measure the financial volatility we are going to use a proxy called VIX, one of the most popular indices of Chicago Board Options Exchange (CBOE) to quantify the stock market's expectation of volatility based on S&P 500 index options. Naturally, it should be expected that when there is a negative economic or financial shock (such as fall of the demand, big defaults in financial markets, drop in oil prices) the VIX rises up (and therefore there is more financial uncertainty). That is exactly what data show us, as it can be seen in the graph below.

[1] DANIEL J., L., MERTENS, K., STOCK H., J., 2020. *Monitoring Real Activity in Real Time: The Weekly Economic Index*. Liberty Street Economics, Federal Reserve Bank of New York.
[2]CASTELNUOVO, E., 2019. *Yield Curve and Financial Uncertainty: Evidence Based on US Data*. Marco Fanno Working Paper Series



The graph starts in 1990 and ends in July 2020. The two peaks coincide with the crisis of 2008 and with the covid-19 crisis in 2020, so it is quite evident that financial uncertainty and volatility are negatively correlated with economic growth and good performances of the stock markets. In the next paragraphs we are going, in particular, to precisely explain the correlation between WEI and VIX indices, that is the main goal of this work, and then we will specify whether it is possible to predict the value of the WEI not only from the VIX, but also from other macroeconomic indicators, building up econometric models through an empirical analysis. Our approach will be empirical because we are going to use data series collected during a long period of observations and we are going to interpret the outcomes of the regressions we will build. We do not know yet what the results will be, but we will proceed through various attempts until we will find a satisfactory model that is able to forecast the value of the WEI with a good precision and adaptation to real data.

2. The Weekly Economic Index

The Weekly Economic Index provides a signal of the current status of the US economy, giving a summary of ten underlying data series that compose, in their aggregate, the value of the WEI. This index is released, as the name suggests, every week. The WEI was developed recently by Daniel J. Lewis, an economist at the Federal Reserve Bank of New York; Karel Mertens, senior economic policy advisor at the Federal Reserve Bank of Dallas; and James H. Stock, professor of economics at Harvard University.

The WEI measures the real economic activity using timely and relevant high-frequency data, representing the common component of ten different daily and weekly series. The ten underlying series may in turn be classified into three categories: consumer behavior, labor market conditions and production[3]:

CONSUMER BEHAVIOUR

1. **Redbook Research (same-store retail sales average)**: Measures year-over-year same-store sales growth for around 9,000 general merchandise stores in the United States.
2. **Rasmussen Consumer Index**: constructed with a daily survey of 1,500 American adults, using questions about personal finances and the economy more broadly.

LABOR MARKET CONDITIONS

3. **Unemployment insurance (Initial claims)**: reports the number of people making new unemployment insurance claims from state unemployment offices.
4. **Unemployment insurance (Continuing claims)**: reports the number of people making unemployment insurance claims for a continuing spell of unemployment from state unemployment offices.
5. **American Staffing Association Staffing Index**: tracks temporary and contract employment with data coming from a large pane of staffing companies.
6. **Federal withholding tax collections**: measures Treasury receipts of income and payroll taxes withheld from paychecks, filtered and adjusted for policy changes.

PRODUCTION

7. **Raw steel production**: estimates the weekly production of raw steel from domestic producers.

[3] https://www.dallasfed.org/research/wei/series

8. **Electric utility output**: measures electricity output for the United Sates (Alaska and Hawaii are not included).
9. **U.S. fuel sales to end users**: estimates gasoline, diesel and jet fuel sales to retailers and end users.
10. **U.S. railroad traffic**: tracks total freight transported, as reported by railroad companies to the Association of American Railroads.

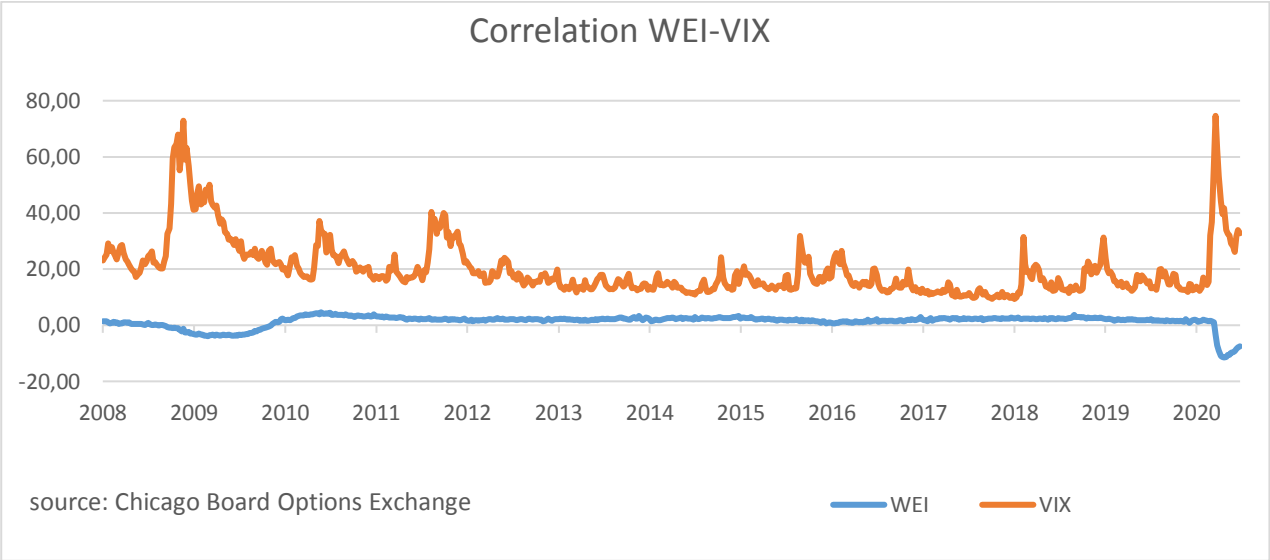
A fundamental question that arises here concerns the aggregation of these series, namely how the input series are transformed in order to be in comparable units to each other. The units for Redbook retail sales and the tax withholding series are year-on-year percentage changes, so that there should not be created problems of aggregation; as for the rest, the other series are converted into comparable units by taking 52-week log changes, thus it is possible to compare and aggregate the different data to form the final Weekly Economic Index we are interested in.

The most important characteristic and, at the same time, advantage of the WEI is that, unlike most common indices, it offers a prompt, early and well-timed illustration of the economic trend in the present or in a short and quasi-immediate term, while many other indices are available only long time after the reference period has ended[4]. This feature is very important especially at this particular time, when the course of the events, the shocks and therefore the economic trends may change abruptly and hence counter-cyclical economic policy measures are to be implemented in response without delay.

[4] McCRAKEN, M., 2020. *COVID-19: Forecasting with Slow and Fast Data*. Federal Reserve Bank of St. Louis On the Economy blog, April 3.

3. Correlation between VIX and WEI

In the previous paragraph it was assumed that financial volatility is correlated somehow with the contemporary status of the economy. As it is said, we are going to use the WEI as a proxy for the status of the economy, and, therefore, we will now focus on the study of the correlation between VIX and WEI indices.



It is evident, from the graph, that there is a certain degree of correlation between WEI and VIX[5], in fact we notice that when the WEI goes down, the VIX simultaneously increases, as it was expected. If we take into consideration the whole sample shown in the graph, the Pearson correlation coefficient between VIX and WEI is equal to -0.5826426: there is therefore a quite strong and negative correlation between the Weekly Economic Index and financial volatility. However, the correlation might not be so clear, especially during periods of "calm" when there is no turmoil. In fact, if we take a sample that considers data only from 02/01/2010 to 25/01/2020, the correlation coefficient is 0.2165684: positive and weak. In order to check whether the overall correlation is significant, we ought to run a model that relates the two indices.

Let us start from the simple linear regression:

$$WEI_t = c + VIX_t + \varepsilon_t$$

Where:

[5] On the relation between uncertainty and business cycle: BLOOM, N., 2014. *Fluctuations in Uncertainty*. Journal of Economic Perspectives, 28 (2), 153-76

- WEI_t is the dependent variable, the Weekly Economic Index;
- VIX_t is the independent variable, the financial volatility;
- c is the constant;
- ε_t is the error term.

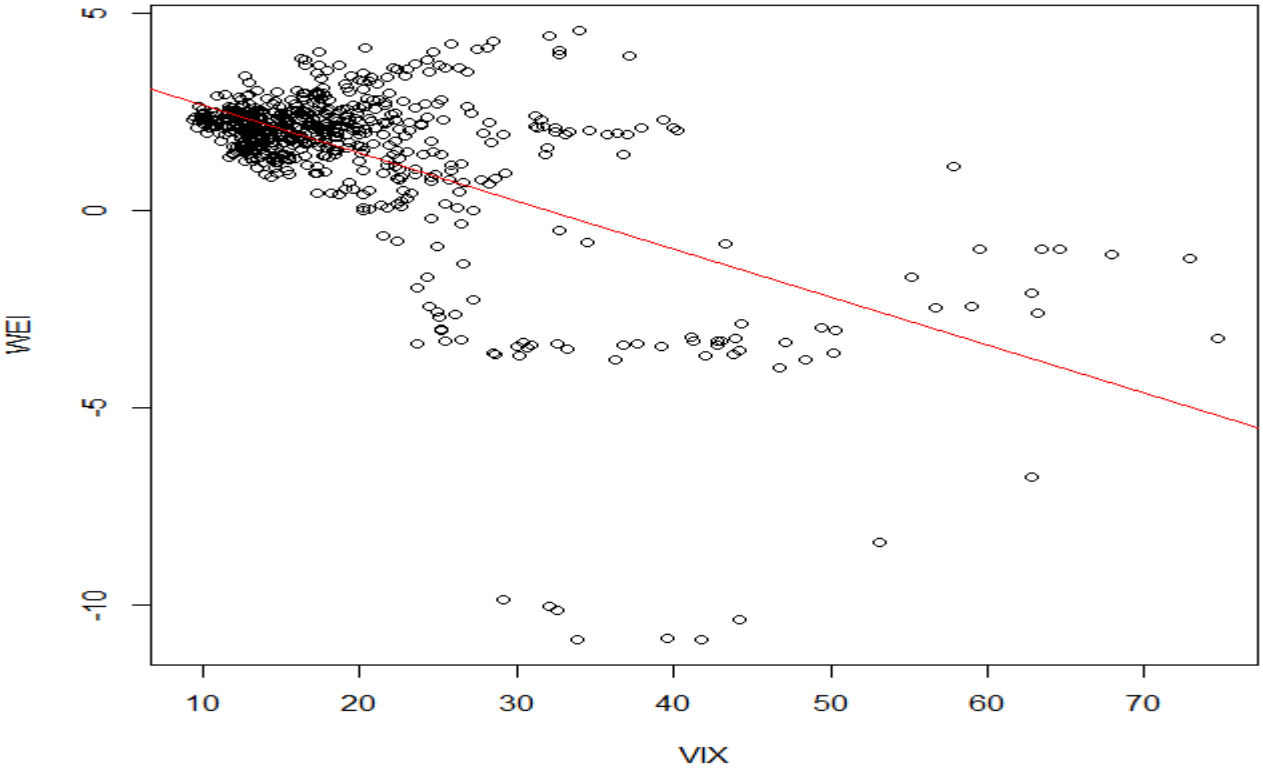
Using the method of Ordinary Least Squares (OLS), with a number of observations of 647 (from 05/01/2008 to 23/05/2020), we obtain the following result:

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.913470   0.148637   26.33   <2e-16 ***
VIX         -0.122013   0.006701  -18.21   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.691 on 645 degrees of freedom
Multiple R-squared:  0.3395,    Adjusted R-squared:  0.3384
F-statistic: 331.5 on 1 and 645 DF,  p-value: < 2.2e-16
```

The negative sign of the VIX points out that there is a negative correlation between financial volatility (and therefore uncertainty) and economic growth[6]. We immediately notice that both the intercept and the VIX are significant according to the t-test and that the F-statistic is major than the p-value (and therefore the coefficients are significantly different from zero). However, the multiple R-squared is quite low, which means that a high proportion of the variance for the dependent variable is not explained by the independent variable, and this is clearly visible from the scatter plot of the two

[6] To study in deep: BLOOM, N., 2009. *The Impact of Uncertainty Shocks*. Econometrica, May 21; CAGGIANO, G., CASTELNUOVO, E., GROSHENNY, N., 2014. *Uncertainty shocks and unemployment dynamics in U.S. recessions*. Journal of Monetary Economics; LEDUC, S., LIU, Z., 2016. *Uncertainty shocks are aggregate demand shocks*. Journal of Monetary Economics; BASU, S., BUNDICK, B., 2017. *Uncertainty Shocks in a Model of Effective Demand*. Econometrica.

variables.



This might be explained by the presence of autocorrelation between the dependent variable, WEI_t, and its lagged values, for example WEI_{t-1}, WEI_{t-2}, WEI_{t-3}...

This means that the present value of the WEI is likely to be influenced and partially determined also by its past values (a phenomenon that occurs in many economic models or variables, for instance in inflation and in the Phillips curve). Consequently, it is necessary to implement an autoregressive model analysis, namely a regression that considers also the lagged values of the variables to capture the interdependencies among multiple time series.

4. Autoregressive model relating WEI to VIX

It was said that in order to make the regression more specified (and, so, more capable to predict the real value of WEI), it is necessary to insert also other variables representing the lagged values of WEI. We should introduce the lags until they become not significant. We could start from the following regression:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + \varepsilon_t$$

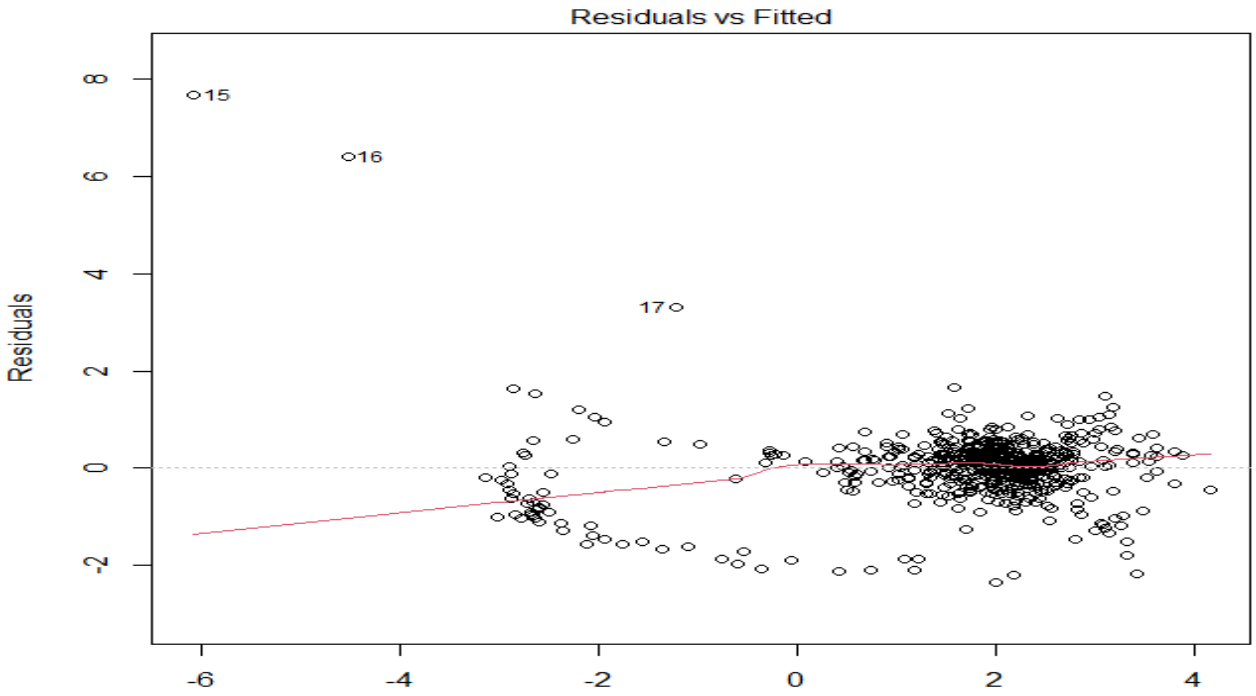
Where WEI_{t-1} and WEI_{t-2} are respectively the 1-week and 2-week lagged values of the WEI.

As it was done before, we use the OLS method and then we apply the Newey-West estimator as a HAC, such that the conditions of the OLS will be respected and to neutralize the possible presence of heteroscedasticity and autocorrelation in the error term. Thus with the OLS we obtain:

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.582830   0.102702   5.675 2.12e-08 ***
VIX         -0.012136   0.003831  -3.168  0.00161 **
WEI1         0.936349   0.030785  30.416  < 2e-16 ***
WEI2        -0.140776   0.022025  -6.392 3.20e-10 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.7067 on 629 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.8021,    Adjusted R-squared:  0.8011
F-statistic: 849.6 on 3 and 629 DF,  p-value: < 2.2e-16
```

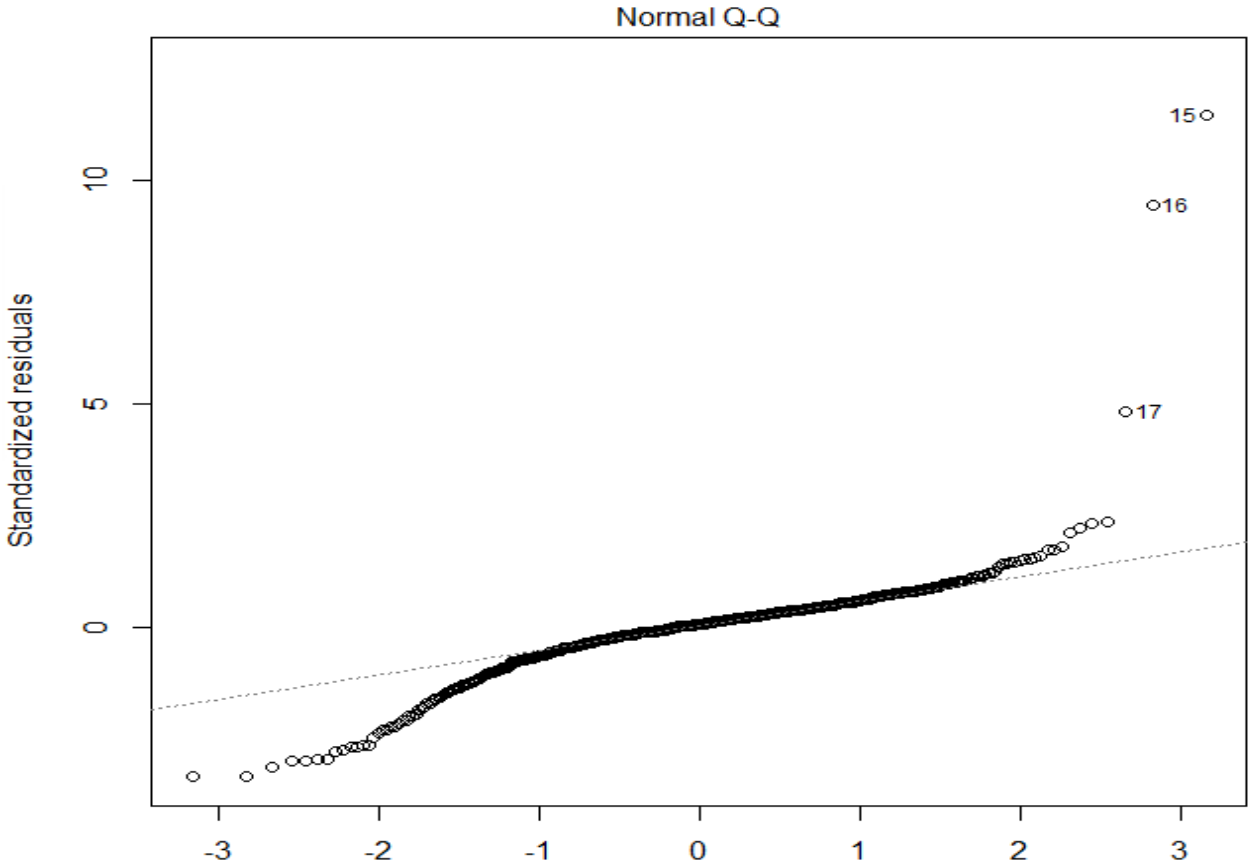
We notice that all the coefficients are significant and different from zero according to the t-test and to the F-test. The adjusted R-squared is notably high and this means that the regression is specified rather well.

However, to verify the goodness of fit we need to look at the the residuals:



Where we notice the clear presence of heteroscedasticity in the error term, this means that the variance of the residuals is not constant.

In addition, if we analyze the Q-Q plot to check the normality of the distribution:



We notice that the tails are heavy. It is therefore necessary to apply the Newey-West estimator for the correction of the eventual presence of autocorrelation or heteroscedasticity in the covariance matrix, so that we are sure that the hypothesis of the OLS are respected. From now on, we are going to apply the Newey-West estimator, used as a HAC (heteroscedasticity and autocorrelation consistent) estimator as a remedy providing robust standard errors to neutralize heteroscedasticity, for all the regressions that will be considered.

Applying the Newey-West estimator, such that we are sure that the conditions of the OLS will be respected, we obtain:

```
t test of coefficients:

             Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.582830   0.239946  2.4290   0.01542 *
VIX         -0.012136   0.009750 -1.2448   0.21368
WEI1         0.936349   0.150789  6.2097 9.648e-10 ***
WEI2        -0.140776   0.136684 -1.0299   0.30344
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

So that the 2-week lagged value turns to be not significant, and also VIX is found to be not significant with robust standard error, so that we can conclude that the present value of WEI is influenced much more from its past value rather than from the contemporary value of the financial volatility.

However, we should not exclude that the past values of the VIX can influence more significantly the present value of WEI, thus, it is necessary to prove this assumption. Let us consider the following regression:

$$WEI_t = c + VIX_{t-1} + VIX_{t-2} + WEI_{t-1} + \varepsilon_t$$

Where VIX_{t-1} and VIX_{t-2} are respectively the 1-week and 2-week lagged values of the VIX.

Using again the Newey-West estimator yields:

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept) -0.1123821  0.2367938 -0.4746   0.63524
VIX1         0.0237580  0.0055960  4.2456  2.51e-05 ***
VIX2        -0.0079834  0.0045887 -1.7398   0.08238 .
WEI1         0.8998185  0.0673327 13.3638 < 2.2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.7184 on 629 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.7954,    Adjusted R-squared:  0.7945
F-statistic: 815.3 on 3 and 629 DF,  p-value: < 2.2e-16
```

It is observed that VIX_{t-1} and WEI_{t-1} are significant, while the second lag of the VIX, VIX_{t-2}, is still significant but to a lesser extent. The adjusted R-squared is quite high and this means that the regression is well specified.

Ultimately we can say that the past value of the WEI influences the present value of the WEI much more than the VIX, and the lagged value of the VIX influences the present value of the WEI more than the present value of the VIX; as a result, we can consider the regression $WEI_t = c + VIX_{t-1} + VIX_{t-2} + WEI_{t-1} + \varepsilon_t$ a valid model to forecast the value of the Weekly Economic Index.

What appears strange from this model is that the financial volatility seems positively correlated with the Weekly Economic Index, suggesting that in a period of economic growth or boom, the financial volatility is higher, but this is not what we expected at the beginning. We can formulate various hypothesis of this discrepancy:

- firstly, it may be actually true that the VIX has a positive effect on the value of the WEI, being an evidence for the theory according to which during a boom the financial volatility grows because there is an increase of investments and therefore of uncertainty[7];
- secondly, it may be due to the data of the sample that were taken during the period of the covid-19 which "disturbed" the correct building of the model (being collected contemporarily while this work is being written);
- thirdly, it may be due to the presence of an omitted-variable bias, namely one or more relevant variables that were not considered by the model and which, as a consequence, correlate with the error term, adding endogeneity (although we could be quite sure that we eliminated the possible endogeneity by adding the lags of the dependent variable).

We are going to consider all these hypothesis, starting from the last one. Once we will have assessed that there are no omitted variables, we will determine whether our sample has been distorted by the covid-19. If we do not find any distortion and the sign of the coefficient of the VIX remains positive even after eliminating the data related to the covid-19, we will consider the first hypothesis (according to which the financial volatility is positively correlated with the economic growth) as the only one valid.

[7] DANIELSSON, J., VALENZUELA, M., ZER, I., 2019. *Financial Risk and Economic Growth, 1870–2016* [online]. Available https://ssrn.com/abstract=3502793

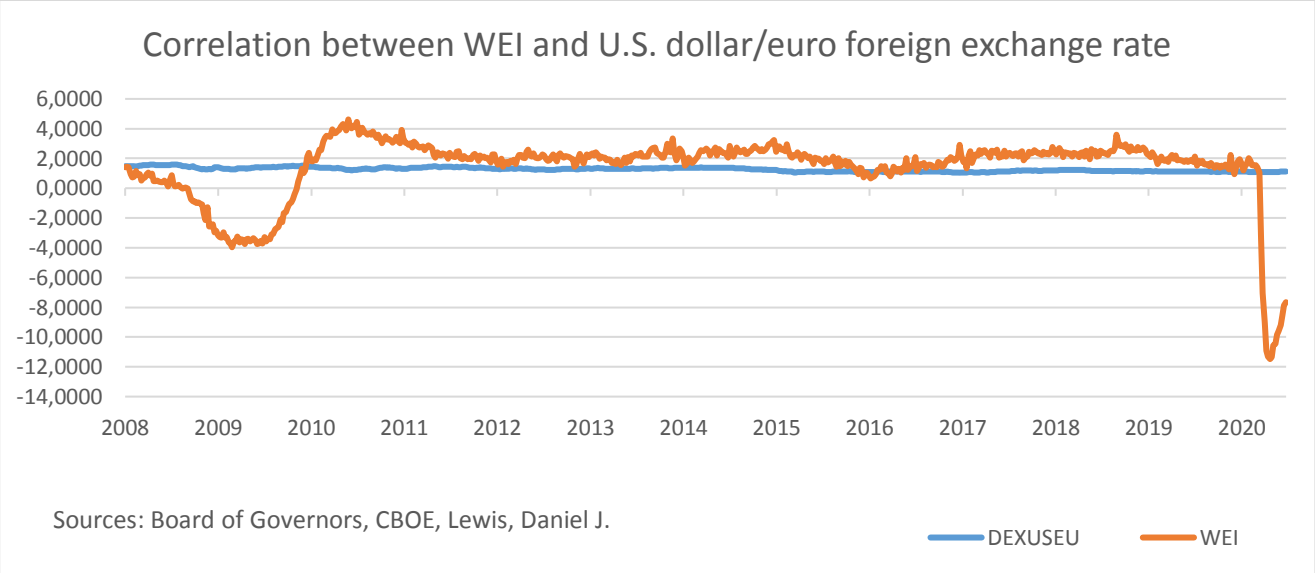
5. New variables inserted into the model

We ought to test whether the presence of other possibly correlated variables changes significantly the result of the regression we built before. Thereby, we are going to introduce, one by one, the following macroeconomic indicators into the model:

- The U.S. dollar/euro foreign exchange rate;
- The 10-year treasury constant maturity rate;
- The 2-year treasury constant maturity rate;
- The 5-year forward inflation expectation rate;
- The weekly hours worked in the manufacturing sector.

5.1. U.S. dollar/euro foreign exchange rate

The U.S. dollar/euro foreign exchange rate expresses the value of the U.S. dollar in terms of the European currency[8]. The following graph that shows the trends of the Weekly Economic Index and the U.S. dollar/euro foreign exchange rate from 2008 to June 2020 suggests that, while the Weekly Economic Index is more volatile, the exchange rate is quite stable. As a result, from the graph it is impossible to establish whether an even small correlation is present between the two variables.



The regression that considers the U.S. dollar/euro foreign exchange rate is:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + DEXUSEU_t + \varepsilon_t$$

[8] https://fred.stlouisfed.org/series/DEXUSEU

Where $DEXUSEU_t$ is the U.S. dollar/euro exchange rate.

Using the Newey-West estimator we obtain:

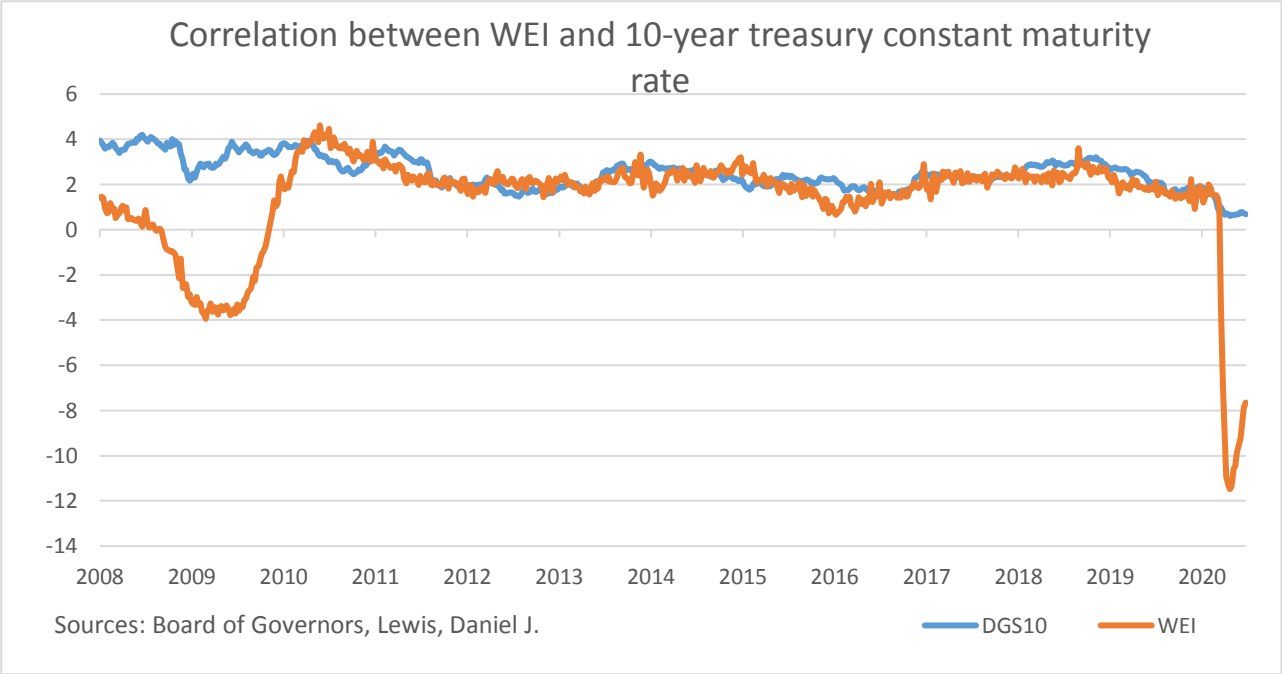
```
t test of coefficients:

             Estimate Std. Error t value  Pr(>|t|)
(Intercept) -1.191486   1.692432 -0.7040   0.48169
VIX         -0.068205   0.037218 -1.8326   0.06733 .
WEI1         0.841619   0.150695  5.5849 3.474e-08 ***
WEI2        -0.070430   0.101483 -0.6940   0.48793
DEXUSEU      2.228876   1.815946  1.2274   0.22013
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.175 on 633 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.7415,    Adjusted R-squared:  0.7399
F-statistic: 453.9 on 4 and 633 DF,  p-value: < 2.2e-16
```

From this outcome it seems that the model is specified pretty well (the adjusted R-squared is pretty high); however, the exchange rate is not a significant variable although its coefficient would have a big influence on the present value of the WEI, looking at the absolute value is major than the other variables. We cannot, as a consequence, claim that the U.S. dollar/euro exchange rate affects the present value of the Weekly Economic Index.

5.2. 10-year treasury constant maturity rate

The 10-year treasury constant maturity rate is an index that published by the Federal Reserve Board based on the average yield of a range of Treasury securities, all adjusted to the equivalent of a 10-year maturity[9]. Yields on Treasury securities at constant maturity are determined by the U.S. Treasury from the daily yield curve, which is based on the closing market-bid yields on actively traded Treasury securities in the over-the-counter market. We take the 10-year treasury constant maturity rate as the long-run nominal interest rate.

[9] https://fred.stlouisfed.org/series/DGS10



From the graph, it is impossible to establish whether there is a clear correlation between the Weekly Economic Index, and therefore the economic growth, and the long-run nominal interest rate. In fact, sometimes the trends of the two indices seem to proceed together, while in other periods the interest rate seems negatively correlated with the WEI. Let us clarify if there is a significant correlation through a regression analysis.

Adding the 10-year treasury constant maturity rate yields the following regression:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + DGS10_t + \varepsilon_t$$

Where $DGS10_t$ is the 10-year treasury constant maturity rate.

Using the Newey-West estimator we obtain:

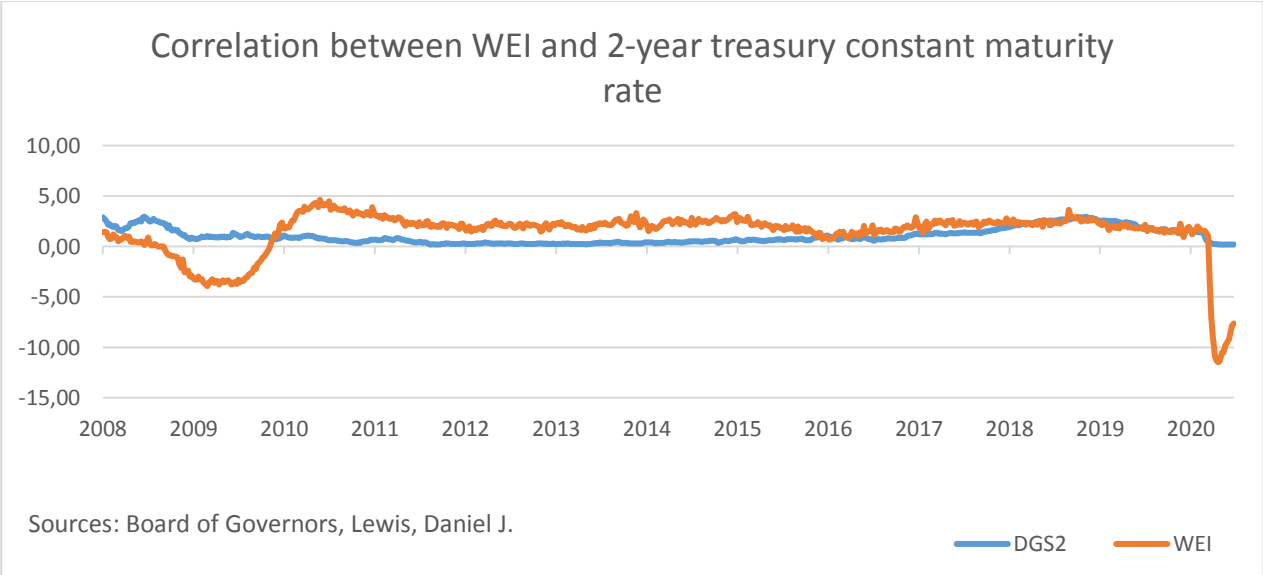
```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.4415904  0.1771925  2.4921   0.01296 *
VIX         -0.0238514  0.0055956 -4.2625 2.341e-05 ***
WEI1         1.1513850  0.1052774 10.9367 < 2.2e-16 ***
WEI2        -0.2870055  0.1309725 -2.1913   0.02880 *
DGS10        0.0981594  0.0754048  1.3018   0.19349
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4708 on 611 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.915,     Adjusted R-squared:  0.9144
F-statistic:  1644 on 4 and 611 DF,  p-value: < 2.2e-16
```

Which seems an exceptionally good model,since the adjusted R-squared is near to 1, conveying that the model can predict the dependent variable, WEI_t, with a good precision, very close to the real value.

However, with the robust standard error that we applied it is evident that $DGS10_t$ is not significant, and therefore it is impossible to state that the 10-year treasury constant maturity rate affects significantly the present value of the Weekly Economic Index.

5.3. 2-year treasury constant maturity rate

The 2-year treasury constant maturity rate is an index published by the Federal Reserve Board based on the average yield of a range of Treasury securities, all adjusted to the equivalent of a two-year maturity[10]. Yields on Treasury securities at constant maturity are determined by the U.S. Treasury from the daily yield curve, which is based on the closing market-bid yields on actively traded Treasury securities in the over-the-counter market. We take the 2-year treasury constant maturity rate as a short-run nominal interest rate.



It is hard to state something about the correlation between the two indices if we just look at the graph. However, the two trends seem to be partially correlated up to a certain extent. Let us run the econometric model to verify the correlation.

The regression that includes also the 2-year treasury constant maturity rate is:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + DGS2_t + \varepsilon_t$$

[10] https://fred.stlouisfed.org/series/DGS2

Where $DGS2_t$ is the 2-year treasury constant maturity rate.

Using again the Newey-West estimator yields:

```
t test of coefficients:

             Estimate Std. Error t value  Pr(>|t|)
(Intercept)  1.534067   0.618437  2.4806   0.01338 *
VIX         -0.063072   0.032988 -1.9120   0.05633 .
WEI1         0.885969   0.150341  5.8930 6.168e-09 ***
WEI2        -0.152259   0.120379 -1.2648   0.20640
DGS2         0.031249   0.140007  0.2232   0.82346
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.204 on 632 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.7298,    Adjusted R-squared:  0.7281
F-statistic: 426.7 on 4 and 632 DF,  p-value: < 2.2e-16
```

Where it is evident that $DGS2_t$ is not significant, not by chance its coefficient is found to be very low and very close to zero, from which it is not significantly different.

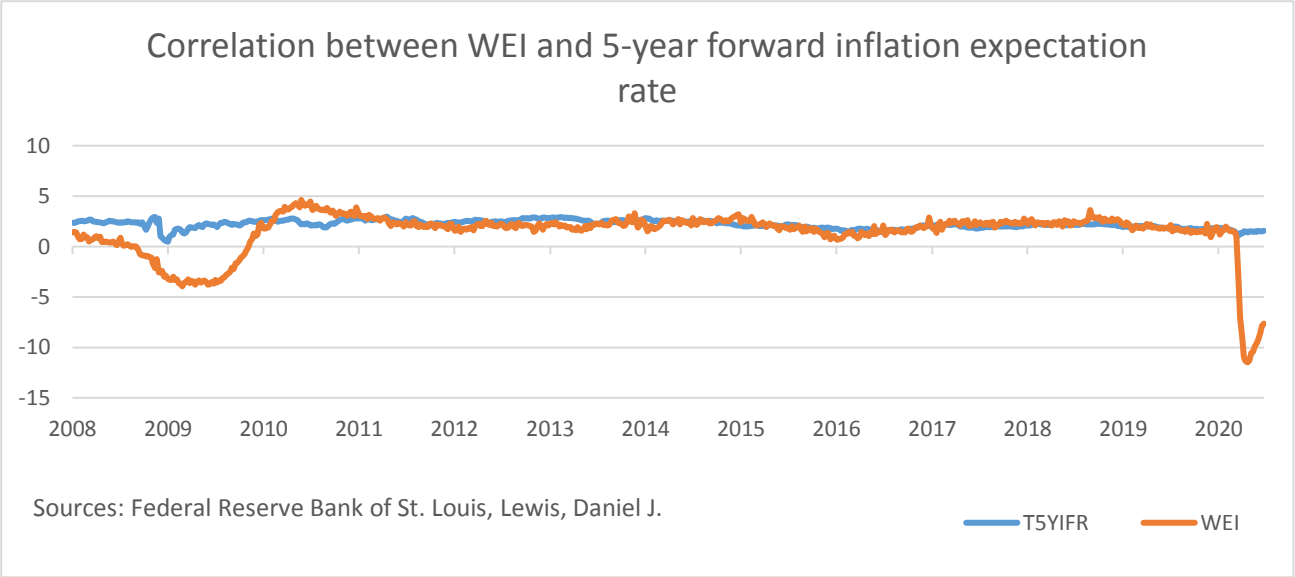
We must then accept the null hypothesis according to which $DGS2_t$ is equal to zero. Hence, we conclude that the 2-year treasury constant maturity rate does not affect the value of the Weekly Economic Index.

5.4. 5-year forward inflation expectation rate

The 5-year forward inflation expectation rate provides an esteem of the expected inflation rate (on average) over the five-year period that begins five years from today[11]. We take this index as a proxy of the future inflation expectation, knowing that, as it is shown in the Phillips curve, the present inflation determines the expectation on the future inflation[12], and, ultimately, the future inflation itself (under the hypothesis of rational expectations).

[11] https://fred.stlouisfed.org/series/T5YIFR

[12] PHELPS S., E., 1967. *Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time*. Economica, 34 (135), 254-281.



The graph seems quite chaotic, even though it is visible a small positive correlation between the two indices in correspondence of 2009-2010 period. Usually, we should expect a rising inflation during an economic boom or expansion, while a drop in inflation in periods of recession. However, since we are considering the expectation on future inflation, this may depend not only on the present inflation rate, but also on the announcements of the policy maker (e.g. the government or the central bank)[13]. For example, if the monetary authority announces, during a period of recession, that it will increase the liquidity lowering the interest rates in order to emerge from recession, and this announcement is considered credible, the inflation expectation will also change (positively). Let us run the regression that considers the 5-year forward inflation expectation rate.

Adding the 5-year forward inflation expectation rate into the model would make the regression become:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + T5YIFR_t + \varepsilon_t$$

Where $T5YIFR_t$ is the 5-year forward inflation expectation rate.

Using still the Newey-West estimator the outcome is:

[13] DRAZEN, A., MASSON R., P., 1994. *Credibility of Policies Versus Credibility of Policymakers.* IMF Working Paper, 94 (49).

```
t test of coefficients:

             Estimate Std. Error t value  Pr(>|t|)
(Intercept) -0.293373   0.580444 -0.5054   0.61343
VIX         -0.058239   0.029205 -1.9942   0.04656 *
WEI1         0.827290   0.137119  6.0334 2.732e-09 ***
WEI2        -0.122310   0.120917 -1.0115   0.31215
T5YIFR       0.819710   0.486989  1.6832   0.09283 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.163 on 633 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.7475,    Adjusted R-squared:  0.7459
F-statistic: 468.6 on 4 and 633 DF,  p-value: < 2.2e-16
```

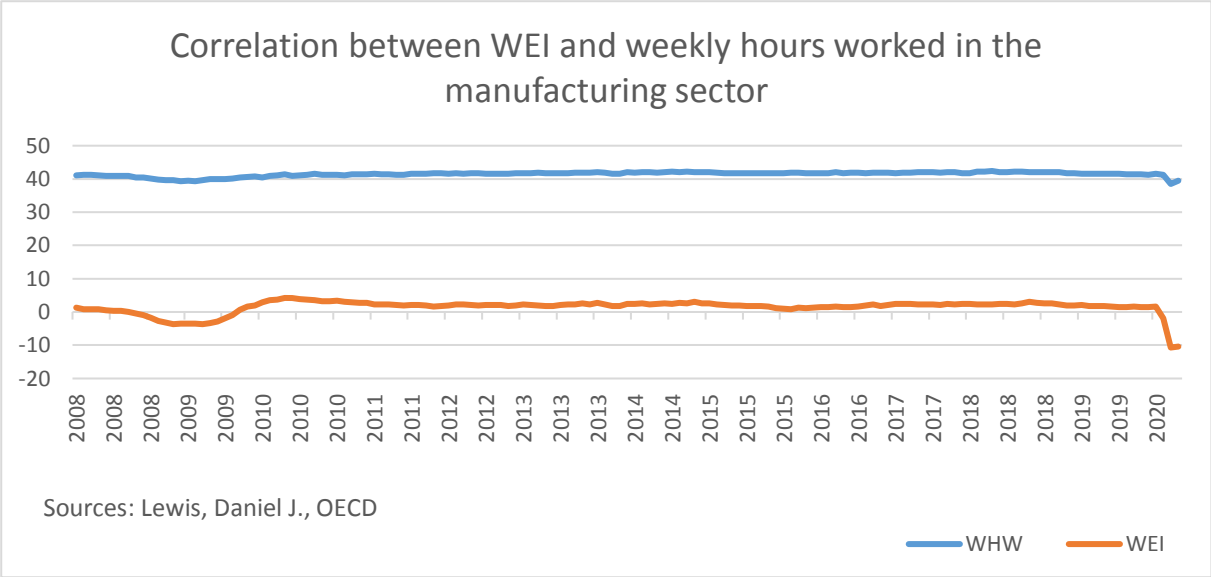
Which seems a very good model. $T5YIFR_t$ is significant with a level of significance of 5%.The adjusted R-squared is quite elevated and so the model should predict with a good precision the real value of the WEI, that means that the theoretical value and the real value of the WEI are not so dissimilar on average.

Hence, we can see that $T5YIFR_t$ is slightly significant with robust standard errors, but we cannot exclude, anyway, that it has a possible influence on the WEI, since its level of significance remains 5%. We are going to take it into account forthcoming.

5.5. Weekly hours worked in the manufacturing sector

The weekly hours worked in the manufacturing sector is a variable that is worth inserting into the model, since we expect that labor is a procyclical variable, as it is said by the real business cycle theory[14]. That means that the hours of labor increase in periods of economic growth, while during periods of recession workers drive away their labor substituting it with leisure, since the opportunity cost of the latter diminished. However, if we have to consider one of the main criticisms to this theory[15], we ought to say that the number of hours worked do not decrease in periods of recession because the employees prefer to substitute labor with leisure, but, rather, because of the increase of unemployment. Anyway, what concerns us is not the reason why the number of hours of labor decreases during a recession, but the mere fact that such drop actually seems to exist.

[14] STADLER W., G., 1994. *Real Business Cycles*. Journal of Economics Literature, 32 (4), 1750-1783
[15] HOOVER D., K., 2008. *New Classical Macroeconomics* [online]. Available at <https://www.econlib.org/library/Enc/NewClassicalMacroeconomics.html>



In fact, we observe from the graph that the number of hours worked slightly decreases during periods of recession, especially in 2008-2009 and in 2020. In this last case, the correlation between the Weekly Economic Index and the hours worked is even more evident, also because many employees were forced to stay at home because of the pandemic. Let us verify such correlation through an econometric analysis.

The regression that includes also the weekly hours worked in the manufacturing sector is:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + WHW_t + \varepsilon_t$$

Where WHW_t represents the weekly hours worked in the manufacturing sector.

Using the Newey-West estimator as usual we obtain:

```
t test of coefficients:

               Estimate  Std. Error t value Pr(>|t|)
(Intercept) -1.1023e+02  1.5811e+02 -0.6971   0.4870
VIX         -1.4943e-03  2.6786e-02 -0.0558   0.9556
WEI1         7.0046e-02  6.6940e-01  0.1046   0.9168
WEI2        -5.5125e-01  6.5390e-01 -0.8430   0.4008
WHW          2.7137e+00  3.8243e+00  0.7096   0.4792
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.075 on 130 degrees of freedom
  (15 observations deleted due to missingness)
Multiple R-squared:  0.7363,    Adjusted R-squared:  0.7282
F-statistic: 90.75 on 4 and 130 DF,  p-value: < 2.2e-16
```

We immediately notice some anomalies in this outcome. In fact most coefficients are ridiculously low, and none of the coefficients is significant.

We must reject the alternative hypothesis and conclude that WHW_t is equal to zero, and that in general this model is not valid at all. The weekly hours worked in the manufacturing sector do not help to forecast the value of the Weekly Economic Index.

6. Analysis with samples not including the covid-19 period

After having analyzed the model adding new variables, and verified that only the inflation expectation, among all these variables changed significantly the model (and so there was probably a slight issue of omitted-variable bias), we conclude that there adding inflation into our model as a regressor could help to forecast the value of the WEI more precisely. The step forward now is to test whether changing the samples of the data such that they do not consider the period of the covid-19 crisis will yield a different outcome. In particular, what concerns us is the sign of the coefficient of the lagged VIX, which has been found positive in the previous regressions, and we suspect that this is due to the distortion provided by the data of the months during the covid-19. To pursue our purpose, we are going to consider samples from 05/01/2008 to 25/01/2020.

Firstly, we analyze again the model with the contemporary value of the VIX and the lagged WEI, to check whether their relation changes significantly if we do not take the covid-19 period into account.

Considering the same regression that was taken into consideration previously:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + \varepsilon_t$$

Applying as we did before the Newey-West estimator the outcome is:

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.0872919  0.1824385  0.4785  0.632484
VIX          0.0018053  0.0081082  0.2227  0.823880
WEI1         1.3174546  0.1314062 10.0258 < 2.2e-16 ***
WEI2        -0.3910179  0.1406792 -2.7795  0.005612 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4944 on 612 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.9056,    Adjusted R-squared:  0.9052
F-statistic:  1958 on 3 and 612 DF,  p-value: < 2.2e-16
```

Which is still a well-specified model, as we can notice from the adjusted R-squared that is very high. However, the coefficient of the VIX is much smaller and not significant according to t-test, therefore it cannot be considered different from zero.

Since the coefficient of VIX is very low and ultimately not significant, we should conclude that normally the financial volatility has a minor effect on the Weekly Economic Index than the one it was believed before considering the sample including the period of the covid-19.

Now let us focus on the regression that considers the lagged values of the VIX:

$$WEI_t = c + VIX_{t-1} + VIX_{t-2} + WEI_{t-1} + \varepsilon_t$$

Running the model with the data that do not include the covid-19 period yields:

```
t test of coefficients:

              Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.2675711  0.2196509 -1.2182   0.2236
VIX1         0.0076576  0.0056831  1.3474   0.1783
VIX2         0.0069815  0.0052873  1.3204   0.1872
WEI1         0.9889048  0.0555827 17.7916   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.5287 on 612 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.8921,    Adjusted R-squared:  0.8916
F-statistic:  1687 on 3 and 612 DF,  p-value: < 2.2e-16
```

The adjusted R-squared is high so the model can forecast well the real value of the WEI. However, we notice that none of the coefficients of the lagged VIX is significantly different from zero.

The outcome shows that the past values of the VIX have still a positive effect on the present value, even using a sample that does not include the covid-19 period, but such effect is not significantly different from zero. Since the positive effect of the past values of the financial volatility is statistically equal to zero, this would confirm the hypothesis that the data during the covid-19 period disturbed and distorted the outcome of the model making the sign of the lagged VIX become positive. However, to be absolutely certain to accept this hypothesis, we ought to take into consideration the fact that previously we found that in the regression that includes also $T5YIFR_t$ (5-year forward inflation expectation rate) this latter regressor was significant with a level of significance of 95% (inferior with respect to the others, and yet it cannot be neglected). Thus, it is necessary to analyze further the regressions that include both the lagged values of the VIX and the inflation expectation rate: one with a sample that includes the covid-19 period, the other with a sample that does not include it.

Hence, let us consider, firstly, the following regression we already analyzed (adding a new lagged WEI because it is significant):

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + WEI_{t-3} + T5YIFR_t + \varepsilon_t$$

With data coming from a sample without the covid-19 period the outcome of the regression is:

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.2266181  0.1890594  1.1987   0.23113
VIX         -0.0220537  0.0049306 -4.4728 9.226e-06 ***
WEI1         0.9974767  0.0718494 13.8829 < 2.2e-16 ***
WEI2         0.1666696  0.0886174  1.8808   0.06048 .
WEI3        -0.3481074  0.0608285 -5.7228 1.652e-08 ***
T5YIFR       0.2312434  0.0928862  2.4895   0.01306 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4303 on 603 degrees of freedom
  (21 observations deleted due to missingness)
Multiple R-squared:  0.9295,    Adjusted R-squared:  0.9289
F-statistic:  1591 on 5 and 603 DF,  p-value: < 2.2e-16
```

Where it is visible that all the regressors, with the exception of the intercept, are significant and the adjusted R-squared is extremely high and close to 1, suggesting that the model is almost perfectly specified. Thus, it can be stated that the inflation expectation rate is positively correlated with the Weekly Economic Index.

Furthermore, if we consider also the lagged values of the VIX, analyzing the regression:

$$WEI_t = c + VIX_{t-1} + VIX_{t-2} + WEI_{t-1} + T5YIFR_t + \varepsilon_t$$

With the sample including the covid-19 period, the outcome with the Newey-West estimator is:

```
t test of coefficients:

             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.964315   1.474165 -0.6541  0.51326
VIX1        -0.063361   0.032539 -1.9473  0.05195 .
VIX2         0.032858   0.030020  1.0945  0.27415
WEI1         0.787361   0.059143 13.3128  < 2e-16 ***
T5YIFR       0.813358   0.626028  1.2992  0.19434
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.196 on 633 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.733,     Adjusted R-squared:  0.7313
F-statistic: 434.3 on 4 and 633 DF,  p-value: < 2.2e-16
```

Where the adjusted R-squared is rather high so it seems overall a good model. However, it is evident that $T5YIFR_t$ is not significant.

If we exclude the data from the covid-19 period, the result will be:

```
t test of coefficients:

              Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.1084655  0.2645203  0.4100  0.68192
VIX1        -0.0217216  0.0088948 -2.4420  0.01489 *
VIX2        -0.0054040  0.0089168 -0.6060  0.54471
WEI1         0.8257078  0.0816371 10.1144  < 2e-16 ***
T5YIFR       0.3220863  0.1550391  2.0775  0.03818 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4921 on 611 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.9071,    Adjusted R-squared:  0.9065
F-statistic:  1492 on 4 and 611 DF,  p-value: < 2.2e-16
```

Where all the coefficients, except for the intercept and the second lag of the VIX, are significant, and the adjusted R-squared is higher than in the model including data from covid-19 period.

We can notice that $T5YIFR_t$ remains significant. As a result, we cannot exclude it from our model to forecast the real value of the Weekly Economic Index. In addition, it is clear that the coefficient of the lagged VIX is negative, unlike the one found in the model that did not include the inflation expectation rate; moreover, since the outcomes obtained through the two samples (one including the covid-19 period, the other one not including it) are significantly different (because in the one including the covid-19 period the inflation expectation rate is not a significant variable), we may claim that the data from the covid-19 period provide distortions. Insofar, through our analysis we have discovered, firstly, that the data of the covid-19 period in 2020 distorted or disrupted the actual model that allows to predict the value of the Weekly Economic Index and, therefore, the current state of the economy. Secondly, we have probably found an omitted-variable bias, since the sign of the lagged VIX changed when we added the inflation expectation rate into the regression. Thus, it is likely that the model was distorted both by the samples and by the absence of a relevant regressor which caused endogeneity, and that means that its effect is included inside the error term, which is, therefore, not on average equal to zero, violating the hypothesis of the OLS. To sum up, two out of the three hypothesis that were formulated previously have found evidences: it is, therefore, possible that our initial model had two flaws: one was the distortion caused by the samples including the covid-19 period, the other one was the fact that relevant and significant regressors were not included inside the model.

However, since we established that the data collected during the period of the covid-19 distorted the results of the regressions, to verify that the omitted-variable bias does not involve also other variables beyond the inflation expectation rate, we have to repeat the analysis of the models that include also such variables (U.S. dollar/euro foreign exchange rate, 10-year treasury constant maturity rate; 2-year

treasury constant maturity rate, weekly hours worked in the manufacturing sector) as we did previously.

Thus, let us start from the model we have considered before (with a new lag in the WEI because it is significant in the sample without covid-19 period):

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + WEI_{t-3} + DEXUSEU_t + \varepsilon_t$$

Not considering the data collected during the covid-19 period the outcome of the regression is:

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.0850859  0.3389967  0.2510   0.80190
VIX         -0.0240901  0.0046914 -5.1350 3.814e-07 ***
WEI1         1.0224112  0.0719545 14.2091 < 2.2e-16 ***
WEI2         0.1685274  0.0847024  1.9896   0.04708 *
WEI3        -0.3560205  0.0609030 -5.8457 8.266e-09 ***
DEXUSEU      0.5284592  0.3088850  1.7109   0.08762 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4341 on 603 degrees of freedom
  (21 observations deleted due to missingness)
Multiple R-squared:  0.9283,    Adjusted R-squared:  0.9277
F-statistic:  1561 on 5 and 603 DF,  p-value: < 2.2e-16
```

Where it can be noticed that the coefficient of the exchange rate is slightly significant, as well as all the other variables with the exception of the intercept, and positively correlated with the WEI. It seems also to have even more influence on the WEI than the financial volatility. Moreover, the adjusted R-squared is extremely high suggesting that the mode is specified very well.

So, $DEXUSEU_t$ is significant with a significance level of 5%. As a consequence, we may say that normally the U.S. dollar/euro exchange rate is correlated with the Weekly Economic Index. This result was not found in the previous analysis probably because of the distortion due to the sample that included the covid-19 period.

Let us considering now the model that includes the 10-year treasury constant maturity rate:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + WEI_{t-3} + DGS10_t + \varepsilon_t$$

Still not considering the data collected during the covid-19 period, the outcome is:

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.5987653  0.1606742  3.7266 0.0002123 ***
VIX         -0.0231214  0.0055245 -4.1852 3.273e-05 ***
WEI1         1.0274029  0.0770373 13.3364 < 2.2e-16 ***
WEI2         0.1559674  0.0898071  1.7367 0.0829518 .
WEI3        -0.3513282  0.0609627 -5.7630 1.319e-08 ***
DGS10        0.0534229  0.0590761  0.9043 0.3661937
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4374 on 603 degrees of freedom
  (21 observations deleted due to missingness)
Multiple R-squared:  0.9272,    Adjusted R-squared:  0.9266
F-statistic:  1536 on 5 and 603 DF,  p-value: < 2.2e-16
```

Where $DGS10_t$ is not significant, even if the adjusted R-squared remains high as before.

We can therefore accept the null hypothesis according to which $DGS10_t$ is equal to zero. Hence, we may neglect the 10-year treasury constant maturity rate from our model safely.

Subsequently, let us take into consideration the regression with the 2-year treasury constant maturity rate:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + WEI_{t-3} + DGS2_t + \varepsilon_t$$

As before, we cut off the data coming from the covid-19 period, which yields:

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.7909848  0.1656200  4.7759 2.250e-06 ***
VIX         -0.0224403  0.0046608 -4.8147 1.867e-06 ***
WEI1         1.0328275  0.0749483 13.7805 < 2.2e-16 ***
WEI2         0.1546898  0.0894681  1.7290   0.08432 .
WEI3        -0.3620790  0.0634778 -5.7040 1.836e-08 ***
DGS2        -0.0573260  0.0381423 -1.5030   0.13338
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4364 on 602 degrees of freedom
  (21 observations deleted due to missingness)
Multiple R-squared:  0.9276,    Adjusted R-squared:  0.927
F-statistic:  1542 on 5 and 602 DF,  p-value: < 2.2e-16
```

Where $DGS2_t$ is not significant according to the t-test with robust standard errors, even though the adjusted R-squared is again extremely high as it was found in the previous models. The 2-year treasury constant maturity rate seems negatively correlated with the WEI, unlike the 10-year treasury constant maturity rate that had a positive coefficient (even though not significant).

$DGS2_t$ is not significant with robust standard errors, as a result we can neglect it from our model, stating that the 2-year treasury constant maturity rate does not affect the Weekly Economic Index, just like the 10-year treasury constant maturity rate.

Afterward, let us consider the model with the weekly hours worked in the manufacturing sector:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + WEI_{t-3} + WHW_t + \varepsilon_t$$

In this case, unlike in the previous regressions, the sample of the data starts from 01/01/2008 to 01/02/2020 because the weekly hours worked in the manufacturing sector are collected monthly. The outcome is:

```
t test of coefficients:

              Estimate Std. Error t value Pr(>|t|)
(Intercept) -29.448068   9.488066 -3.1037 0.002388 **
VIX           0.024268   0.014149  1.7151 0.088927 .
WEI1          0.160329   0.081032  1.9786 0.050172 .
WEI2         -0.313151   0.104734 -2.9900 0.003391 **
WEI3         -0.086123   0.048571 -1.7731 0.078765 .
WHW           0.757496   0.227690  3.3269 0.001169 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.4354 on 119 degrees of freedom
  (21 observations deleted due to missingness)
Multiple R-squared:  0.6142,    Adjusted R-squared:  0.598
F-statistic:  37.9 on 5 and 119 DF,  p-value: < 2.2e-16
```

This is the regression where we found some anomalies in the analysis that considered the covid-19 period in the sample, and in fact we can notice some oddities: the coefficient of the intercept is exceptionally high, VIX_t has a positive sign, the overall effect of the lagged values of the WEI is negative, and the adjusted R-squared is lower than the previous models. Despite that, WHW_t is clearly significant. However the outcome of the regression still looks strange because the signs of the coefficients are not those we should expect. This can be explained by the fact that the weekly hours worked in the manufacturing sector are already partially explained by the Weekly Economic Index. In fact, the Weekly Economic Index is determined also by certain proxies of the production (for instance, the raw steel production), and, therefore, inserting an explanatory variable that represents the number of hours worked weekly seems redundant. That is probably why the coefficients of the regression are strange. Another clue for which this model should be considered incorrect is that its adjusted R-squared is equal to 0.598, so it is lower than the adjusted R-squared of the model that does not include WHW_t, which is 0.9052, implying that the model is better specified if this latter variable is neglected. We do not notice this phenomenon with any other added variable we have considered: in fact all the other regressions, including those with non-significant added variables, had an adjusted

R-squared major than the model that considered only the lagged values of the Weekly Economic Index and the financial volatility. For this reason, it is reasonable to claim that a model that does not include the weekly hours worked in the manufacturing sector could forecast the real value of the Weekly Economic Index better than the model that includes them.

7. Conclusions

After having run and analyzed all these models, we are able to shape some conclusions. As we remarked before, this essay is being written while the global financial and economic situation is perhaps more uncertain than ever, since the entire world is currently in the middle of a huge recession and nobody knows what is going to occur in the next months, when different and opposite scenarios are all likely to take place. It is not easy to forecast precisely whether there will be another lockdown in the next months, or a new crisis (the political situation, internationally, is also very tense), or the resolution of the present one. The impossibility to predict the development of events condemns finance and economy to remain in a state of high uncertainty that is the main cause of the financial volatility shocks, which is the subject of this work.

Since we are in the middle of a recession, the business cycle is not over yet. We know that financial volatility is one of the variables that react quicker and almost immediately in a financial or economic shock, as it happened, for example, in the 2008 crisis when the economic recession was anticipated by a tremendous increase in financial volatility, caused by the drop of the prices of stocks and bonds and the rise of risk-premiums. In that case, the effects on the real economy were experienced only some time after the financial crisis. It is highly possible that in this moment the economy is facing exactly the same temporal bias: the financial volatility already reacted counter-cyclically, but other significant variables have not reacted yet. This explains why we found different results when we ran the models with a sample that includes the year 2020 and with a sample that does not include it: a bias due to covid-19 outbreak and the consequent economic crisis. The different results that have been found which prove the aforesaid distortion are:

- In the model that considers the lagged values of the VIX, if it is run with a sample that includes the period of the outbreak, the coefficients of the two lagged VIX have an overall positive effect and are found to be significant. However if the same model is run with a sample that does not include the period of the outbreak, the coefficients of the lagged VIX are not significant, and, thus, have not an effect on the present value of the Weekly Economic Index that statistically differs from zero;
- In the model considering the U.S. dollar/euro foreign exchange rate, if is run with the sample that includes the period of the outbreak, the coefficient of the exchange rate is not significant, on the other hand if it is run with the sample that cuts off the data coming from the period of the outbreak, its coefficient is found to be significant and positive;
- In the model of the lagged values of VIX that adds the inflation expectation, if it is run with the sample that includes the period of the outbreak, the coefficient of inflation expectations

is not significant, however if it is run with the sample that excludes the period of the outbreak, its coefficient is found to be significant and positive.

The second important aspect we found is the presence of omitted-variable bias in the first and original model that considered only VIX and WEI, which is shown by the change in the VIX coefficient when another significant regressor is added. When we insert $T5YIFR_t$ into the model that considers the lagged values of the WEI, the coefficient of the VIX becomes higher (in absolute value), while the overall effects of WEI_{t-1} and WEI_{t-2} becomes lower, because a bigger part of the dependent variable is explained by the inflation expectation. A similar phenomenon occurs when $T5YIFR_t$ is added into the model that considers the lagged values of the VIX, especially if the sample of the regression does not include the period of covid-19: the overall effect of VIX_{t-1} and VIX_{t-2} becomes negative and significant, while the coefficient of WEI_{t-1} becomes lower. We detected a small omitted-variable bias also when it comes to insert the exchange rate into the model, such that the coefficients of VIX_t and the lagged values of the WEI react in the same way as before.

Eventually, since the aim of this essay is to underline an empirical model that allows to forecast the current value of the Weekly Economic Index, in order to conclude it is necessary to establish which regression can predict the actual value of the WEI more precisely.

Let us consider the model that includes both the inflation expectation and the U.S./euro foreign exchange rate:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + T5YIFR_t + DEXUSEU_t + \varepsilon_t$$

If we run the model with the sample that excludes the period of the outbreak, applying the OLS method we obtain the following result:

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.169188   0.200688   0.843    0.400
VIX         -0.021416   0.002521  -8.496  < 2e-16 ***
WEI1         1.123254   0.038275  29.347  < 2e-16 ***
WEI2        -0.282716   0.035858  -7.884 1.46e-14 ***
DEXUSEU     -0.109156   0.221324  -0.493    0.622
T5YIFR       0.293475   0.073315   4.003 7.03e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4645 on 610 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.9174,    Adjusted R-squared:  0.9167
F-statistic:  1355 on 5 and 610 DF,  p-value: < 2.2e-16
```

Where it is clear that, although the model seems very well-specified (the adjusted R-squared is notably high), the coefficient of the U.S./euro foreign exchange rate is not significant.

It is, therefore, necessary to neglect it from the model. The best model that allows to predict in the most precisely way the current value of the Weekly Economic Index is the one that includes only the inflation expectation:

$$WEI_t = c + VIX_t + WEI_{t-1} + WEI_{t-2} + T5YIFR_t + \varepsilon_t$$

The model run with the OLS method yields the following result:

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.092266   0.126216   0.731    0.465
VIX         -0.021835   0.002372  -9.207  < 2e-16 ***
WEI1         1.125026   0.038082  29.542  < 2e-16 ***
WEI2        -0.281624   0.035768  -7.874 1.58e-14 ***
T5YIFR       0.267801   0.051593   5.191 2.86e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4643 on 611 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared:  0.9174,    Adjusted R-squared:  0.9168
F-statistic:  1695 on 4 and 611 DF,  p-value: < 2.2e-16
```

Where all the coefficients are significant (with the exception of the intercept). The adjusted R-squared is even slightly higher than the one in the previous model (0.9168 against 0.9167): the predictive power of the model is very precise.

Applying Newey-West to be sure that the conditions of the OLS are respected and there is no heteroscedasticity:

```
t test of coefficients:

              Estimate Std. Error t value  Pr(>|t|)
(Intercept)  0.0922661  0.1872740  0.4927  0.622416
VIX         -0.0218347  0.0050447 -4.3283 1.756e-05 ***
WEI1         1.1250262  0.1044343 10.7726 < 2.2e-16 ***
WEI2        -0.2816244  0.1306355 -2.1558  0.031489 *
T5YIFR       0.2678010  0.1008620  2.6551  0.008135 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

All the coefficients remain significant with a satisfactory significance level.

Thus, the final conclusion is that in order to build a good model that is able to forecast precisely the current value of the Weekly Economic Index, it is better to add the 5-year forward inflation expectation rate to the model that already considers the lagged values of the WEI, respectively one

and two weeks backward, and the index of financial volatility. As it was expected, in the last model the financial volatility has a negative (but relatively low) effect on the present value of the Weekly Economic Index, suggesting that high financial volatility is correlated with poor economic performances. The overall effect of the past values of the WEI is positive, as it is natural when we deal with time series, and the effect of the inflation expectations is also positive, confirming that rising inflation is associated with economic growth[16].

In the end we can claim that the econometric model we just found might be useful for policymakers to know the current status of the real economy not only through the past values of the WEI, but also through the present expected financial volatility and the present expectations of 5-year inflation rate. So, we found also that the Weekly Economic Index is influenced and affected also by expectations: if they change, then also the real economy subsequently follows them. It is also remarkable the fact that none of the variables present in our final model is really controlled by the government. VIX is given by investors' expectations in the stock markets, the lagged values of WEI are something that belongs to the past and cannot be modified in the present, while the inflation expectations may be influenced and changed by government announcements (if credible) but not directly controlled as it would be, for instance, the interest rate. Nonetheless, the empirical model we have built up is still useful to predict, knowing the data about the independent variables, the value of the Weekly Economic Index and therefore to figure out where the economy is heading, although it does not provide an explanation about the policies that should be taken in case we wanted to normalize and stabilize the fluctuations or the drops of the real economy.

[16] BARRO J., R., 2013. *Inflation and Economic Growth*. Society for AEF: Annals of Economics and Finance, 14(1), 121-144

Bibliography

BARRO J., R., 2013. *Inflation and Economic Growth*. Society for AEF: Annals of Economics and Finance

BASU, S., BUNDICK, B., 2017. *Uncertainty Shocks in a Model of Effective Demand*. Econometrica

BLANCHARD, O., AMIGHINI, A., GIAVAZZI, F., 2016. *Macroeconomia. Una prospettiva europea.* Milano: Il Mulino

BLOOM, N., 2009. *The Impact of Uncertainty Shocks*. Econometrica, May 21

BORRA, S., DI CIACCIO, A., *Statistica. Metodologia per le scienze economiche e sociali*. 3° ed. Milano: McGraw-Hill Education

CAGGIANO, G., CASTELNUOVO, E., GROSHENNY, N., 2014. *Uncertainty shocks and unemployment dynamics in U.S. recessions*. Journal of Monetary Economics

CASTELNUOVO, E., 2019. *Yield Curve and Financial Uncertainty: Evidence Based on US Data*. Marco Fanno Working Paper Series

DANIEL J., L., MERTENS, K., STOCK H., J., 2020. *Monitoring Real Activity in Real Time: The Weekly Economic Index*. Liberty Street Economics, Federal Reserve Bank of New York

DRAZEN, A., MASSON R., P., 1994. *Credibility of Policies Versus Credibility of Policymakers*. IMF Working Paper

HOOVER D., K., 2008. *New Classical Macroeconomics* [online]. Available at https://www.econlib.org/library/Enc/NewClassicalMacroeconomics.html

LEDUC, S., LIU, Z., 2016. *Uncertainty shocks are aggregate demand shocks*. Journal of Monetary Economics

McCRAKEN, M., 2020. *COVID-19: Forecasting with Slow and Fast Data*. Federal Reserve Bank of St. Louis On the Economy blog, April 3.

PHELPS S., E., 1967. *Phillips Curves, Expectations of Inflation and Optimal Unemployment over Time*. Economica

STADLER W., G., 1994. *Real Business Cycles*. Journal of Economics Literature

STOCK H., J., WATSON W., M., 2016. *Introduzione all'econometria*. 4° ed. Milano, Torino: Pearson Italia

Web references

https://fred.stlouisfed.org/

https://libertystreeteconomics.newyorkfed.org/

https://www.dallasfed.org/

https://www.hbs.edu/

https://www.jimstock.org/