On some consequences of COVID-19 in EUR/USD exchange rates and economy

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Abstract. Here we analyze several economical variables which have been affected by the period of COVID-19. In particular, EUR/US exchange rates are addressed. Oil prices have been very volatile and many other economical variables have changed their behavior.
We show by application of statistical tests for normality, including QQ-plots and e Shapiro-Wilk that exchange rates of EUR to US from 10/13/2019 to 4/9/2020 are substantially deviating from normality and outliers are present. It is clear that changes to the economical variables have been of interest.

Keywords: Exchange Rates, COVID-19, ARIMA, Modelling

0.1 Exchange Rates 10/13/2019 - 4/9/2020.

An exchange rate is the value of a currency in a given country compared with another country. They will rise or fall based on a country's supply and demand of imports/exports. It is one of the most useful tools to measure an economic growth or decline in the country.
We use exchange rates and other economic indicators to measure and predict the effect of COVID-19 on the United States economy. Abrupt changes of economic variables have been previously studied in Stehlik et al. (2017) [6], and also in [9] and [10].

Taking a quick look on the original data, it is obvious that something significant happened between January and March, as it is show in Fig. 1. There are significant peaks and valleys that are shown in succession that must be due to an extraneous force in the economy; COVID-19. At the beginning of February was when the World Health Organization reconvened the Emergency Committee and assessed a very high global risk level.
If we examine the quantile-quantile plot of the exchange rates of EUR to USD

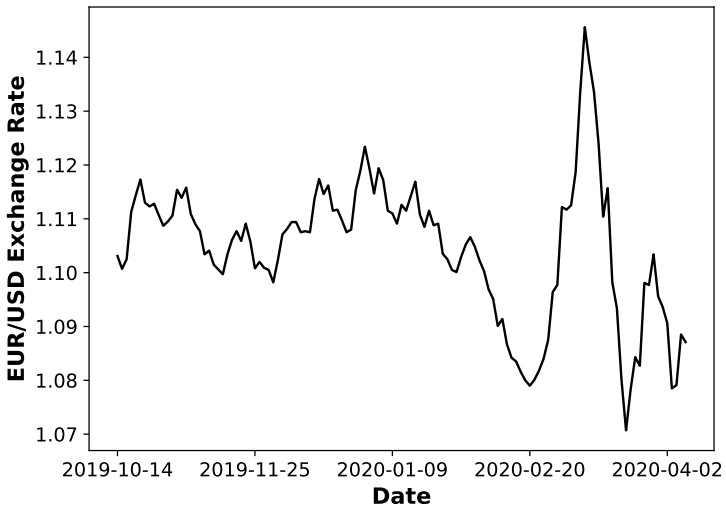

Fig. 1. Exchange rates of EUR to US from 2019/10/14 to 2020/4/9. Last days of February begin to experience higher volatility exchange rates as it can be see in the abrupt peak continued by a sharp decrease.

from 2019/10/14 to 2020/4/9 in Fig. 2, we can see there is a strange object in the lower left portion that is very unique. Along with it, the Shapiro-Wilk test of normality gives a value of 0.94648 and a p-value of 1.236e-05. And the Jarque-Bera with 2 degrees of freedom gives a χ^2 value of 12.727, and a p-value of 0.001723; all showing strong non-normality.

After identifying specific datapoints in the QQ-plot of Fig. 2, we can see that nearly every non-normal plot comes after the dates near the magenta color, i.e. dates that are closer to the pandemic outbreak. We also plotted a histogram of the data in Fig. 3 to potentially identify the strange object further and this was the result.

The histogram in Fig. 3 shows that the data is bimodal, meaning that there is a high concentration of two different means. The reason for this outcome could be that the data has the same variance; days of the week. The lower concentration is dealt with COVID-19 impacting world trade hence the exchange rate decreasing.

After observing this, we decided to split the data into two in Fig. 4, as the histogram shows there are essentially two different datasets. We split at February 5th. If we compare the two QQ-plots of the split data in Fig. 4, we can see that both are much more normal. While not confidently normal, judging by the outliers and the Shapiro-Wilk values for both of 0.97353 and a p-value of 0.03971, and then 0.9489 with a p-value of 0.02248. This provides another explanation for the object in the original QQ-plot.

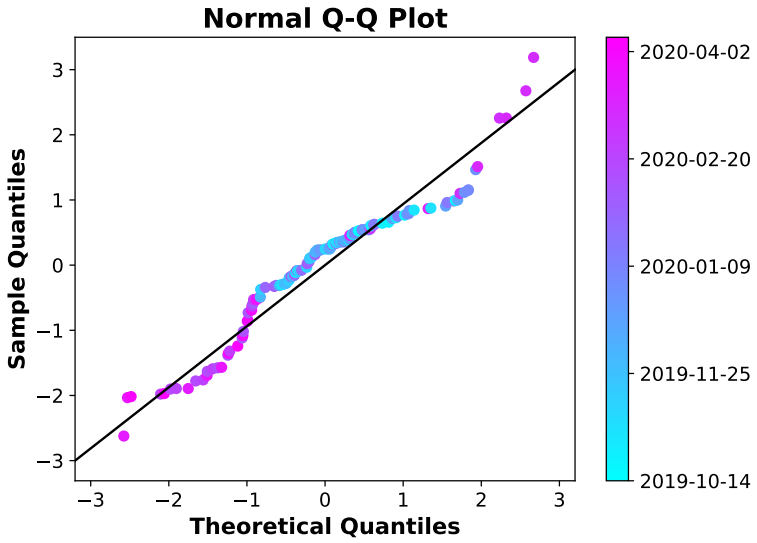

Fig. 2. QQ-plot of exchange rates of EUR to US from 2019/10/14 to 2020/4/9. Dates closer to magenta color are the days in which the COVID-19 has a major impact in the global economy

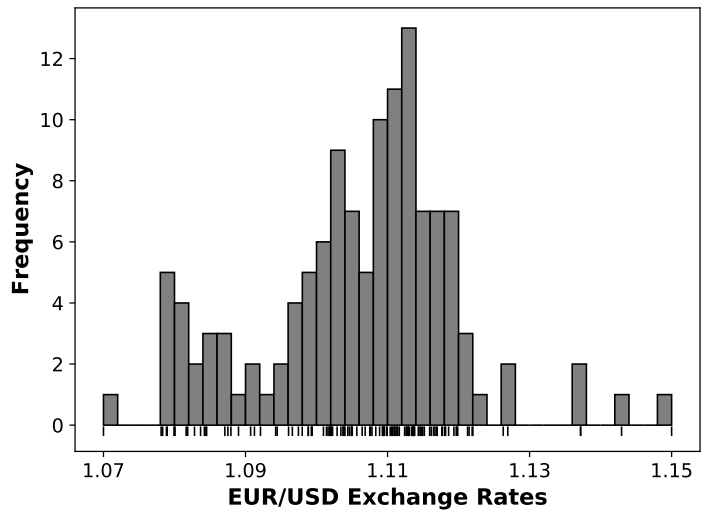

Fig. 3. Distribution of exchange rates of EUR to US from 2019/10/13 to 2020/4/9.

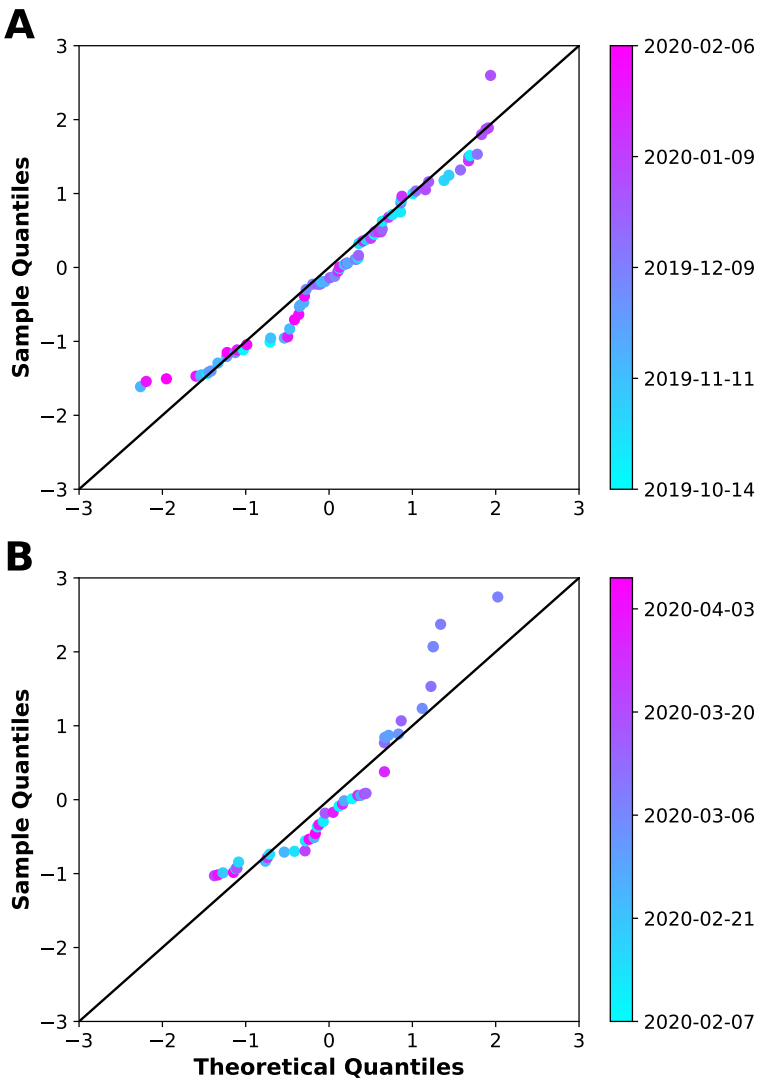

Fig. 4. QQ-plot of exchange rates of EUR to US. A depicts the data from Q-Q plot of exchange rates from dates 2019/10/14 to 2020/2/6, and **B** displays the Q-Q plot for exchange rates from 2020/2/7 to 2020/4/3.

The global dollar appreciation can be measured as the Nominal/Real Advanced Foreign Economies Dollar Index [2], this daily index in Fig. 5 is presented by the Governors of the Federal Reserve System in order to measure the strength of the US Dollar against other currencies that are used in international trades. We shortly present the values of the Index in order to show differences with the exchange rate of EUR/US, which are basically that the COVID-19 impact negatively the Dollar against EUR which was effectively captured with the Nominal Advanced Foreign Economies Dollar Index. As the EUR/US exchange rate (as depicted in Fig. 1) increases in the last days of February 2020, the Dollary Index loose its strength decreasing until the March 9th, when the global markets begin to fall, causing the liquidation of the volatile assets, such as stocks, in order to change it for safe haven assets as gold or US Dollar.

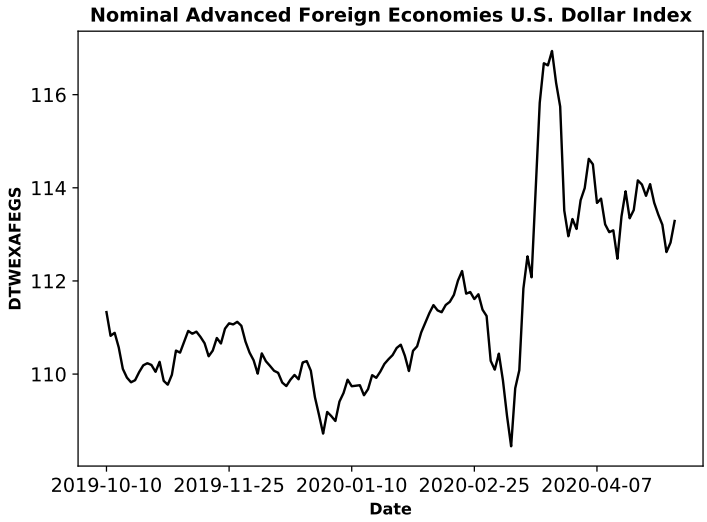

Fig. 5. Federal Reserve Nominal Advanced Foreign Economies U.S. Dollar Index. Data provided by the Board of Governors of the Federal Reserve System (US). This index measures the appreciation of the dollar against other currencies that are used in international trades. In this figure we showed the index from 2019/10/10 to 2020/5/4, i.e. we include months before and after the COVID-19 outbreak.

1 Forecasting EUR/US Exchange rates

1.1 Finding a Model for Forecasting.

In order to predict, we need to forecast the data. In order to do that, we must to apply correct models to the data. After careful deliberation and programming,

we came across one model for both original data and post-COVID data. We will, however, be focusing more on the post-COVID data as that will be more useful for forecasting in the near future.
Here are the models we found to be most appropriate for the data. Bolded are models we chose to forecast due to lowest AIC, BIC and highest log-likelihood. We found these models by applying autocorrelation function plots, partial autocorrelation function plots, sample extended ACF plots, and subset ARMA plots. Then, we eliminated non-significant coefficients to find our very best models.
In order to find the best model we test several parameters in the ARIMA model ($p, q \in \{0, 1, \ldots, 10\}$ and $d \in \{0, 1, 2\}$) and we choose the ones that has the lowest AIC, BIC and highest log-likelihood.
The meaning of ARIMA is "Autoregressive Integrated Moving Average". AR (AutoRegressive) indicates the strength of the correlation of the data's own previous values on itself. MA (Moving Average) indicates that the regression error is a linear combination of previous error terms. The "I"indicates the difference of its own values. If the original data is not stationary, the first difference of the data is needed ($Y_t - Y_{t-1}$), and "I"becomes equal to 1 for the first difference assuming it is then stationary.

1.2 Forecasting: 34 days in the future (due to the difference of observed data and current date)

As it was seen in the data from the European Central Bank [1] presented in Fig. 1, we can see, the data averages around 1.185-1.19 with a peak of 1.10985 on May 2nd and a low of 1.07444 on April 24th.
If we look at the forecast for the data Fig. 6, it relies heavily on the average of all the data and small rise at the very end. It most certainly does not serve as a good predictor for the data, as it forecasts the data to be above 1.10 on average, which it most certainly is not.
The forecast for the data after the impact of COVID-19 appears to be much more accurate in Fig. 7. It continues the trend and stays below 1.10. Most predicted values occur between 1.089 and 1.095. The 95% confidence limits (gray trend lines closest to the middle) naturally increase as time goes on but stay between approximately 1.06 and 1.3, or more closely 1.075 and 1.2, which nearly all 34 real datapoints apply to. This shows a slight but noticeable strengthen in the USD by nearly 3% after COVID. It also shows a level of consistency to the data, meaning that we can fairly accurately predict that real life EUR to USD exchange rates will most likely around 1.09.

2 Discussion: What Does this Mean for the Economy?

It is not clear where the abrupt peak of the EUR/USD exchange rate between end of February and beginning of April 2020 originates from. COVID-19 can hardly

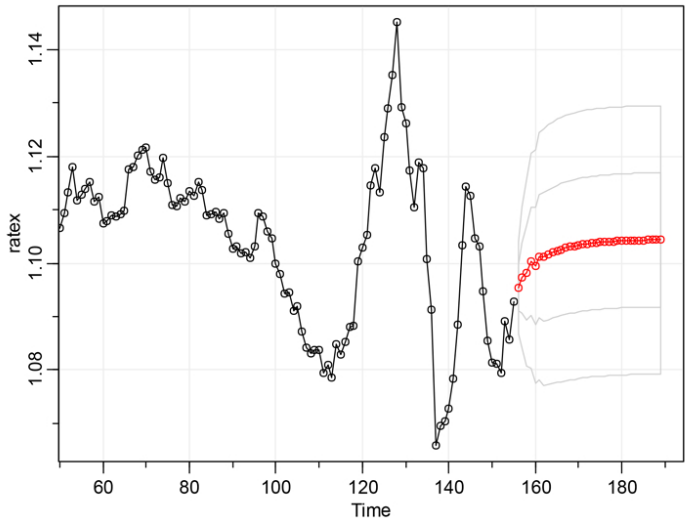

Fig. 6. ARMA(1,7) model with MA 3,4,5,6 missing. The model in this figure is $Y_t = 1.1045 + 0.8677Y_{t-1} + 0.2857e_{t-1} + 0.331e_{t-2} - 0.2403e_{t-7} + e_t$

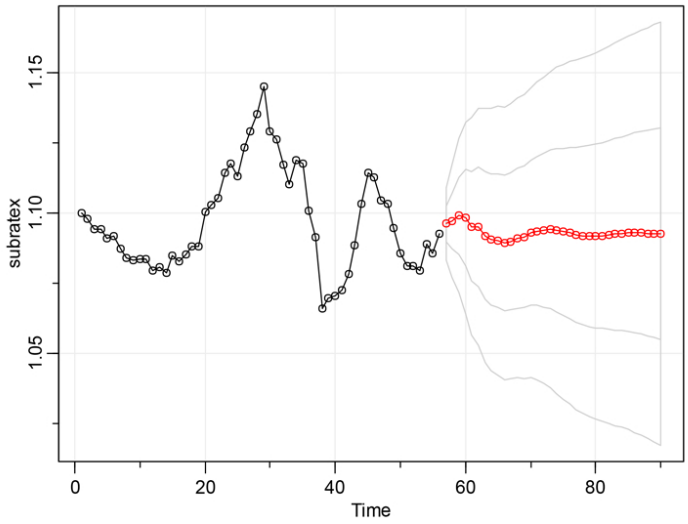

Fig. 7. AR(7) model of the difference with AR 3,5,6 and mean zero. The model in this figure is $\Delta Y_t = 0.1994Y_{t-1} + 0.1918Y_{t-2} - 0.22Y_{t-5} - 0.2633Y_{t-7} + e_t$

explain it since the pandemic affected European countries in the same way as it affected the US. An explication could be that the US government declared somewhat earlier than European countries the national emergency concerning the COVID-19 outbreak. ([8]; [7]. In the moment European countries took similar actions as the US government the EUR/USD exchange rate normalized.

Oil Prices are incredibly volatile during harsh economic changes. If we look at oil prices as of recent in Fig. 8, we see a significant dip due to COVID [3]. It fell over 70% in a few weeks, below $20/barrel for the first time since the 1990's. It averaged below $0/barrel during the month of April for the first time ever. This is most likely due to the stay-at-home orders and national hysteria over the pandemic. If we look at historical data, mostly focusing on 2008, we can see there was both a quick yet enormous rise and dip in 2008. It climbed to $143.68/barrel after an increase of 25% in three months. The OPEC blamed the weak US dollar. It also fell below $40/barrel in the next five months. In 2015, EUR to USD exchange rate decreased by nearly 20% (strengthening of USD) and oil dropped severely as well.So we can corroborate the well-known inverse correaltion between oil price and USD.

Finally, we look at the Federal Funds Rate over time [4] in Fig. 8. This is the interest rate at which the Federal Reserve Bank lends to banks and credit unions. When it is high, the economy is doing well. If it is low, the economy is not. A low FFR shows that no one is borrowing to buy a house or start a business or any other reason a person or company may need a significant loan. If we look at historical data, we can see it was over 5% in 2006 and 2007 before the recession. It then dipped below 0.10% by December of 2008. In the aftermath of the recession, it began to climb slowly up to 2.40%. But since February 17th, it has dipped to 0.05% and below. This is the lowest it has ever been.

We only briefly need to touch on unemployment rate [5] in Fig. 10 as the graph explains itself. Unemployment increases during times of poor economic performance but the current unemployment rate during COVID-19 is unique in that it is astronomically high. It makes the 2008-2010 unemployment seem insignificant.

3 Conclusion

It is evident from this data that USD/EUR exchange rates were bound to fall, and they did, though they seem to currently be stabilizing. It is also obvious, from all the data collected, that there is strong evidence to conclude we are headed for a major economic recession, assuming we aren't already in one. We claim that we assumed models to be correct, since working with real data put an extra challenges to the simple model fitting. Our approach is more linking to benchmarking of the real data situation. All the figures, except 6 and 7 were made using Python, otherwise was `R` software.

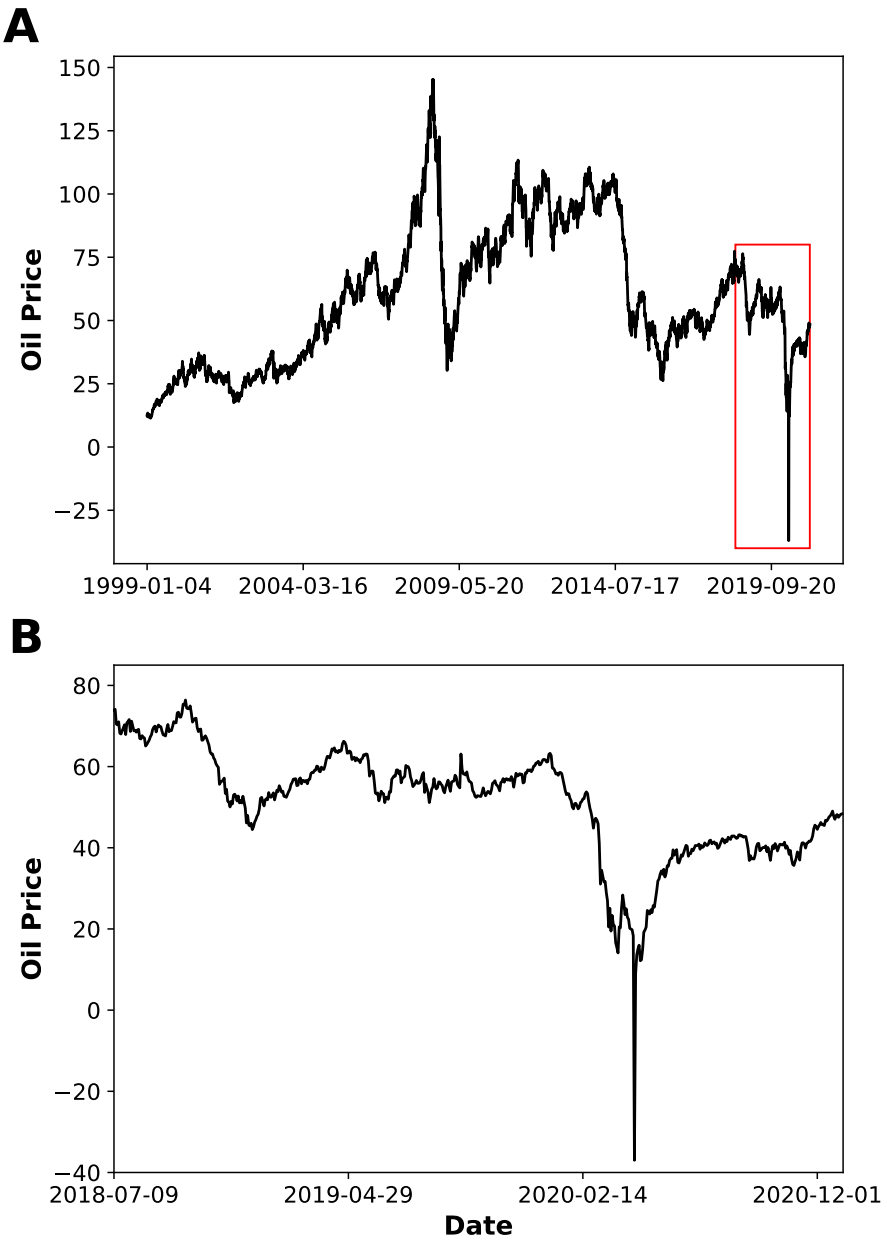

Fig. 8. US Oil price's comparison with historical prices since 1999. Panel **A** shows historial data until December 2020, inside this panel the red box is zoomed in panel **B** which shows data from november 2019 to April 2020.

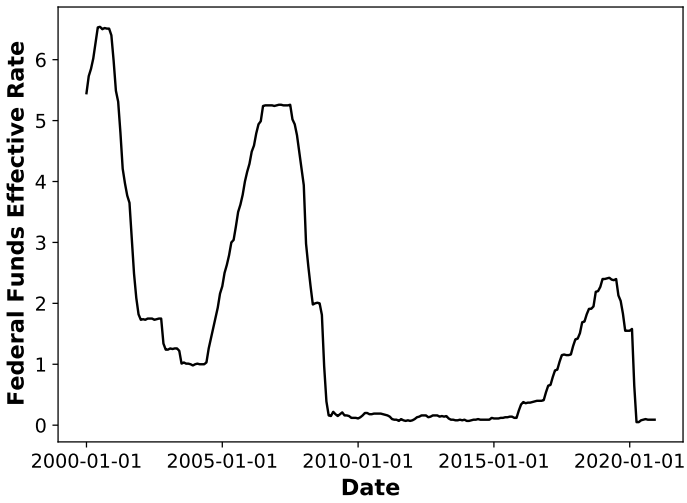

Fig. 9. Federal Funds Rate over time. Before the last two market crashs, i.e. Internet Bubble in the late of 2002 and the financial crisis of 2008, fund rates dropped considerably from previous peak. The same can be seen in months prior the 2020 March black swan.

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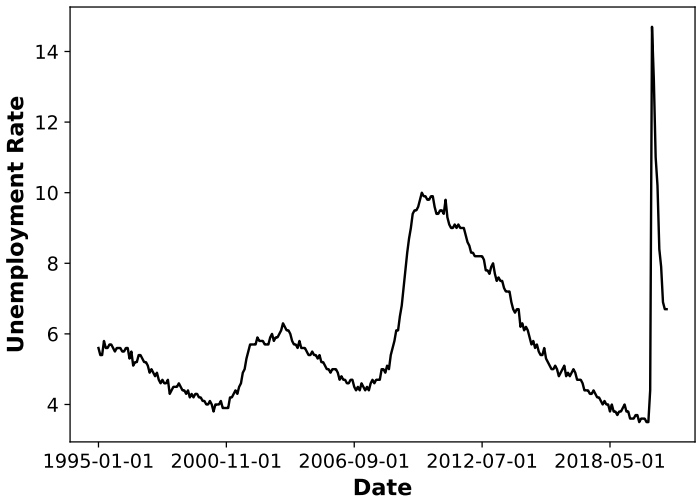

Fig. 10. Unemployment Rate over time. Notice the levels for the unemployment rate, this kind of abrupt peak has never been recorded. Mostly because since since 1918 influenza pandemic, we haven't experience a deadly global pandemic with lockdowns that force almost every work in the world to close its doors.

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