Visualising Predictions for the US Recessions with the Yield Curves

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To access the visualisations, please follow the link: https://tabsoft.co/2yanEVd

1. Introduction

In light of the current economic climate, there have been uncertainties and fears for future economic prospects since the start of the global pandemic Covid-19. In the US, economic recession could be the country's potential threat in the near future. Therefore, there is an urgent need for predicting the US recession. The yield curve, which is a macro-economic metric, could be used for that purpose. This report will shed some light on the yield curve by trying to understand and visualise them so that the following questions will be answered

- How are the US recessions visually predicted by the yield curves?
- Will the US experience an economic recession in the near future?
- Why is visually predicting the US recessions important?

Accordingly, the report will be constructed as follows: 2) Methodology, 3) Results, 4) Discussion & 5) Conclusion.

2. Methodology

a. Data Description

There are two main data sources used in the report. Firstly, bond yield data are from the US Federal Reserve's website (The US Federal Reserve 2020). The data is the time series of the yields on bonds with different maturities including 3 months, 6 months, 1 year, 2 years, 5 years and 10 years. The data availability or, specifically, the starting date for each type of bond differ from each other; the earliest is on 2nd January 1962 and the latest is on 4th January 1982. The ending date for all types of bonds is 9th March 2020. To balance the data loss issue with the need for visualising the relationship between the US recession with yields on bonds, the date of the 1st January 1976 is chosen as the starting date. Secondly, data for GDP growth (%), GDP (in US dollars) and Income groups are from the World Bank's website (The World Bank 2020). These data include several attributes including year (numeric), GDP in dollars (numeric), GDP growth in percentage (numeric), Income Groups (categorical) & geographical data for countries around the world (latitude & longitude).

Before visualising, the data is processed by using tidyverse, readxl & stringr packages in RStudio. This step is to gather, join, reshape and clean the data needed for the visualisations in the following step.

b. Tableau Public – The visualisation tool

Tableau is the leading data visualisation software at the moment (Select Hub 2019). In the Business Intelligence industry, Tableau is responsible for the biggest share of 15.5% in the market along with Cognos IBM, QlikView and other top products (Enlyft 2020). Accordingly, tableau's functionality, e.g. click-and-drag and interactivity, and its ease of use for the non-tech audience are the direct explanations for the

software's growing popularity. Tableau Public and Tableau Desktop are the two main versions. The former is free; meanwhile, the latter is the paid version. In this report, Tableau Public is used to visually explain and predict the US recessions by examining the yield curves.

c. Design Principles:

Visual encoding is a rule mapped the underlying data to be expressed visually. The data can be categorised as ordered items or unordered items. There is no complete guide showing how different types of data should be visually encoded in a specific manner. However, the utmost importance of visually encoding is to ensure the expressiveness principle, i.e. expressing all the facts in the data and only the facts in the data, and effectiveness principle, i.e. presenting data in a straightforward, unambiguous and cost-effective manner. By the way of illustration, the graph below shows how data might be visually encoded (Munzner 2015). Although choosing encodings, which achieve the best effectiveness, should be prioritised, flexibly combining different encoding methods needs to be considered to help the audience engage more in the visualisations.

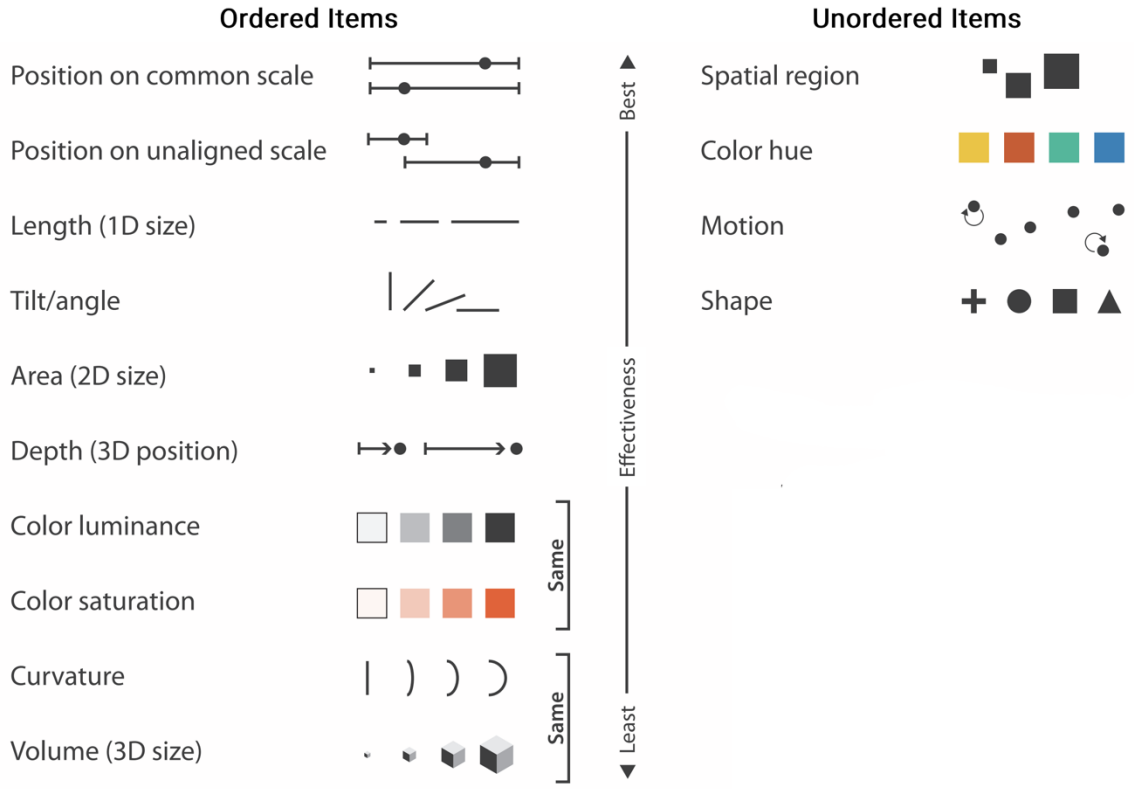


Figure 1. Visual Encoding (Munzner 2015)

To ensure good practices of visualising data, there are four common issues that any visualisation composers must be cognisant of. Firstly, *Chart Junk* refers unnecessary elements including heavy grid lines, unnecessary text, pictures surrounding the visual, shading or 3d components and ornamented chart axes in graphs/charts which make audience comprehend the information presented by such graphs/charts more difficultly (Tufte 2001). Thus, simplicity is more desirable when it comes to visualising data. Similarly, the idea of *data-ink ratio* introduced by Tufte (2001) also promotes clarity for visualisations in which higher data-ink ratio, i.e. the

proportion between the non-erasable ink used for the presentation of data with the total ink, is preferable (InfoVis 2020). Importantly, besides that, *Design Integrity* must be rightly emphasised in any visualisations to avoid visualisation lies that might either unintentionally convey wrong messages or deliberately distort realities. Therefore, due to the varied contexts, both the audience and those making data visualisations must be keenly aware of the underlying data presented by its visualisation on a case-by-case basis (Yau 2020). Combined all together, finally, effectively *Telling a story* will help the audience engagingly comprehend the visualisations. This final stage requires those composing data visualisations to 1) start with a good question, 2) repeat the main message, 3) highlight the answer and 4) call audience to action (if necessary) (Udacity 2017).

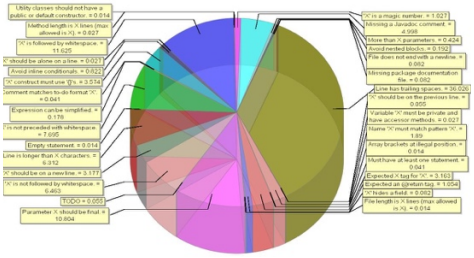


Figure 2. Chart junk (Frey 2013)

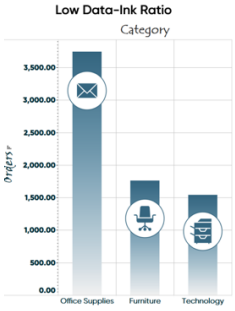
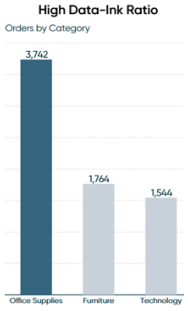


Figure 3. Data-Ink Ratio (Ryan 2020)



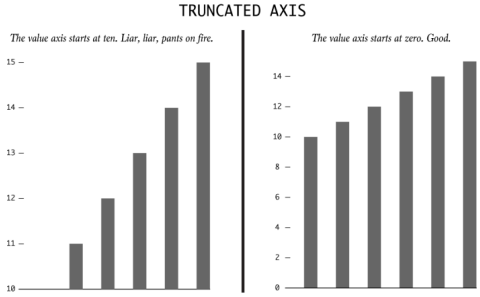


Figure 4. Design Integrity (Yau 2020)

3. Results

a. US Treasury Bonds

To understand the yield curve, firstly, understanding the US Treasury Bonds is necessary. By definition, the US Treasury Bonds are the US government debt instruments issued by the US Treasury to finance government spending as an alternative to taxation. There are various types of bonds from short-term to long-term. The maturities of bonds range from 3 months up to 30 years and a few in between (Haubrich 2006). People can buy directly from the US Treasury or from those who possessed the bonds. Considered as the safest investment, the US Treasury Bonds are the most liquid and the most traded government financial assets in the world. Holders of the US Treasury Bonds include US's public bodies, private companies, individuals and foreign/international entities including China, UK & Ireland as the major foreign holders of the US debts (ECLA 2019) (Amadeo 2020a). It is not an exaggeration that the US Treasury market can offer an aggregate opinion of everybody in the world what they think might happen to the US economy and, by extension, the global economy.

$$Yield\ on\ a\ bond\ (\%) = \frac{A\ coupon\ on\ a\ bond}{Market\ price\ of\ a\ bond}$$

For a US Treasury bond, there are three main components including Coupon on a bond, Yield on a bond & Market price of a bond (formula). Talking about coupon on a bond, it is the amount of money that investors earn annually per 100 US dollars

investment. The coupon is directly influenced by the interest rate which is the US Federal Reserve's monetary tool to control the economy. When the economy is booming, the interest rate is high so that inflation can be controlled. By contrast, the interest rate is low when the economy is stagnant to encourage people to borrow money to stimulate the economy. The coupon is fixed but the yield on a bond will vary inversely with the bond price which is influenced by the investors. The market price of longer-term bonds is more likely to be dictated by the investors since investors tend to trade bonds from each other when the maturity is not reached. Otherwise, direct transactions with the US Treasury are more preferable for shorter-term bonds. In another word, yields on longer-term bonds are more influenced by the investors; meanwhile, yields on shorter-term bonds are more directly decided by the US Federal Reserve (Wall Street Journal 2019). This phenomenon shapes the trend of the yield curve which will be explained in the following section.

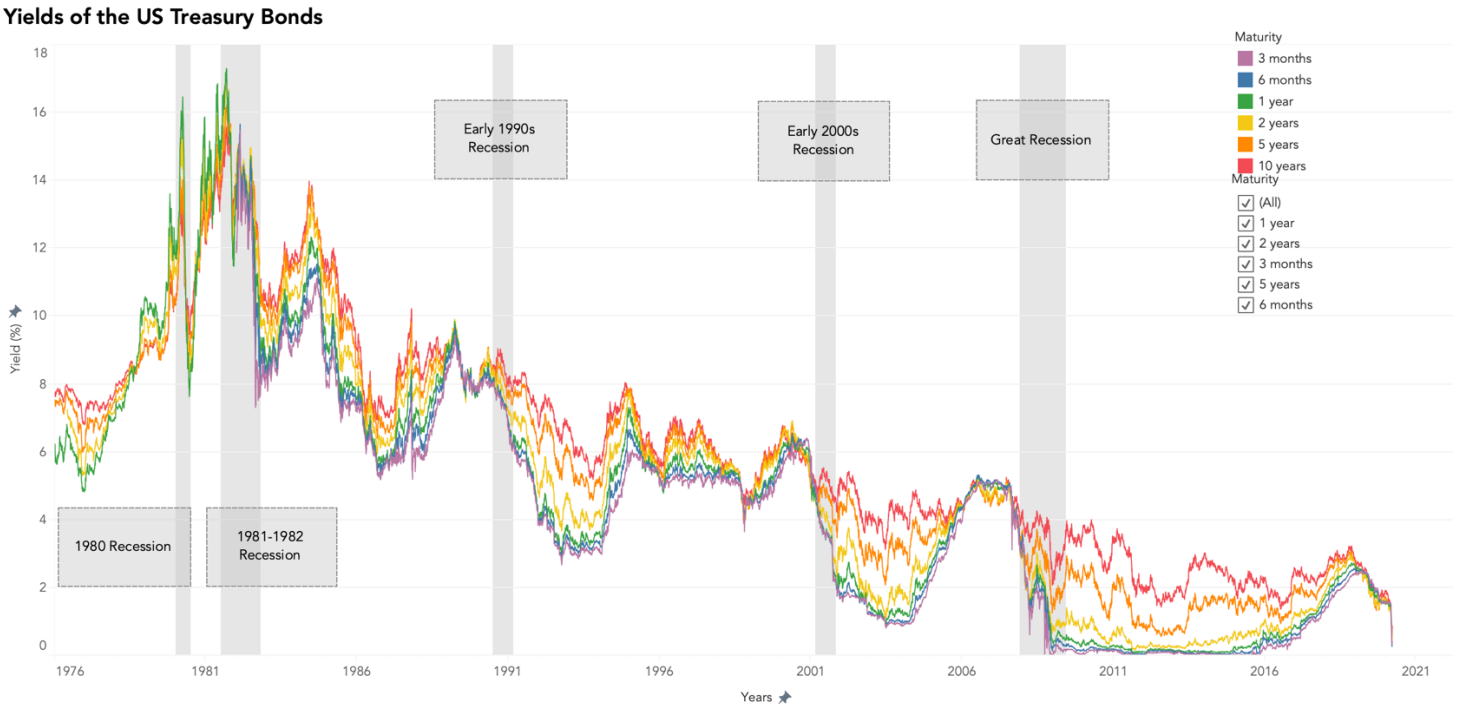


Figure 5. Yields on the US Treasury Bonds

The line chart above depicts yields on bonds with different maturities ranging from 3 months to 10 years in the period between 1976 to present. Most of the time, yields on longer-term bonds are higher than yields on shorter-term bonds. Besides, there is a downward trend of yields from 1980 to the present. The peak of the yield was recorded on 3rd September 1981 with 17.31% for one-year maturity bond. During the period from 1980 to 1982, the record-high yields were explained by the high-interest rates set by the US Federal Reserve to tackle double-digit inflation, high employment rates and negative GPD growth rates. In the final quarters of 2008, 2011, 2013 & 2015, the lowest yield was 0% for three-month maturity. The logical explanation is that the US Federal Reserve kept the interest rate at 0% from 2008 to 2015 in response to the Great Recession and sluggish growth rates afterwards (Amadeo 2020b).

b. The Yield Curve

The yield curve is simply the plot of yields on bonds against their maturities. According to (Estrella & Mishkin 1996), the yield curve is a simple yet effective tool that can mirror the healthiness of the economy and predict recessions. When the economy is growing, the yield curve is up-sloped or healthy. When the economy is about to decline, the yield curve is down-sloped, unhealthy or inverted. Besides the yield curves, the yield spread chart is equivalently helpful in speculating the economy. The yield spread is the difference between the yield on a long-term bond with the yield on a short-term bond. Commonly, the yield spread between 10 years with 2 years or between 10 years with 3 months are employed. The spread is positive when the yield curve is healthy. The spread is negative when the yield curve is unhealthy or inverted.

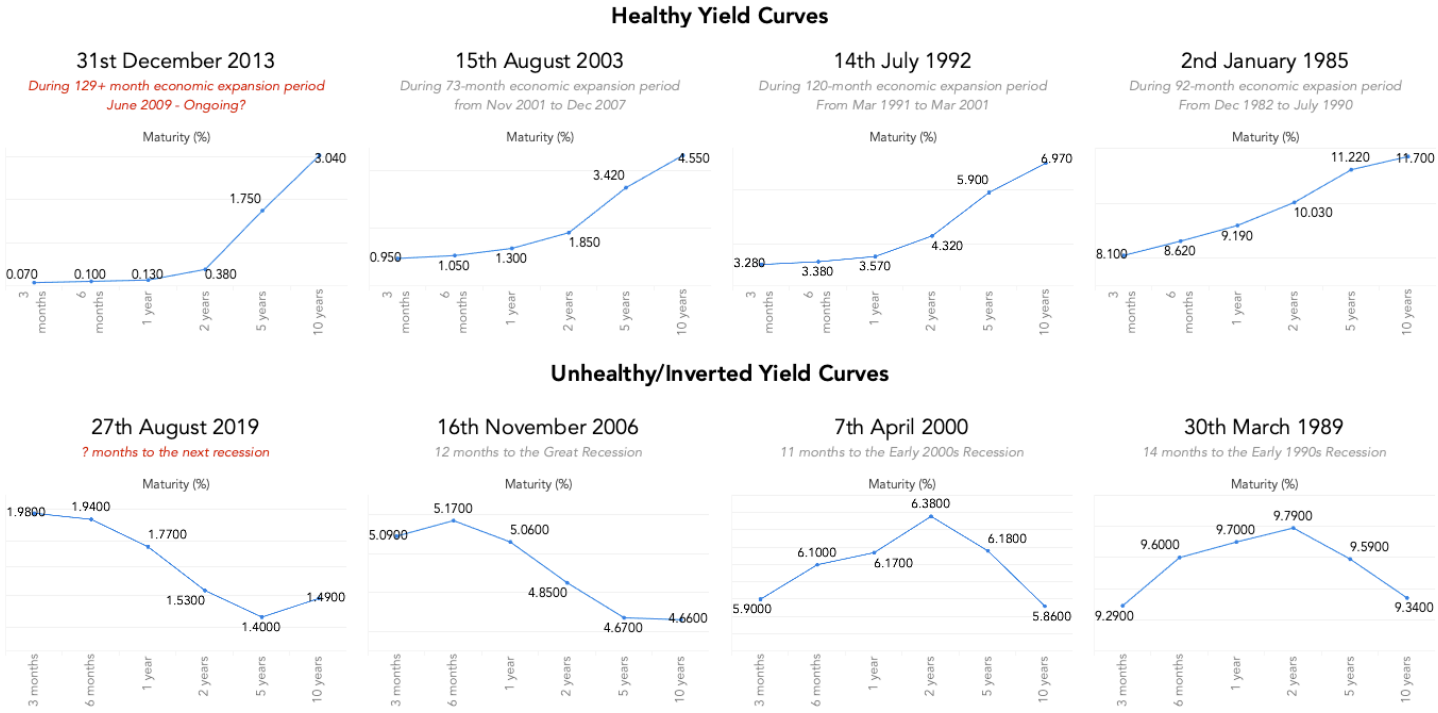


Figure 6. Healthy Yield Curves vs Inverted/Unhealthy Yield Curves

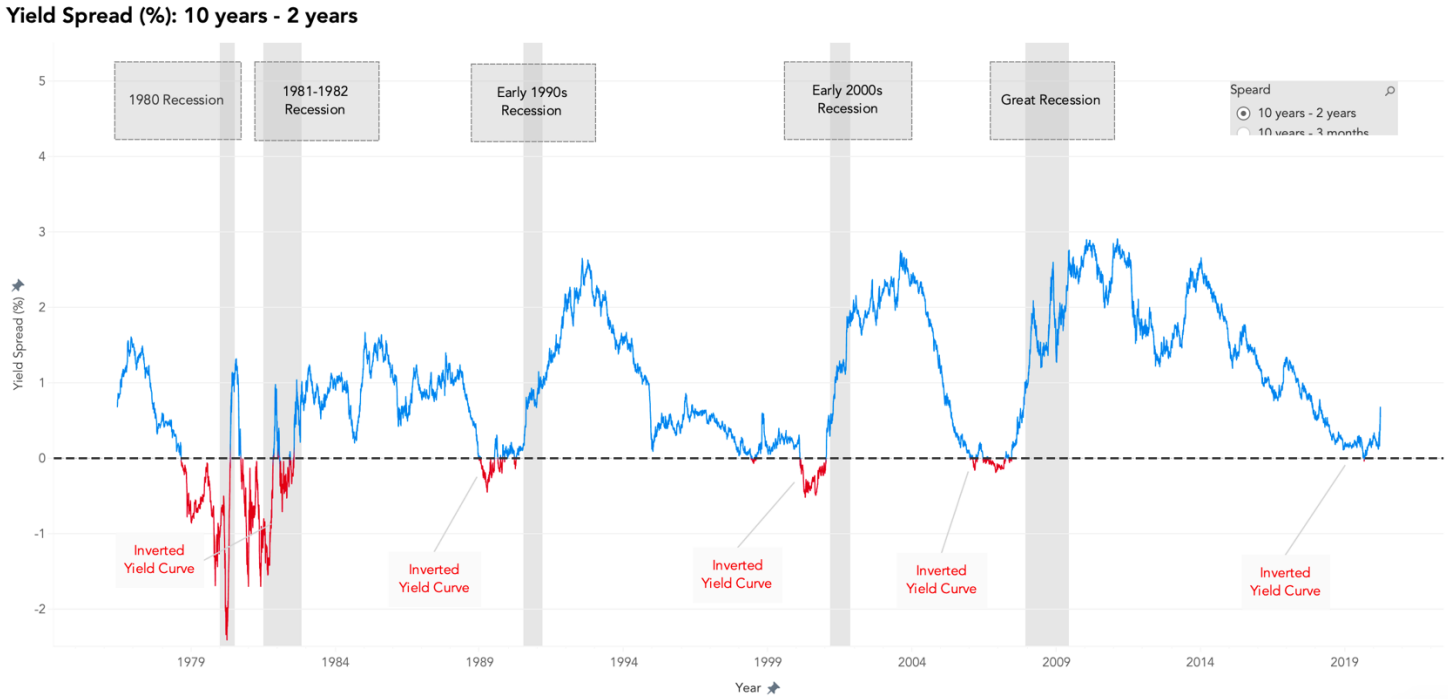


Figure 7. Yield Spread between yields on 10-year and 2-year bonds

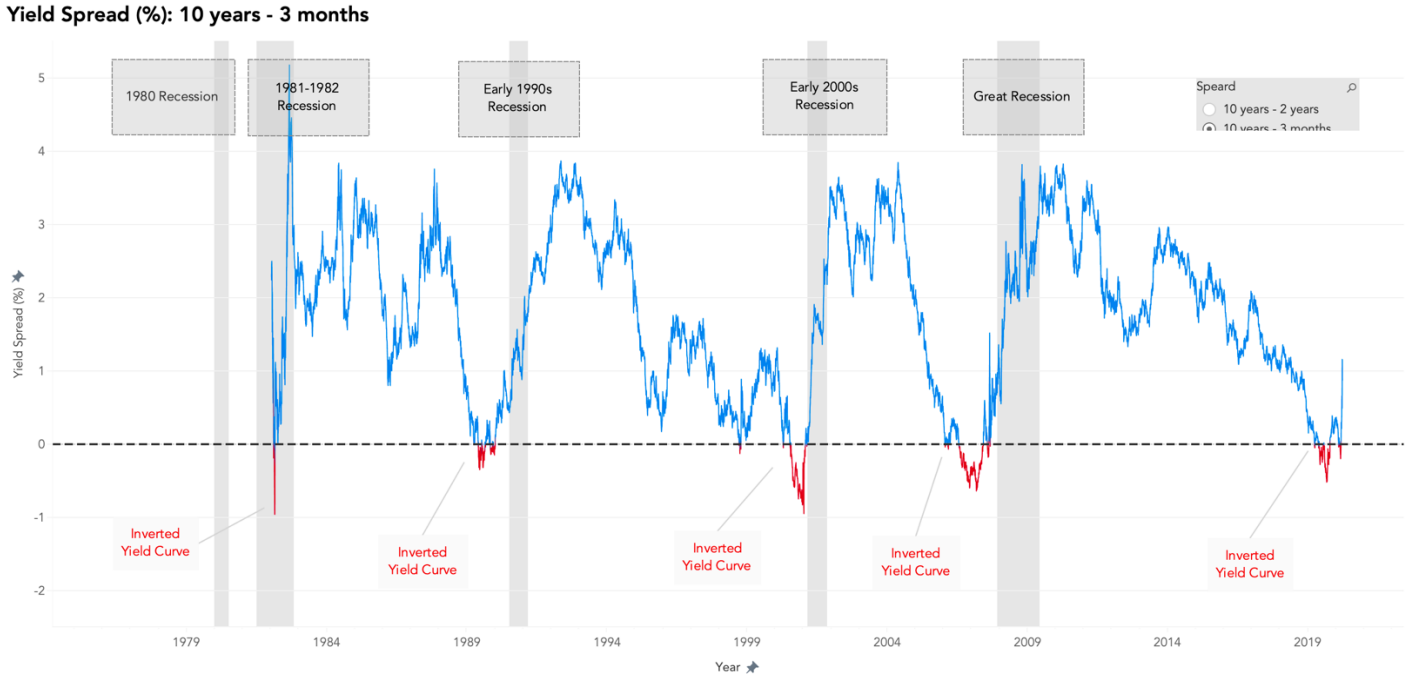


Figure 8. Yield Spread between yields on 10-year and 3-month bonds

When the economy is expanding, the yield curve becomes healthy and up-sloped. Yields on longer-term bonds are greater than yields on shorter-term bonds. Because, to stimulate the economy, the US Federal Reserve lowers the interest rate causing low yields on short-term bonds. Meanwhile, investors prefer risky investments to the Treasury Bonds whose market prices go down accordingly. This makes yields on long-term bonds going up. In such situations, healthy yield curves are observed during periods of economic expansion. Since World War II, durations of the economic expansions range from 12 months up to more than 120 months.

The current economic expansion is the longest period with 129 months and still counting. Nevertheless, amid the coronavirus pandemic in 2020, the current expansion is highly likely to come to a halt in the next few months.

Besides, the yield curve becomes down-sloped and inverted when there is an upcoming recession. When the economy grows too fast, the US Federal Reserve increases interest rate to control inflation. Yields on short-term bonds, thus, increase correspondingly. Investors are now in favour of safe investments like the Treasury Bonds. It triggers an increase in demand for the bonds, subsequently leading to an increase in their market price. As the market price of the bonds going up, the yields on the long-term bonds go down. Therefore, the yield curves tend to be down-sloped or inverted, i.e. greater yields on shorter-term bonds than yields on longer-term ones. According to (Estrella & Mishkin 1996), the inverted yield curves signal an upcoming slowdown or even recession in 6 to18 months. It clearly shows in Figure 7 and Figure 8 that the inverted yield curves (in red) appear right before recessions. Recently, one of the most apparent inverted yield curves was observed on 27th August 2019 as illustrated in Figure 6 above. This was shocking news for many investors during that period. Combining the fear of the economic decline with the current global pandemic, many economists foresee the next recession which will be even more severe than the Great Recession in 2008-2009, somewhat, an economic depression to come in 2020 or 2021 at the latest.

c. Why is visually predicting the US recessions important?

The US economy accounts for almost a quarter of the global GDP (Figure 9), one-fifth of the global FDI, one-third of the worldwide stock market capitalization. The US is the prime export destination for around one-fifth of countries around the world. The US dollar is the most widely-used currency in global trade and financial transactions (Kose et al. 2017a).

The magnitude of the US economy together with the ever-increasing globalisation make the rest of the world highly exposed to the world's biggest economy. Figure 10 suggests that, to a certain degree, there is a strong correlation between the word's GDP growth and the US's GDP growth in which both the former's and latter's troughs and peaks are observed simultaneously. According to Kose et al. (2017b), business cycles in the US and other Advanced Economies, as well as Emerging Market and Developing Economies are highly synchronous due to global trades and financial linkages. Unquestionably, the healthiness of the US economy is somehow the direct reflection upon the global economy's performance. Scrutinising the US economy and predicting its future recessions seem not to be the US's matters only but also other countries' considerations in the age of interconnectedness.

Appropriately, it implies great merit of understanding and visualising the yield curve. Policy-makers, corporations, academic bodies and even the public members could conveniently use the curve to evaluate and predict the healthiness of the US economy or even the world's thanks to its simplicity. Nevertheless, a single yield curve cannot provide a full picture of the US economy. The curve should be used for

reference purpose only. Any assumptions or predictions based on the yield curves must be cautiously justified. To make sound forecasts, fully studying other macroeconomic metrics and carefully considering the differences in the political and socio-economic contexts between countries is a must.

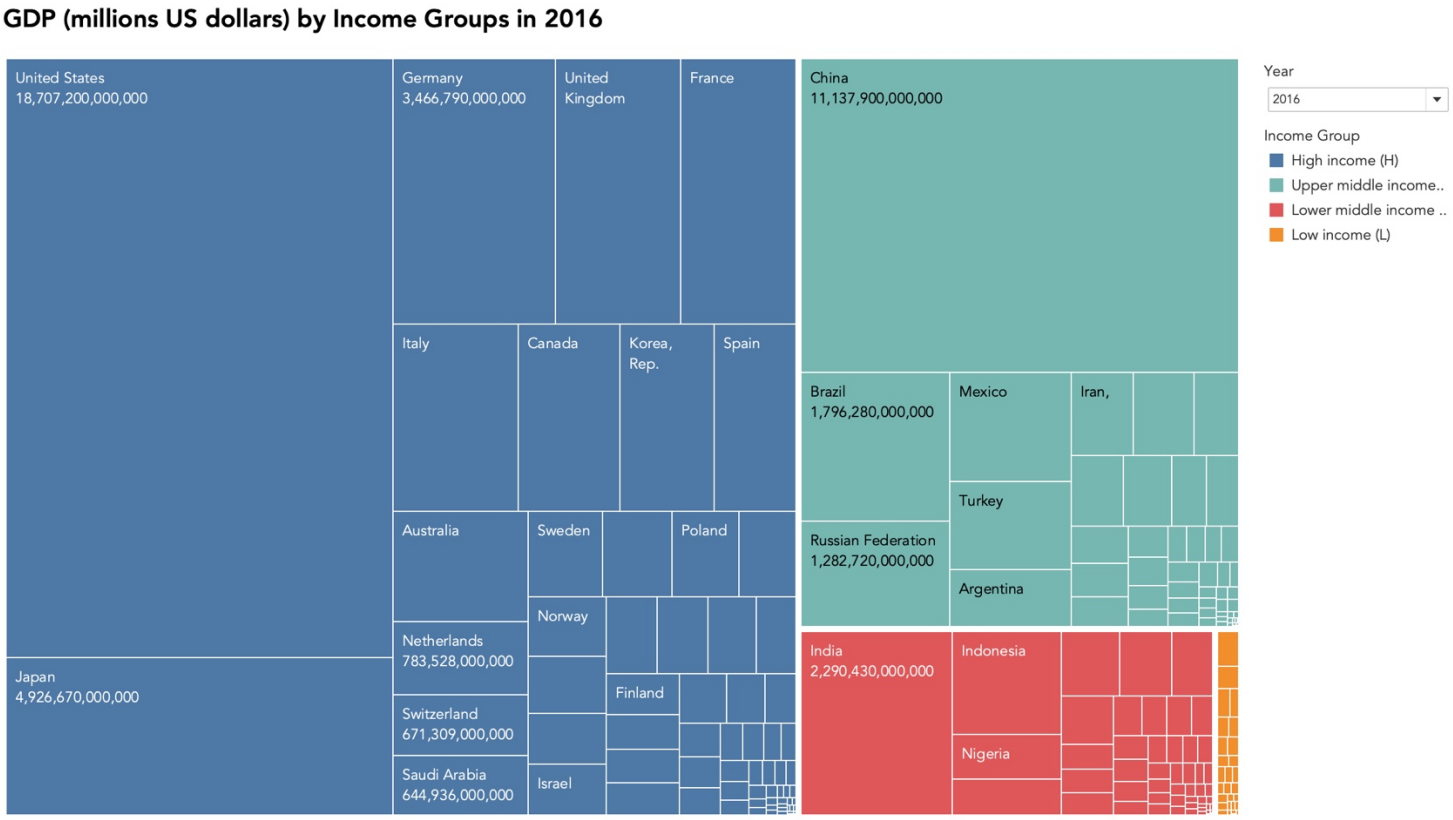


Figure 9. GPD by Income

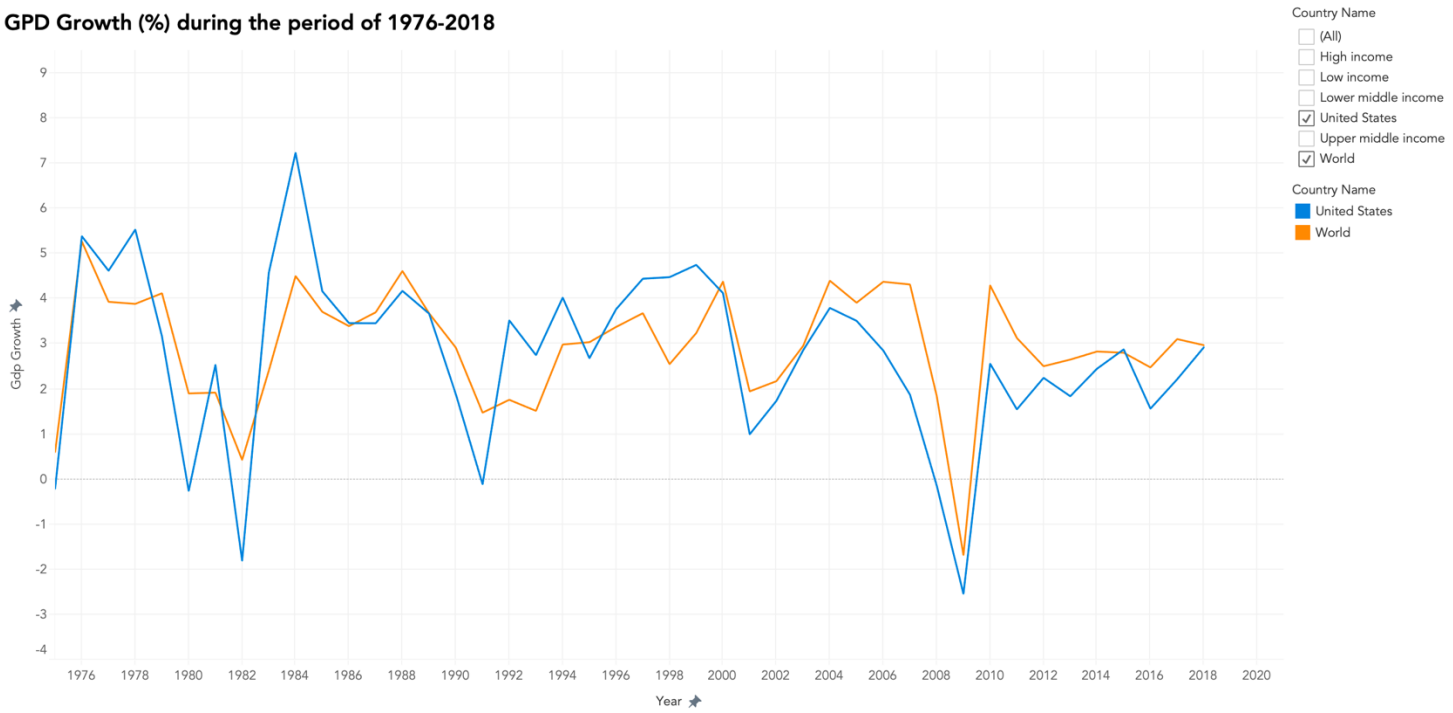


Figure 10. GDP Growth (%)

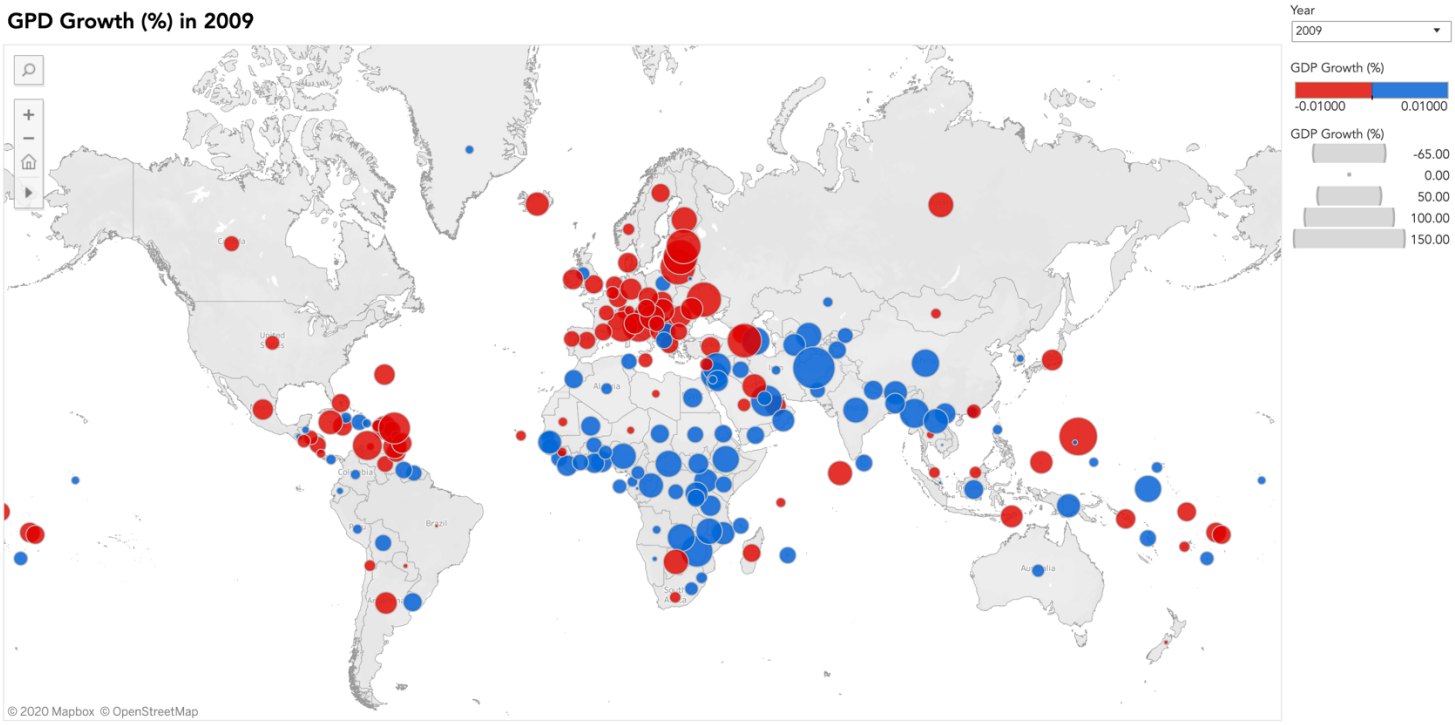


Figure 11. GDP Growth Map

4. Discussion

This univariate method of examining the yield curves or the yield spreads is fairly simple and straightforward to predict recessions in the US. However, to formulise and even improve recession probability forecast, Katayama (2008) suggested multivariate modelling of the yield spread, the S&P 500 Index and non-agricultural employment growth. Katayama's approach offered robust forecast performance which is superior to the use of the yield curves alone. Accordingly, this idea could be promisingly used for future work regarding predicting and visualising US recessions.

In terms of data-processing and visualising tools, there are several pros and cons for the use of RStudio and Tableau Public in this report. With regards to advantages, RStudio offers powerful libraries to gather, reshape and process data which then could be readily used for visualisation in the Tableau Public. Additionally, shareability in the Tableau Public seems to be the attractive feature empowering users to develop their visualising skills quickly by learning from other Tableau users on the Tableau Public Gallery which is known as the "social network" for the Tableau user community. Nevertheless, there are some downsides when it comes to visualising practices. Reproducibility could be a major drawback for the Tableau Public that making a single chart and its components including axes, legends, colours and formats could be fairly time-consuming since copies and pastes are not available in the software. Unquestionably, it leads to a tough challenge for duplications within a chart and between different charts in the Tableau Public. Besides, data associated with charts in the Tableau Public could be employed anonymously by other people without the owner's consent. That privacy issue is

handled by the Tableau Desktop which, however, might not be economical for some, i.e. 70 US dollars/month/user (Tableau 2020).

5. Conclusion

To encapsulate, the report combined macro-economic theories, design principles and capability of RStudio and Tableau Public software to provide a full account of visualising predictions for the US recessions with the yield curves. Correspondingly, there are three key takeaways that respond to the research questions outlined in the beginning as follows:

- When the yield curves are inverted or the yield spreads are negative, it signals an upcoming recession in 6 to 18 months. The yield curves, which are plots of yields on bonds against bond maturities, reflect the US Federal Reserve's monetary policy regarding the interest rate and the investors' sentiment of how healthy the economy is.
- There is likely to be an economic recession in the US in 2020 or 2021 at the latest as several inverted yield curves were observed in August 2019.
- Due to the global interconnectedness and the US's significant influence on the world, it is important to understand and visualise the yield curves so that predicting recessions for the US and other countries could be made. However, fully studying other macro-economic metrics together with carefully considering the differences in political and socio-economic contexts between countries are necessary to provide confident predictions.

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