PIRAEUS BANK

# *Modelling Recession Probability in US Economy*

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# Outline of the study

- **As the old adage goes expansions do not die of old age, rather they die due to the impact of excesses** (either in the real economy or financial markets) that the preceding years of strong growth and unchecked animal spirits have created.

- In that respect **the challenge for every economist is to try to identify, in a robust and accurate manner, the arrival of the turning points in each business cycle.** This challenge is more important in the current juncture, given the deterioration in both market sentiment and macro data in the US economy.

- **As always though, one could argue that this time is different given that the US economy has been expanding for an unusually long period of time,** monetary policy struggles to identify neutral levels and the macro economy is complicated with the cross-currents between tariffs and trade wars on one side and fiscal stimulus and tax cuts on the other.

- **Many analysts and investors have become more and more worried with the flattening of the US yield curve.** The term spread – the difference between long-term and short-term interest rates – has been an accurate predictor of future economic activity. **In fact, every US recession in the past 60 years was preceded by an inverted yield curve.** Moreover, a negative term spread was always followed by a considerable economic slowdown.

# Methodology of the study

- **We investigate in both univariate and multivariate probit model context the recession probability for 6, 12 and 24 months ahead for 14 different economic and financial variables variables.** In the short horizon (6 months), the difference between the rate of change of the leading and coincident indicators (denoted by DLDC) seems to be the most appropriate variable for recession probability estimation. In the long term (12 or 24 months) the yield curve slope seems to be the most suitable variable for recession probability estimation.

- Then, we try to enhance the estimation by using a combination of variables. **We conclude that the DLDC and the yield curve slope together with other macro & financial variables such as real policy rate, credit spread and stock market volatility, enhance our ability to estimate the probability of a recession in the US economy.**

- **The abrupt tightening of monetary policy and high degree of uncertainty over the future economic outlook are the most important indicators for triggering a recession.** Term spread reflects the difference between the short-term interest rates, which are driven by monetary policy decision, and long-term interest rates, which reflect mainly long-term growth prospects. **The sudden tightening of monetary policy** can also be reflected in the considerable divergence between the current real policy rate and its medium or long-term year average (for instance a five year moving average).

# Findings of the study

- **When the growth rate of the current conditions (coincident) indicators exceeds considerably the growth rate of the leading – expectations indicator can be a harbinger of high uncertainty over the future economic activity.** By the same token, when the yields of the corporate bonds exceed considerably the yields of the respective government bonds can be a precursor of high uncertainty and tepid business confidence over the expected economic outlook and financial conditions.

- **According to our estimates (based on the available data at the end of 2018), there is relatively low probability for recession for the next 12 or 24 months and extremely low probability for the next six months.** Furthermore, the anticipated softening in Fed's monetary policy will probably reduce further the estimated probability of recession, due to lower real fed fund rate, higher yield curve slope and lower credit spread.

- Moreover, a possible fiscal stimulus and/or **a mutual resolution of trade tariffs problem with China and the other major trade partners** will also probably reduce further the estimated probability of recession, due to higher confidence and leading indicators with higher domestic and foreign new orders.

# Definition of Recession

Business cycle contractions in the US economy affect global economy and global financial markets severely. NBER estimates the exact dates of the contractions (i.e. recessions) of the US business cycle since 19th century!

The NBER does not define a recession in terms of two consecutive quarters of decline in real GDP (as Eurostat does). Rather, a recession is defined as a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real GDP, real income, employment, industrial production, and sales (wholesale and retail).

## US Business Cycle Contraction Dates*

| BUSINESS CYCLE REFERENCE DATES | | DURATION IN MONTHS | | | |
|---|---|---|---|---|---|
| Peak | Trough | Contraction | Expansion | Cycle | |
| *Quarterly dates are in parentheses* | | *Peak to Trough* | *Previous trough to this peak* | *Trough from Previous Trough* | *Peak from Previous Peak* |
| | December 1854 (IV) | -- | -- | -- | -- |
| June 1857(II) | December 1858 (IV) | 18 | 30 | 48 | -- |
| October 1860(III) | June 1861 (III) | 8 | 22 | 30 | 40 |
| April 1865(I) | December 1867 (I) | 32 | 46 | 78 | 54 |
| June 1869(II) | December 1870 (IV) | 18 | 18 | 36 | 50 |
| October 1873(III) | March 1879 (I) | 65 | 34 | 99 | 52 |
| March 1882(I) | May 1885 (II) | 38 | 36 | 74 | 101 |
| March 1887(II) | April 1888 (I) | 13 | 22 | 35 | 60 |
| July 1890(III) | May 1891 (II) | 10 | 27 | 37 | 40 |
| January 1893(I) | June 1894 (II) | 17 | 20 | 37 | 30 |
| December 1895(IV) | June 1897 (II) | 18 | 18 | 36 | 35 |
| June 1899(III) | December 1900 (IV) | 18 | 24 | 42 | 42 |
| September 1902(IV) | August 1904 (III) | 23 | 21 | 44 | 39 |
| May 1907(II) | June 1908 (II) | 13 | 33 | 46 | 56 |
| January 1910(I) | January 1912 (IV) | 24 | 19 | 43 | 32 |
| January 1913(I) | December 1914 (IV) | 23 | 12 | 35 | 36 |
| August 1918(III) | March 1919 (I) | 7 | 44 | 51 | 67 |
| January 1920(I) | July 1921 (III) | 18 | 10 | 28 | 17 |
| May 1923(II) | July 1924 (III) | 14 | 22 | 36 | 40 |
| October 1926(III) | November 1927 (IV) | 13 | 27 | 40 | 41 |
| August 1929(III) | March 1933 (I) | 43 | 21 | 64 | 34 |
| May 1937(II) | June 1938 (II) | 13 | 50 | 63 | 93 |
| February 1945(I) | October 1945 (IV) | 8 | 80 | 88 | 93 |
| November 1948(IV) | October 1949 (IV) | 11 | 37 | 48 | 45 |
| July 1953(II) | May 1954 (II) | 10 | 45 | 55 | 56 |
| August 1957(III) | April 1958 (II) | 8 | 39 | 47 | 49 |
| April 1960(II) | February 1961 (I) | 10 | 24 | 34 | 32 |
| December 1969(IV) | November 1970 (IV) | 11 | 106 | 117 | 116 |
| November 1973(IV) | March 1975 (I) | 16 | 36 | 52 | 47 |
| January 1980(I) | July 1980 (III) | 6 | 58 | 64 | 74 |
| July 1981(III) | November 1982 (IV) | 16 | 12 | 28 | 18 |
| July 1990(III) | March 1991(I) | 8 | 92 | 100 | 108 |
| March 2001(I) | November 2001 (IV) | 8 | 120 | 128 | 128 |
| December 2007 (IV) | June 2009 (II) | 18 | 73 | 91 | 81 |

*Source: US NBER

# Can we predict a recession?

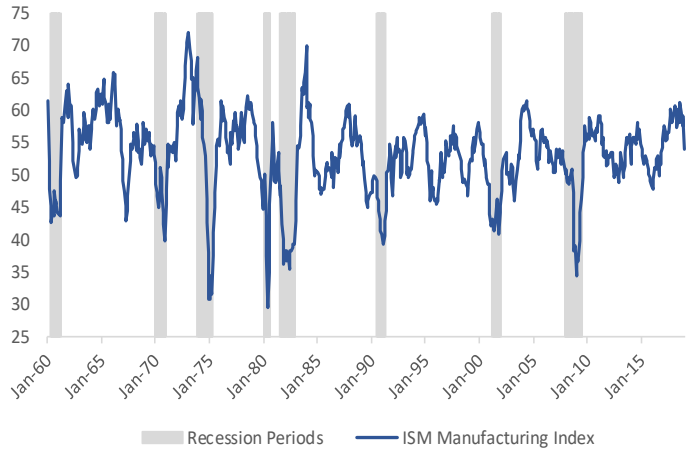
Estimating the probability of US recession for six, twelve, and twenty four months ahead is critical for both macroeconomic forecasting and asset allocation purposes. Looking at the relative literature we observe that several economic and financial variables have been proposed as plausible candidates for providing a credible signal for an upcoming recession.

- Leading indicators, such as ISM Manufacturing Index, Consumer Sentiment Index and Leading Index of Conference Board.
- Yield curve data, such as slopes of 10Y-2Y, 10Y-3M and 30Y-3M.
- Credit spreads, such as IG or HY corporate bond yield vs 10Y Treasury bond yield.
- Stock market data, such as volatility or return on the S&P500 Index.
- Hard economic data, such as labor market data, manufacturing orders and real policy rate.

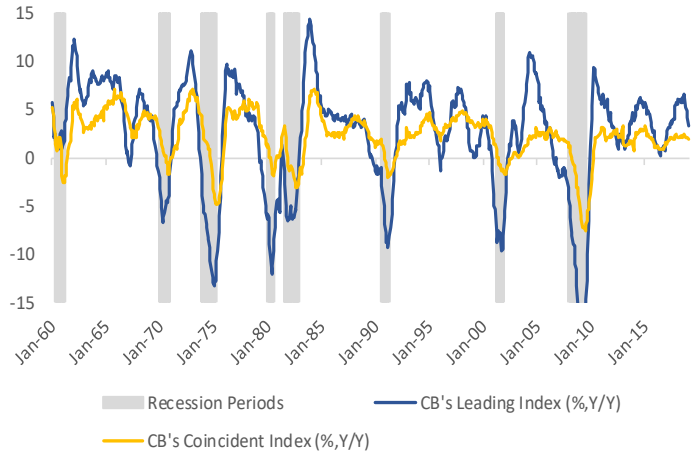
Source: Piraeus Bank Research

# Some indicative charts

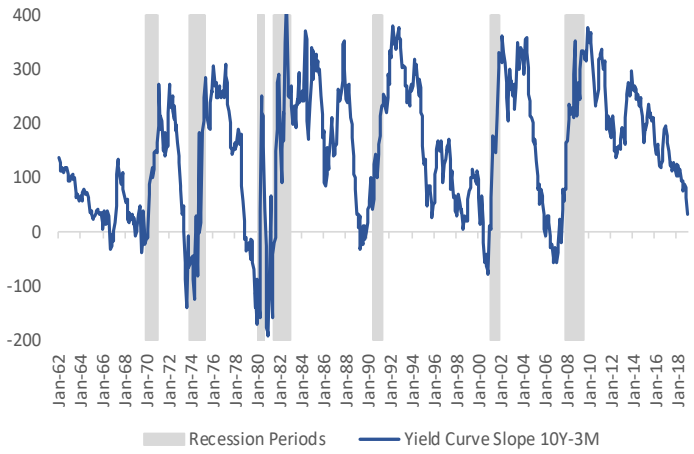
## ISM Manufacturing Index vs Recession Periods



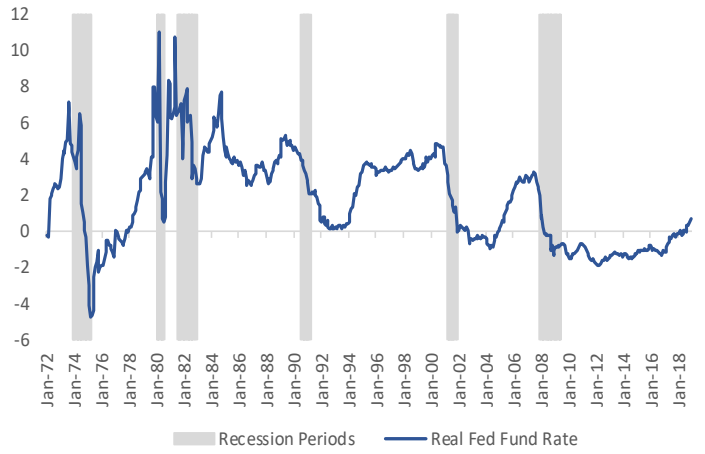

## Change in Leading Index vs Recession Periods




## 10Y-3M Spread vs Recession Periods




## Real Fed Fund Rate vs Recession Periods




Source: Datastream, Fed, NBER, CB, BLS, BEA, Fed Bank of St Louis, Census, Piraeus Bank Research

# First Step of Recession Detection

We will investigate whether there are variables which can predict recession for six, twelve, and twenty four months ahead at some level of statistical significance. We use 42 different univariate probit models for 14 different economic and financial variables (as shown in the following table) for three different forecasting horizons (6 months, 12 months and 24 months ahead).

$$Pr(Y_t=1|X_{j(t-k)}) = \Phi(\alpha + \beta X_{j(t-k)}) \Longleftrightarrow Y_t^* = \alpha + \beta X_{j(t-k)}$$

$$0 \le Pr(Y_t=1|X_{j(t-k)}) \le 1$$

*We use the McFadden R-squared indicator to select the best model for each time horizon.*

*where Y* takes the value of 1 when recession occurs and 0 otherwise, $X_j$ represents 15 different economic-financial variables, Φ is the cumulative distribution function of the standard normal distribution and k = 6 months, 12 months and 24 months.*

| |
|---|
| ISM Manufacturing Index (ISM) |
| Change in CB's Leading Index (DLI) |
| Change in Core Capital Goods Orders (CGO) |
| Unemployment Rate (Deviation from MA(5Yr)) (DUR) |
| Real Fed Fund Rate (Deviation from MA(5Yr)) (DRR) |
| US-10Y Yield minus US-3M Yield (SPR10Y3M) |
| US-10Y Yield minus US-2Y Yield (SPR10Y2Y) |
| US-30Y Yield minus US-3M Yield (SPR30Y3M) |
| US Corporate AAA Yield minus US-10Y Yield (SPRA) |
| Stock market impied volatitily index VIX (Deviation from MA(5Yr)) (DVIX) |
| UoM's Consumer Expectations Index minus UoM's Consumer Current Conditions Index (DCCI) |
| UoM's Consumer Sentiment Index (CSI) |
| ISM Manufacturing New Orders Index minus ISM Manufacturing Inventories Index (DISM) |
| Change in CB's Leading Index minus Change in CB's Coincident Index (DLICI) |

Source: Datastream, Fed, NBER, CB, BLS, BEA, Census, Fed Bank of St Louis, Piraeus Bank Research

# Conclusions from the first step

DVIX, SPR10Y3M and DLICI provide the best signal (i.e. the best model "fit") over a 6-month horizon. ➡ DLICI gives the best.

DRR, SPR30Y3M and DLICI provide the best signal over a 12-month horizon.
➡ SPR30Y3M gives the best.

DRR, SPR10Y2Y, SPRA and DLICI provide the best signal over a 24-month horizon.
➡ SPR10Y2Y gives the highest.

- Yield curve spreads – slopes and difference between the annual change rate of CB's Leading Index and the annual change rate of CB's Coincident Index seem to be useful in all cases. **Indeed, yield curve slopes have predicted correctly the seven out of the seven most recent recession episodes.**
- Sizable deviation (from the five year moving average) of stock market volatility index and real Fed Fund Rate seem to be useful in some cases. Credit spreads also seem to be useful in some cases reflecting heightened uncertainty.
- Data from **leading indicators** and **stock market volatility** seem to be more useful when we need to predict the probability of recession over shorter time horizon. Data from **yield curve slopes, credit spreads and real policy rate** seem to be more useful when we need to predict the probability of recession for 12 or more months ahead.

Source: Piraeus Bank Research

# Second Step of Recession Detection & Conclusions

We will investigate whether there are combinations of variables which can predict recessions for six, twelve, and twenty four months ahead at better level with multivariate probit models. The selection of explanatory variables is limited from the univariate scope, due to the fact that we employ variables with historical record large enough to cover at least the last five recession periods. We should note that during the first half of the ’80’s decade two recession episodes took place.

For six months ahead, we select the multivariate probit model which includes DLICI, SPR10Y3M and SPRA as explanatory variables and comprises the last seven recession periods.

For twelve months ahead, we select the multivariate probit model which includes DLICI, SPR30Y3M and DRR as explanatory variables and comprises the last five recession periods.

For two years ahead, we select the multivariate probit model which includes DLICI, SPR10Y2Y, SPRA and DRR as explanatory variables and comprises the last five recession periods.

We could enhance the above models by including DVIX as an additional explanatory variable but this inclusion does not meet our self-imposed constraint of a sample size that includes at least the last five recession periods.

Source: Piraeus Bank Research

# Intuitive interpretation of our results

**The sudden tightening of monetary policy** is probably the most important reason to trigger a recession. Yield curve slopes flatten and even invert during these periods as short rates climb above the level of the long term interest rates.

**The sudden tightening of monetary policy** can also be reflected in the considerable divergence between the current real policy rate and its five year average. Another appropriate metric could be the considerable divergence between the current real policy rate and its neutral – natural level (as defined by Laubach – Williams econometric approach). When the former exceeds considerably the latter can be too burdensome for the economy, especially when households and non-financial corporates are highly leveraged.

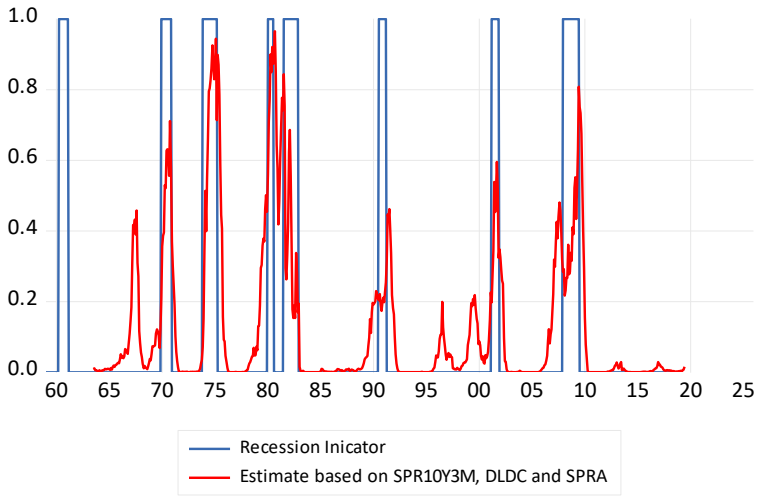
**The considerable discrepancy between the leading (expectations) indicators and current – coincident indicators** is also one of the most important reasons to trigger recession. Specifically, when the growth rate of the current conditions (coincident) indicators exceeds considerably the growth rate of the leading – expectations indicator can be a forerunner of a recession period.

The widening of the credit spreads is also one of the most indicative reasons for triggering recession. When the yields of the corporate bonds exceed considerably the yields of the same maturity government bonds can be **a flag of high uncertainty over the expected economic outlook and financial conditions.** Likewise, high uncertainty can also be reflected in the sudden increase of the stock market volatility indicator (the considerable divergence between the current VIX level and its five year average).

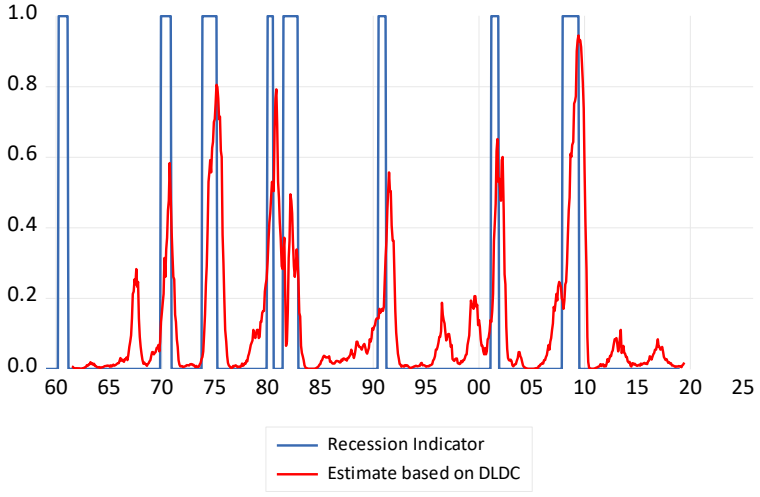
Source: Piraeus Bank Research

# Recession Probability: 6 months ahead

## Estimate with the multivariate probit model




## Estimate with the univariate probit model



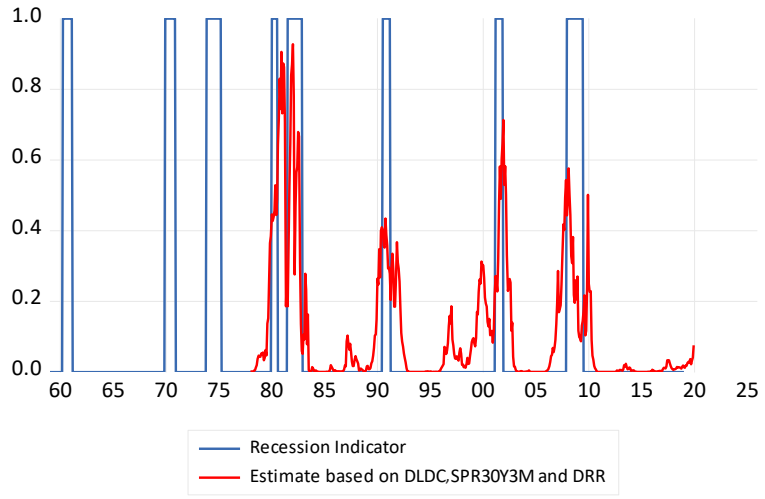

Based on the available data at the end of 2018, both models (univariate and multivariate) estimate less than a 5% probability of recession for the next six months (Jun. 2019)

Therefore, there is no reason for worrying for recession for the next six months according to our estimates.

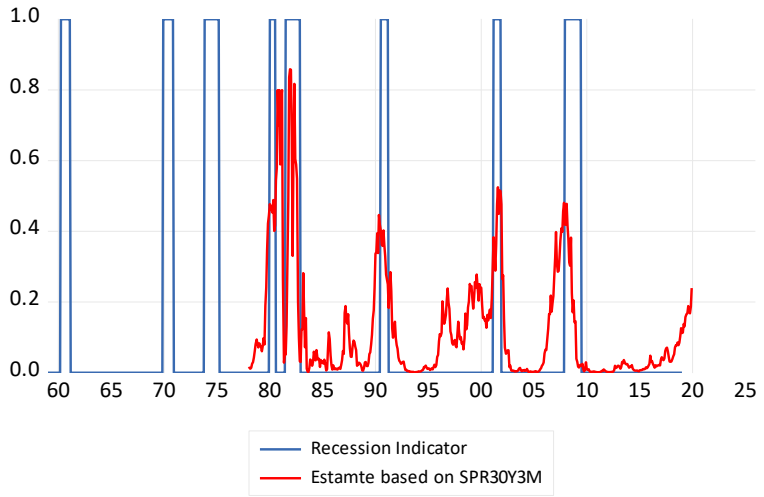
Source: Piraeus Bank Research

# Recession Probability: 12 months ahead

## Estimate with the multivariate probit model




## Estimate with the univariate probit model



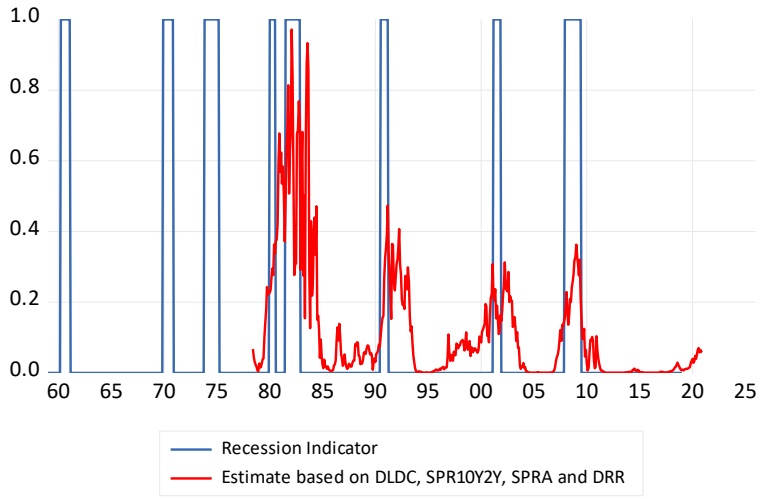

The univariate model estimates almost 25% probability of recession for the next 12 months (Dec. 2019).
The multivariate model estimates almost 10% probability of recession for the next 12 months (Dec. 2019).
Taking into consideration more variables (than simply the yield curve spread – slope) the estimate of the probability of recession declines.

Therefore, there is relatively low probability for recession for the next 12 months according to our estimates. We should note that the anticipated softening in Fed's monetary policy will probably reduce further the estimated probability of recession, due to the anticipated lower real fed fund rate, higher yield curve slope and lower credit spread. Moreover, a possible fiscal stimulus and/or a mutual resolution of trade tariffs problem with China and other major trade partners will also probably reduce further the estimated probability of recession, due to higher confidence and leading indicators.

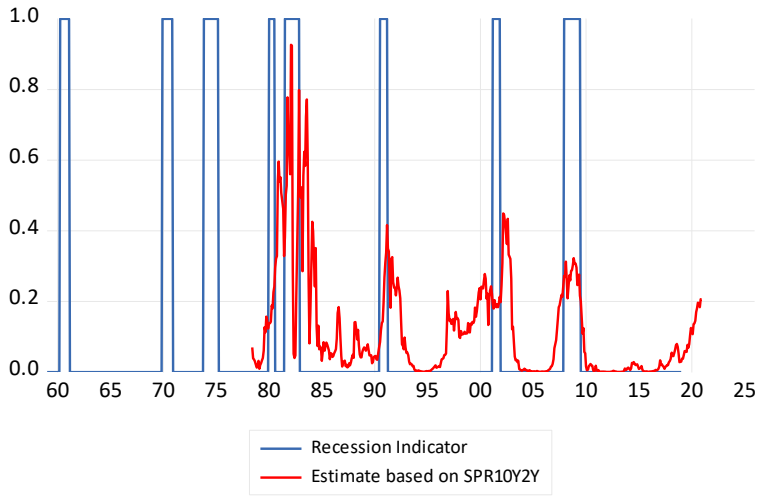
Source: Piraeus Bank Research

# Recession Probability: 24 months ahead

## Estimate with the multivariate probit model




## Estimate with the univariate probit model




The univariate model estimates almost 20% probability of recession for the next 2 years (Dec. 2020).
The multivariate model estimates almost 10% probability of recession for the next 2 years (Dec. 2020).
Taking into consideration more variables (than simply the yield curve spread – slope) the estimate of the probability of recession again declines.

Therefore, there is relatively low probability for recession for the next 2 years according to our estimates. Again, we should note that the anticipated softening in Fed's monetary policy will probably reduce further the estimated probability of recession.

Source: Piraeus Bank Research

# Appendix with Quantitative Results

## 24 months ahead

$$Prob(recession)_t = -0.109 - 0.105*DLDC_{t-24M} - 1.09*SPR10Y2Y_{t-24M} + 0.185*DRR_{t-24M} + 0.005*SPRA_{t-24M}$$

(p-value) (0.00) (0.00) (0.01) (0.01)

with McFadden R_sq = 35%

## 12 months ahead

$$Prob(recession)_t = -0.465 - 0.145*DLDC_{t-12M} - 0.727*SPR10Y2Y_{t-12M} + 0.115*DRR_{t-12M}$$

(p-value) (0.00) (0.00) (0.07)

with McFadden R_sq = 41%

## 6 months ahead

$$Prob(of\ recession)_t = -1.089 - 0.255*DLDC_{t-6M} - 0.425*SPR10Y3M_{t-6M} + 0.003*SPRA_{t-6M}$$

(p-value) (0.00) (0.00) (0.07)

with McFadden R_sq = 45%

## Concluding Remarks

- Lower term spreads lead to higher probability of recession.
- Higher divergence of real policy rate from its medium or long-term average leads to higher probability of recession.
- Higher credit spreads lead to higher probability of recession.
- Lower leading indicators compared to coincident indicators lead to higher probability of recession.

Source: Piraeus Bank Research

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