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A NEW WAY OF FORECASTING RECESSIONS

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ABSTRACT

This paper proposes a new way of displaying and analyzing macroeconomic time series to form recession forecasts. The proposed data displays contain the last three years of each expansion. These allow observers to see for themselves what is different about the last year before recession. Based on a statistical model, the most recent data are then probabilistically inserted into these images where the recent data are most similar to the historical data. This amounts to a forecast. The traditional probit model used to forecast recessions inappropriately treats every observation as a separate experiment. This new method deals with these intra-correlation issues. The one variable that is causing a recession alarm is inflation. The unemployment rate is also alarming if the covid-19 data are omitted. The slope of the yield curve, the three-month Treasury yield, and housing starts are all two or three years from the end of the expansion. A probit model that conducts a "horse race" among these five variables reveals it is the bond market variables that best predict recessions. This leaves the Fed under control, but the 1970s data suggests it takes a recession to combat high inflation.

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A data appendix is available at http://www.nber.org/data-appendix/w30247

1. Introduction

The contributions of this paper are data displays that capture clearly the evidence of forthcoming recessions and a statistical analysis that turns that visual evidence into recession forecast probabilities. The visual displays contain the last three years of data from each expansion, which allow us literally to see the symptoms of an oncoming recession in the year before recession in contrast with the two earlier years. A model-based statistical analysis determines probabilistically where the most recent data belongs in the three years of data. This is the basis for answers to the question: which is more probable, a recession in one year, two years or three years.

My implicit advice is that economists should "show" the evidence in support of their beliefs, where the word show refers to visual images that can be processed by the audience. I believe that members of the audience can easily understand how the proposed figures capture the relevant data and can "see" where the most recent data best fits in the historical data, which confirms the formal numerical analysis.

The "foil" for this new idea is the frequently used estimation method which deploys a binary dependent variable referring to either the recession periods or to the last year of expansions. As documented in the companion paper Keil, Leamer and Li(2022) the first recession forecasting model with a binary dependent variable for recession and an interest rate explanatory variable was studied by Estrella and Hardouvelis (1991). Stock and Watson (2003), and Wheelock and Wohar (2009) offer very useful surveys of the earlier literature on this subject.[2]

[2] Leamer(2009) was (apparently) the first to use an indicator of the last year of expansions as the dependent variable. The idea of forecasting recessions by contrasting the data in an alarm period with a comparison period has been discussed in Keil, Leamer and Li(2022). Their method of contrast is to estimate a probit model with a binary dependent variable equal to one in the last year of expansions and zero otherwise, and to use an interest rate spread and other variables as the explanatory variables. They exclude from the comparison group both recessions and recoveries.

I explain in Section 2 that a probit analysis can search numerically for ways in which the last year of expansions was different from the earlier expansion data, and it discovers very relevant information but I argue here that the image of the data underlying a probit analysis doesn't come close to revealing the information contained in the new figures. In addition, the probit model doesn't control for the fact that recessions months/quarters are necessarily adjacent to other recession months/quarters. The probit analysis is based on the implicit assumption that each observation is another independent experiment. The data displays recommended in this document reveal that the effective number of experiments is the number of expansions in the data set, which is either six or seven in the cases discussed below, far less the probit observation count of 489. In addition, translating the probit probabilities assigned to the most recent 12 months into a recession-in-the-next-year prediction is a complicated task which can lead to an improbably large probability of recession.

The discussion of the new methodology in Section 3 focuses on the spread between the yield of the 10-year Treasury and the 3 month Treasury. The interest rate spreads in Figure 2 reveal that a flat or inverted yield curve is a symptom of the last year of the expansion, but the current slope of the yield curve of about 140 basis point fits best the third year before recession not the first. I have identified in the graph both the Volcker and the Burns data. Volcker and Burns chose record negative values of the interest rate spread not long before the recessions came. Their choices are very relevant for today's situation.

Section 4 is a discussion of the recession probabilities suggested by other variables. This section includes the 3-Month Treasury yield, the inflation rate, the unemployment rate and housing starts. The three-month Treasury yields in Figure 10 grew steadily across the three years before recessions but the most recent data wants to be placed as far from the end of the expansion as possible. The inflation image, Figure 13, raises great concern because it reveals that inflation rose to very high levels in the year before recessions in the Volcker and Burns eras, and the current dramatic increase in inflation matches those episodes. The unemployment image, Figure 16, reveals that our current low unemployment rate is also a symptom of the last year of recession, if the covid-19 data are excluded. With the covid-19 data our recent unemployment levels have taken a path never seen before. The housing starts data illustrated in Figure 19 reveals that starts decline very near the end of the expansion, and the housing starts through May 2022 do not support the conclusion that we are in the last year of this expansion.

Section 5 mixes together the conflicting evidence offered by these five variables into a single conclusion about the recession risks. This is where the visual images falter because they work well only for one variable at a time. The probit approach which is criticized in Section 2 is used in this section to create a "horse race" among the variables that might predict recessions. The conclusion is that it's the bond market yields , not inflation, unemployment or housing starts that are the critical forecasting variables. It's an inverted yield curve which is correcting itself with an increase in the spread, and also a high 3-month Treasury yield that best predict the outcome. This implies that the Fed can avoid a recession with wisely chosen values of the 3-month Treasury. But can those choices control inflation? Section 5 includes a discussion of the Phillips curve data comparing inflation and unemployment during the troubling 1970s. Figure 22 which displays the inflation and unemployment rates from 1959 through 1981 has three recessions with big jumps in the unemployment rate followed by big reductions in inflation. That confirms that it took a recession to bring the rate of inflation down in the 1970s.

2. Probit Study Issues

Table 1 is an estimated probit model with the binary dependent variable equal to one in the 12 months before recessions and the explanatory variable T10Y3M equal to the yield on a 10-year Treasury minus the yield on a 3 Month Treasury. The sample excludes recessions and recoveries, and extends from the first month after the recovery from the 1953 recession, 1955M07, to the month before covid19 wrecked the data, 2020M02. The z-statistic equal to -9.080 suggests that the impact of the interest rate spread is highly detectable, but the correlations across time of the data are ignored and the z-statistic is overstated.

I teach my students that data analysis should have three steps: pictures, stories and last of all numbers. Table 1 has a bunch of complicated numbers which should come after the pictures, first, and the stories, second. I firmly believe that the pictures and stories do a better job describing the data than numbers. For example, the essence of this probit study is captured by Figure 1 which is a scatter diagram comparing the binary variable indicating the last year of expansions on the vertical axis with the interest rate spread on the horizontal axis. The data points are represented with black circular markers, with the data in the last year of the expansions at the top and the data in the other periods at the bottom. The curve linking these two clusters of points is the estimated probit model reported numerically in Table 1. This figure shows exactly where that curve is located. A spread of zero intersects the probit curve a little above the 50 percent mark. What this means is that a spread of zero predicts a 50 percent chance that this month is in the last year of a recession. For that to be the case the recession must start no later than 12 months into the future. Moreover at the May 2022 spread of 1.92, this probit model assigns the probability 0.003, virtually zero. That is all very relevant information.

An important problem is that this probit analysis treats every observation as a separate experiment. In a time series setting, it is always appropriate to explore what happens if you include a lagged dependent variable. When the lagged dependent variable is added to the probit model in Table 1 Eviews responds with the error message: “Quasi-complete separation: _1YRPRE(-1)>0 perfectly predicts binary response success.” The results reported in Table 2 address this problem by showing what happens if instead of all 12 months before recessions only one month is included. The top row refers to the month that is included beginning with -12 referring to 12 months before recession. The last column labelled ALL reports results from the probit model reported in Table 1. The bottom row reports the number of observations with the dependent variable equal to one. This varies because there are only seven months between the end of the recovery after the 1980 recession and the subsequent 1981 recession. The numbers 8 or 9 refer to the number of recessions for which data are included. This contrasts with a count of 103 in the column labelled ALL. This count of more "experiments" than recessions is one reason why the z-stat in the ALL column is so much larger than in the one-month-at-a-time columns. But this change in the model still leaves 386 observations in the expansions before the last year, and treats all of them as separate experiments. This issue and also correlation issues are dealt with in the next section.

Another feature in Table 2 that deserves attention is the fact that estimated coefficient in the ALL column (-1.33) is larger than any of the single month coefficients. This moves the conversation into how to use these models to predict future recessions. Table 3 reports the probit forecast probabilities assigned to the 12 most recent months June 2021 to May 2022 for each of the models identified in Table 2. The last column reports T10Y3M, the spread between the 10-year and the 3-month Treasury yields. The probabilities in each of these columns move inversely with the T10Y3M data. The next-to-last column reports the probabilities assigned by the model with all 12 months before recessions included. Per this model, there is a 4% chance that June 2021 is in the last year of the expansion, in other words that June 2022 will be in recession.

The yellow-shaded diagonal identifies the implications of June 2022 being a recession month. This makes June 2021 twelve months before recession and July 2021 eleven months before recession, and so on. Each of these probabilities on the diagonal are relying on a different spread and a different model, but all are predicting a recession in July 2022. How, I ask rhetorically, should we combine them for a probability of a recession in July 2022?

The shaded region above the yellow diagonal refers to events that we can assign zero prior probability if we take as given that there will be no official recession at any point through May 2022. Thus, for example, June 2021 can be 12 months before recession but cannot be eleven months or fewer before recession. The SUM* column sums across columns the probability on and below the diagonal. These are meant to complete with the ALL column, but are much smaller.

The column START* uses the ALL probabilities to form probabilities for recession starts in each of the months from June 2022 to May 2023. The first two probit probabilities 0.034 and 0.061 in the ALL column refer to June and July 2021 being in the year before recession. The only way that a recession could start in June 2022 is if June 2021 were in the last year of the expansion, which has probability 0.34. The only way a recession could start the next month in July 2022is if June 2021 were *not i*n the last year of expansion and July 2021 is, which occurs with probability (1-0.034)*0.037=0.061. The required absence of earlier starts at each month of the calculation translates into the start probabilities that are increasing reduced from the original probit estimates. These start probabilities sum to 33.9% - that is the probability that a recession will begin in one of the 12 months beginning 2022M06. The biggest risks are in July and August. We will need to see what the new method suggests about the regression probabilities.

3. An Innovative Alterative

A Useful Image

The method discussed in this document makes use of the kind of visual display of the data in Figure 2 which depicts the monthly average interest rate spreads in the last three years of previous expansions since 1953, including only the expansions with three years of data preceding the recession. The legend refers to the last month of these seven expansions, the oldest episode ending 1958M08 and the most recent ending 2007M12. This image is clearly revealing that a flat or inverted yield curve is a symptom that occurs most frequently in the last year of the expansion, although there were inverted yield curves in the months 13 to 17 in the episode that ended in 2007M12, and also in the months 13 and 14 in the episode that ended in 1980M01. There are no cases of inverted yield curves in the 3rd year before recessions.

The largest negative spreads occurred at the ends of the expansions labelled 1973m11 and 1980m01, when the Fed Chairs were Arthur Burns and Paul Volcker respectively. Volcker became Fed Chair in August 1979. That month and the subsequent Volcker months are revealed with black markers in this image. The current debate is whether we need to repeat the 1970s to control inflation with the kind of very aggressive monetary policy used by both Burns and Volcker.

The causal story that explains the effect of an inverted yield curve on the economy points out banks make intermediation profits by taking deposits at low rates of interest and making longer term loans at higher rates. When the slope of the yield curve is at zero, there are no intermediation profits and the banks are forced to concentrate on risk management by identifying the borrowers who are most likely to pay back the loan and to charge higher rates of interest to the less credit-worthy borrowers. When Burns and Volcker chose inverted yield curves in excess of 100 basis points they made it much harder for banks to fund loans for homes, consumer durables, equipment and software, and business structures.

The monthly means of these interest rate spreads are depicted in Figure 2 with open circles. These means are moving lower as the recession gets closer, attaining negative values 6 months before the next recession, but the mean spreads rise in the last four months before recessions presumably as the Fed started to worry about the imminent recession.

Triangular markers identify the 12 months of data ending in June 2022, placed hypothetically not at the end of the expansion, but at 21 months before the next recession. I ask rhetorically: do you like the placement of these most recent data? Do you agree that the current steep yield curve is clearly incompatible with the last year of the historical data? Can this visual conclusion be turned into a number? That is a goal of the numerical analysis that comes next.

My first opinion is that Figure 2 does a better job of defining the forecasting task and revealing the historical evidence than Figure 1 which depicts the probit scatter diagram of the binary indicator versus the predictor.

Probabilistic Assessment

The placement of the last several months of data into Figure 2 comes from treating the historical data as seven independent draws from a multivariate normal distribution with a mean vector $\boldsymbol{\mu}$ and a covariance matrix $\boldsymbol{\Omega}$.

$$f(\boldsymbol{y}_j|\boldsymbol{\mu},\boldsymbol{\Omega}) = (2\pi)^{-n/2}|\boldsymbol{\Omega}|^{-1/2} exp\left[-\frac{1}{2}(\boldsymbol{y}_j-\boldsymbol{\mu})'\boldsymbol{\Omega}^{-1}(\boldsymbol{y}_j-\boldsymbol{\mu})\right] \qquad j = 1,2,\ldots,p \quad (1)$$

$$\boldsymbol{y}_j: (36\times 1), \quad \boldsymbol{\mu}: (36\times 1), \quad \boldsymbol{\Omega}: (36\times 36)$$

Then to locate, for example, the two most recent values optimally among the 35 alternative locations we can extract the 2-dimensional adjacent subsets of the mean and variance,

$$\boldsymbol{\mu}_i^s = \begin{bmatrix}\boldsymbol{\mu}_{i+1}\\ \boldsymbol{\mu}_i\end{bmatrix}, \qquad \boldsymbol{\Omega}_i^s = \begin{bmatrix}\boldsymbol{\Omega}_{i+1,i+1} & \boldsymbol{\Omega}_{i+1,i}\\ \boldsymbol{\Omega}_{i,i+1} & \boldsymbol{\Omega}_{ii}\end{bmatrix}, \qquad i = 1,2,\ldots 35$$

Assuming prior probabilities for each of the 35 outcomes equal to 1/35, the posterior probability that the data **r** comes from the ith distribution is just the normalized likelihood value

$$P(i|\boldsymbol{r}) = \frac{|\boldsymbol{\Omega}_i^s|^{-1/2} exp\left[-\frac{1}{2}(\boldsymbol{r}-\boldsymbol{\mu}_i^s)'(\boldsymbol{\Omega}_i^s)^{-1}(\boldsymbol{r}-\boldsymbol{\mu}_i^s)\right]}{\sum_{k=1}^{35}|\boldsymbol{\Omega}_k^s|^{-1/2} exp\left[-\frac{1}{2}(\boldsymbol{r}-\boldsymbol{\mu}_k^s)'(\boldsymbol{\Omega}_k^s)^{-1}(\boldsymbol{r}-\boldsymbol{\mu}_k^s)\right]}, \qquad i = 1,2\ldots,35 \qquad (2)$$

Estimation Method

The probabilistic assessment just discussed requires knowledge of $\boldsymbol{\mu}$ and $\boldsymbol{\Omega}$. Estimation of these parameters is based on the assumed density function for the matrix of data $\boldsymbol{Y} = [\boldsymbol{y}_1 \quad \boldsymbol{y}_2 \quad \cdots \quad \boldsymbol{y}_p]$

$$f(\boldsymbol{Y}|\boldsymbol{\mu},\boldsymbol{\Omega}) = (2\pi)^{-np/2}|\boldsymbol{\Omega}|^{-p/2} exp\left[\sum_{j=1}^{p} -\frac{1}{2}(\boldsymbol{y}_j-\boldsymbol{\mu})'\boldsymbol{\Omega}^{-1}(\boldsymbol{y}_j-\boldsymbol{\mu})\right]$$

In principle, we can use the data $\boldsymbol{Y}$ to estimate the unknown parameters $\boldsymbol{\mu}, \boldsymbol{\Omega}$,but with only seven draws from this distribution the observed covariance matrix is singular. To deal with this I write the covariance matrix as a function of the correlation matrix **R**

$$\boldsymbol{\Omega} = \boldsymbol{DRD}$$

$$\boldsymbol{D} = diag(\sigma_1, \sigma_2, \dots, \sigma_{36})$$

and I impose an autocorrelation structure on the correlation matrix

$$R_{ik} = \rho^{|i-k|}.$$

With the correlation matrix restricted to the autocorrelation structure, this leaves only 36 plus 1 parameters needed to describe the covariance matrix and another 36 means, all of which can be determined by maximum likelihood. It turns out that the maximum likelihood estimates of the means **μ** do not depend on **D** or **R**. They are just the 36 means of the data $\hat{\mu}_i = \bar{y}_i$. I use an iterative algorithm to seek the maximum likelihood estimates of **D** and **R**. With the estimated means equal to the sample means, I initially set **R** equal to an identity matrix and compute estimates of the 36 standard errors σ_i. Given the means and these standard errors, I maximize the likelihood by varying the value of ρ. Figure 3 illustrates the log-likelihood which has a maximum at $\hat{\rho} = 0.94$. This high value for the correlation captures the fact that the episodes depicted in Figure 2 tend to have long periods when they are above or below the overall mean.

Incidentally, a problem with a probit study is that it treats every observation as a separate experiment and it thus doesn't account for the fact that the year before recession has a sequence of 12 values of the dependent variable equal to one. To express this differently, the data displayed in Figure 2 reveal that there are only seven experiments in the data, and every point displayed in this figure is not a separate experiment. The multivariate analysis uses the correlation matrix to correct for the substantial intertemporal correlations in the data. In contrast, the probit scatter Figure 1 treats each and every point as a separate and independent experiment.

The next step is to maximize the likelihood by varying the 36 standard errors holding fixed the estimates of the means $\hat{\mu}_i$ and the estimate of the correlation $\hat{\rho}$. Table 5 reports the initial (univariate) estimates of the standard errors when $\hat{\rho} = 0.0$ and the revised values when $\hat{\rho} = 0.94$. Figure 4 illustrates these two estimates of the standard errors. The maximum likelihood estimates are smaller for the older years but larger for the most recent year.

One last step is to repeat the estimation of ρ using the revised estimates of the standard errors, and to halt if there is no substantial change. Otherwise repeat.

<u>**Forecast Distribution**</u>

To assign a probabilistic placement of the recent values of **r** into the mix of 36 observations, we need a forecast distribution for each case. It is convenient to proceed as if the maximum likelihood estimates are errorless. There is one very serious error in that. .A forecast distribution for $\boldsymbol{r} = \boldsymbol{\mu}_i^s + \boldsymbol{\varepsilon}_i^s$ has two sources of uncertainty: the residual $\boldsymbol{\varepsilon}_i^s$ and the mean $\boldsymbol{\mu}_i^s$**.** With a limited number of observations, we should not be treating the estimate of the mean $\boldsymbol{\mu}_i^s$ as errorless. In a univariate case, with a residual variance σ_i^2 the sampling uncertainty of μ_i is σ_i^2/p where p is the number of observations. Given σ_i^2 the predictive variance thus becomes (1+1/p) σ_i^2. With p=7, this means the forecast variance is 1.14 times the residual variance, and the predictive standard error is 1.07 times the residual standard error. This multiple applies to all elements of the covariance matrix. Table 5 has a final column that reports the forecast standard errors using this adjustment. This increase in the standard errors makes it more difficult to determine where to locate **r** in the figure, basically because it means there is less information to rely on.

A full Bayesian analysis would deal also with the uncertainty in **R** and **D**, but in my judgement this is not the biggest issue. A more important point is that it seems sensible to tie the adjacent means together with a prior distribution. This would increase the effective sample size at each point, and reduce the predictive standard errors, allowing a more precise location for **r**. It would also be sensible to have a prior distribution that ties the adjacent standard errors together. More on these issues later.

Univariate Analysis

The vector **r** that is placed among the 36 months via the formula (2) can have any length. I have chosen to discuss lengths 1, 2, 6, and 12, beginning in this section with length 1.

Table 5 reports the spread between the 10-year Treasury rate and the 3-month Treasury rate monthly during the final 36 months of the last nine expansions. The column identifiers at the top of the table count the number of expansions from 1 to 9, but with 2 and 6 excluded because they do not have three years of data before their recessions. The column identifiers in the next row of table, e.g. 1957m08, refer to the last months of the seven expansions. The row labels in the first column count the number of months until the next recession, with 1 at the bottom referring to the month before recession and the oldest data at the top, 36 months before the recession. The last four columns indicate the mean, simple standard deviation, the maximum likelihood standard deviation and the forecast standard error, adjusted upward by $(1+7^{-1})^{0.5}$.

The green data in this table refer to the recovery period when payroll jobs were returning to their previous peak levels. These green periods occur in the third year before recessions, mostly in episodes 1957M08 and 1973M11. Keil, Leamer and Li(2022) exclude the recovery periods from their probit analysis but include the rest of the expansions, not just the last three years. The focus on the last three years of expansions in this document excludes most of the recovery periods but not all. The exclusions in both cases are designed to produce an appropriate comparison period to contrast with the "alarm" period which is the last year of the expansion.

The potential need to exclude the recovery periods in this paper can be studied by looking at the data for 1957M08 and 1973M11, keeping mind that the Fed is likely to be maintaining low interest rates during the recovery periods in order to bring the employment level back to normal. This implies that the yield curve will be unusually steep during the recoveries, and a reduction from that unusual steepness signals a transition from recovery to normal expansion, but not a transition from normal expansion to recession, which is the target of the analysis in this document. But take a look: the green highlights in Table 5 don't capture extreme spreads which occurred especially in the 1990M07 episode. From this I conclude it is ok to include these recovery periods.

When studying these data, I will first take a univariate approach which asks where among the 36 months is the best place to locate a single value of the spread. In the next section, I take a multivariate approach with the vector of 36 spreads before each recessions treated as a draw from a multivariate normal distribution. The multivariate approach is the right choice since it deals with the high levels of correlations among the 36 spreads, capturing not just the level of the variable but also various changes. The univariate approach is reported for introductory purposes including a discussion of how the standard errors across the 36 months influence the calculations.

The univariate probabilistic work that comes next may be best understood if we begin with Figure 5 which depicts the error bands for the 36 means based on the adjusted forecast standard errors. A two-way red arrow identifies a subset of the 36 months for which the error bands include the value 1.40, which is the June 2022 value of the interest rate spread. That interval extends from month 36 to month 13, casting doubt on month 12 and less, the year before the next recession.. But at the very end there is another two-way arrow playing the same role. That makes it seem that 1.40 might be observed in the last several months before recessions. A two-way arrow for the spread = 0.75 goes all the way from 36 to 1, suggesting that a slope of 1.00 might be observed at any month. The two-way arrow for the spread = 0.00 goes all the way from 24 to 1, and the two-way arrow for the spread = -0.50 goes from

15 to 1. If the standard errors were smaller, then the error bands would squeeze together and the two-way arrows for the four spread levels would all get shorter. That is how better information in the form of smaller standard errors provides better information about the placement of the spreads.

Can the messages in Figure 5 show up in the univariate analysis? The univariate version of (1) assigns a probability to each of the 36 months

$$P(i|r) = \frac{\frac{1}{\sigma_i}\exp\left(-\frac{1}{2}\left(\frac{r-\mu_i}{\sigma_i}\right)^2\right)}{\sum_j \frac{1}{\sigma_j}\exp\left(-\frac{1}{2}\left(\frac{r-\mu_j}{\sigma_j}\right)^2\right)} \qquad (3)$$

This probability depends on the difference between the value r and the mean μ_i and also on the standard error σ_i If σ_i^2 were free to vary the numerator of (3) is maximized when $\sigma_i^2 = (spread - \mu_i)^2$ but reduced when a small σ_i^2 makes the difference $(spread - \mu_i)^2$ more consequential or when a large σ_i^2 makes the data unreliable.[3]

Figure 6 uses formula (3) to create a set of probabilities assigned to each of the 36 months depending on four different hypothetical values of the most recent month spread, 1.40, 0.75, 0.00 and -0.50, thus show how the predictions change as the yield curve flatters, and then inverts. If the spread is 1.40 the probabilities are high in the third year before recessions, collapse in the middle of the second year and they move up just a bit in the several months before recession, quite consistent with the error bands in Figure 5. If the spread is flatter at 0.75, the probabilities are spread broadly across all three years before recession, which captures the wide interval in Figure 5 for this case. If you look carefully at

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[3] $\ln(f) = -\frac{1}{2}\ln(2\pi) - \ln(\sigma_i) - \frac{1}{2}(spread - \mu_i)^2/\sigma_i^2$

$$\partial\ln(f)/\partial\sigma_i = -\frac{1}{\sigma_i} + \frac{2}{2}(spread - \mu_i)^2\sigma_i^{-3} > 0$$

$$(spread - \mu_i)^2 > \sigma_i^2$$

Figure 5 you will notice that the error band is shortest at month 8 (smallest standard error) and 0.00 is almost in the middle of the interval. That combination is what gives rise to the spike up at month 8 for spread=0.00 in Figure 6. The important conclusion is: Figure 6 appropriately captures the information in Figure 5 but provides a much more accurate visual display.

Figure 7 reports these same probabilities but summed over the three 12-month periods before recessions, indicated by the numbers -3 , -2 and -1 with blue, red and grey bars. The spread of 1.40 produces a 55% probability that this spread value is in year 3, the farthest from recession. The probability that this is in the last year of an expansion is only .07. The contrasts greatly with the 0.20 that is implied by the probit analysis discussed above.

The spread of 0.75 has more of a mixture of possibilities, but most for year 2. A spread of zero makes the probability of year 1 rise to 0.68 and a spread of -0.50 increases that probability to 0.82. That's a clear univariate conclusion analogous with the information conveyed by the probit scatter, Figure 1

The June spread was 1.40, which strongly supports the conclusion that a recession is not going to occur for a couple of years. But the Fed seems likely to reduce this spread more in the future and change this forecast. An important message of Figure 7 is that the Fed would be wise if they avoided slopes less that 0.75 if they want to avoid a recession.

Multivariate analysis

Figure 8 has the probabilistic placement of four different vectors of data ending May 2022: 1 month, 2 months, 6 months and 12 months.

The farthest to left that the two-month data can be placed is month 35. To deal with the missing data for month 36, I set the likelihood for the 36th month equal to the likelihood for the 35th month, which means that the 36 and 35 probabilities are identical. The 6-month and the 12-month cases likewise have 6 and 12 identical probabilities in this picture.

The one-month curve is the same as the 1.40 curve in Figure 6, peaking in month 26 in the third year before recession. The two-month placement has a spike up in probability in month 30. Yhe peaks for the 6-month and 12-month studies are both in month 21 in the second year before recession. All four probabilities tail off to near zero in the year before recession but pick up a bit in the months immediately preceding the recession.

Figure 9 has these same probabilities but accumulated over the three different years. The probability of being a year before recession is maximized in the 1 month case but with the very small number 0.06. This is a huge conflict with the probit estimate. The 12 and 6 month probabilities favor the second year while the 2 and 1 month probabilities favor the third month.

The most accurate probabilistic assignment would have one month with probability one and zeroes for all the others. More generally, the accuracy of the assignment can be measured by the standard errors of the probabilities which is greatest (0.076) for the 6-month case. Next come the 12-month, the 2-month and the one-month standard errors equal to 0.050, 0.040 and 0.20. Takeaway: rely on the 6-month assignment of probabilities: the most likely outcome is a recession in 18 months after 2022M06. The chance of a recession in the next year is only 0.01.

4. Other Variables

Historically, few forecasters have predicted recessions but currently there is a lot of talk about an imminent recession. For example, Domash and Summers(2022) report "We find that, given the current inflation level of nearly 8 percent and unemployment below 4 percent, historical evidence suggests a very substantial likelihood of recession over the next year or two." They provide tables and a probit model in support of this conclusion, but no visual information.

The data on the interest rate spread discussed in the previous section does not support this conclusion but there are several other variables that need to be looked at, including the inflation rate and the unemployment rate as suggested by Domash and Summers(2022) and also housing starts suggested by Leamer(2008) whose title was "Housing IS the Business Cycle."

The Fed seems to think that it is the short-term rate of interest that is the critical medicine they can dish out, not the slope of the yield curve. Figure 10 displays 3-month Treasury interest rates in the last three years of seven complete expansions, including an optimally placed set of the most recent 6 months of data. This image has elevated interest rates from the middle of the third year before recession until 4 months before recession when rates fell. Figure 11 has the probabilistic placement information and Figure 12 the probabilities assigned to each of the three years before recession. Bottom line here the bond market is not signaling a recession soon, neither the slope of the yield curve nor the yield of the three-month Treasuries.

Figure 13 displays CPI based annual inflation rates in the last three years of seven complete expansions. The average inflation rates rose a bit in the second year before recession and rose by about 2 percentage points in the last year. The inflation facing Arthur Burns got very high but it was Paul Volker who experience a 14% rate in the month before the recession. The current high and rising 12 months is placed mostly in the year before recession. Figure 14 is the probabilistic placement of the most recent data, 1 month, 2 months, 6 months and 12 months. In all cases the probability seems concentrated in the year before recession, which is confirmed by the bar charts in Figure 15 which has about a 90% chance of being in the last year before recession regardless of the length of the current data considered. This is strong support for the Domash and Summers statement about inflation.

Figure 16 illustrates the unemployment data for seven expansions. The mean is steadily declining in the third and second years before recession, leveling off at around 4.5% in the 12^{th} month before recession and elevating a bit beginning the 4^{th} month before recession. The Volker unemployment data reveal that when he was dishing out huge interest rate inversions illustrated in Figure 2 the unemployment rate was very high and going higher. While the dual mandate of the Fed is inflation and employment, the Fed seems to have abandoned any employment concern at that time. Volker wanted to stop inflation.

This unemployment image includes two different 12 months of recent data; the actual 12 months ending in 2022m05 pushed toward the left in the figure and 12 months with the 24 months of covid-19 afflicted data from March 2020 to February 2022 removed, pushed toward the right. The problem with the actual unemployment data in the 12 months ending 2022m05 is that the unemployment rate collapsed from 5.9 percent in June 2021 to 3.6 percent in May 2022, unlike anything in the image. The hypothetical recent 12 months of data includes three recent months from March to May 2022, and the rest from June 2019 to February 2020, before covid hit. This is acting like covid was a short period with shut doors followed by a recovery period after the doors opened us, returning us the same condition we had in February 2020. Figure 17 and Figure 18 which display the probabilities implied by the unemployment data are based on the hypothetical data. For 6 months or 12 months of data the probability that May 2022 is the last year of which leads to the conclusion that the probability that we are in the last year of recession is over 60%, which is consistent with Domash and Summers conclusion, but to that attach a big asterisk to reveal how the data have been manipulated. And you can ask the question: if covid-19 leads you to omit 12 months of data for unemployment, why not the other variables?

A variable that is not included in the Domash and Summers study is housing starts. It is the next one I would look at. Leamer(2008) offered evidence in support his title “Housing is the Business Cycle” and Leamer(2015) repeated the point: “Housing Really is the Business Cycle.” In those papers Leamer argued that the Fed can affect the timing of home building but not the totals, meaning that exceptional levels of housing starts must come from the past recession or from the future recession. Low interest rates after recessions may pick up sales that did not occur because of the recession, but the 2001 recession had little effect on housing starts and the low interest rates in 2002-2005 move home building from the future to the present, creating a very fragile market by 2007.

Figure 19 depicts the housing starts in six complete expansions. The mean housing starts was on the rise in the third year before recession, was fairly flat in the second year before recession, and declined from 1.7 million per year to 1.4 million per year in the 12 months before recession. Arthur Burns and Paul Volker both experienced a huge decline in housing starts before their recessions began, in part because of the apparent overbuilding in the second year before the recessions and also the inverted yield curve they both created.

The most recent 12 months had increasing housing starts but a big fall from 1.8 million in April to 1.5 million in May. As it stands through May of 2022, these 12 months of data are most accurately placed in the third year before recession. Figure 21 reports the annual summaries of the placement probabilities. If we use the 12 months of recent data the probability of the third year before recessions is 77 percent. The other cases are less clear about the favored year.

5. Recession Risks

With regard to recession risk, the inflation data are very alarming, the unemployment data are also alarming if we omit the covid-19 data, but neither the slope of the yield curve, nor the 3-month Treasury yield, nor housing starts are issuing alarms. For that matter, the inflation data seems also affected by supply-chain covid issues, and the alarm may be a miscue. In other words, inflation could get lower without a recession. One possibility is that the images which say the recession is imminent have been seriously compromised by the covid-19 shutdown and subsequent opening up. Rather than simply excluding the covid-19 data from the unemployment display, as I have done, another solution is to wait for a string of three years of data not affected by covid. I prefer a different interpretation.

The alarms issued by the inflation image and the unemployment image be only a forecast that the Fed will create an inverted yield curve, as it has in the past, and then the recession will occur. A more optimistic view is that the Fed is now aware how a steep yield curve allows banks to make risky loans because of the intermediation profits that come from deposits at low rates and longer term loans at high rates. As explained below, if the Fed left some intermediation profit but lowered the spread from the current 140 basis points only to 75 basis points, that would leave the recession risk low. Rather than following the path of the Burns and Volcker, the Fed might try to follow the episodes that ended in 1957M08 and 1990M07, when the spread did not invert. But those episodes did not come with reductions in inflation.

This last paragraph is suggesting a multivariate approach that combines the spread, inflation and unemployment in a single model. To extend what has already been discussed we might build a model with 108 (3 times 36) means and a 108 by 108 covariance matrix. That would easily overwhelm our data set. But the probit analysis can easily deal with this setting. Table 4 reports four different probit models with different explanatory variables all based on the same data. The first column has the probit already discussed with a single explanatory variable equal to the interest rate spread T10Y3M. Column(2) includes also the 3-month yield, the unemployment rate, the inflation rate and housing starts. It's the two bond market variables with z-values in excess of 2 in absolute value that help most to predict recession, not inflation or unemployment or housing starts. In other words, controlling for the bond market variables removes inflation and unemployment as predictors of recessions. Column (3) controls for lagged effects by including the first difference of each of the variables as well as the current variable. Here an increase in inflation has a z-value equal to 2.00. Column (4) is estimated with stepwise regression omitting sequentially the variable with the lowest z-value. Here we retain the spread, the change in the spread, the 3-month rate, the change in the inflation rate and the change in the unemployment rate which doesn't quite make the cut. Column (5) has the final stepwise outcome with variables with z-values less than two in absolute value omitted. Here it is only the bond market that predicts recession: A negative but rising spread, and a high 3-month rate.

So here is the message to the Fed: If you are careful not to raise the 3 month Treasury too much, the bond market will not predict a recession soon. But it needs to be asked: if a careful Fed avoids recessions can it control inflation.

1970s Decisions

There is much that can be learned about inflation and recessions by taking a closer look at the 1970s. Figure 22 illustrates the relationship between inflation and unemployment from May 1959 to July 1983. Periods of rising inflation are colored red, and periods of falling inflation are colored blue. The dotted lines are designed to help distinguish different episodes. The green at the bottom represents the early 1960s when inflation was low and the unemployment rate was variable. The first red increase in inflation began in January 1965 and was accompanied by falling unemployment rate, tracing out what then was called the Phillips curve, and helping to establish the Fed target of 2 percent inflation and 4 percent unemployment. Inflation peaked in February 1970 when Arthur Burns became Fed Chair, at which point a recession drove the unemployment rate from 4 to 6, and then inflation took a bit fall. A rightward pointing arrow makes the point: it takes a significant increase in unemployment to bring inflation down. Two other rightward pointing arrows confirm the same outcome in November 1974 (Burns) and March 1980 (Volcker). The three red episodes are all Phillips curves showing what happens to inflation as unemployment falls. But these shifted dramatically to the right. Beginning in January 1965, a drop of unemployment from 6 percent to 5 percent unleashed a rise in inflation that from 3% to over 11%. Beginning in December 1976, a drop of unemployment from 8 to 6 unleashed another spike up in inflation, from 5% to almost 14%. This feels like a Covid-19 crises with public health officials getting Covid not completely under control but then another variant emerges and is worse than the last. It took the Volker unemployment level in excess of 10% to rid the economy of the inflation disease.

6. Conclusion

I have offered what I regard to be strong support for a new visually-based way of forecasting recessions, but I also admit that it treats each explanatory variable separately and fails to deal with multiple forces acting at the same time. We'd better retain the probit analysis for that purpose.

These images collectively make a recession in the next year quite improbable, but that conclusion depends on the assumption that the most recent data are being generated by the same economic system / policy mix that have been responsible for the historical data. With that caveat in place, it remains a fact of life that the only way for an economist to see forward is to look backward.

7. References

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8. Tables

Table 1 Probit model Expressing Year Before Recession a function of the Interest Rate Spread, T10y3m

Dependent Variable: _1YRPRE (last year of expansion)
Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)
Sample: 1955M07 2020M02 IF RECESSION_NBER=0 AND RECOVERY=0
Included observations: 489
Convergence achieved after 7 iterations
Coefficient covariance computed using observed Hessian

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.143	0.110	1.297	0.195
T10Y3M	-1.328	0.146	-9.080	0.000

McFadden R-squared	0.352	Mean dependent var	0.211
S.D. dependent var	0.408	S.E. of regression	0.331
Akaike info criterion	0.676	Sum squared resid	53.479
Schwarz criterion	0.693	Log likelihood	-163.189
Hannan-Quinn criter.	0.682	Deviance	326.378
Restr. deviance	503.470	Restr. log likelihood	-251.735
LR statistic	177.092	Avg. log likelihood	-0.334
Prob(LR statistic)	0		
Obs with Dep=0	386	Total obs	489
Obs with Dep=1	103		

1955M07 is the first month after the recovery from the 1953/1954 recession
2020M02 is the last month before the Covid-10 Shutdown

Table 2 Effect of Restricting Data to One of the 12 Months Before Recession

Dependent Variable: 12 Months Before Recession
Sample: 1955M07 2020M02 IF RECESSION_NBER=0 AND RECOVERY=0

Including Only One Month of the 12, or all 12
1955M07 is the first month after the recovery from the 1953/1954 recession

2020M02 is the last month before the Covid-10 Shutdown

Month Before Recession	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	ALL
Constant													
Estimate	-0.95	-0.91	-0.91	-0.80	-0.71	-0.72	-0.68	-0.68	-0.77	-0.80	-0.83	-0.85	0.14
z-Stat	-5.95	-5.42	-5.43	-4.64	-3.77	-4.04	-3.92	-3.94	-4.78	-5.01	-5.23	-5.49	1.30
T10Y3M													
Estimate	-0.44	-0.52	-0.52	-0.76	-1.05	-0.97	-1.24	-1.22	-0.82	-0.78	-0.66	-0.60	-1.33
z-Stat	-2.61	-2.59	-2.59	-2.89	-2.80	-3.03	-3.51	-3.53	-3.40	-3.42	-3.23	-3.17	-9.08
McFadden R-squared	0.14	0.16	0.16	0.23	0.28	0.31	0.39	0.38	0.30	0.31	0.25	0.22	0.35
Obs with Dep=0	386	386	386	386	386	386	386	386	386	386	386	386	386
Obs with Dep=1	8	8	8	8	8	9	9	9	9	9	9	9	103

Table 3 Probit Forecast Probabilities

Month Before Recession Included in Model

	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	SUM*	ALL	START*	T10Y3M
Jun-21	0.007	0.005	0.005	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.007	0.034	0.034	1.48
Jul-21	0.011	0.008	0.008	0.003	0.000	0.001	0.000	0.000	0.002	0.002	0.005	0.007	0.019	0.061	0.059	1.27
Aug-21	0.012	0.009	0.009	0.003	0.001	0.001	0.000	0.000	0.003	0.003	0.006	0.008	0.030	0.068	0.061	1.23
Sep-21	0.009	0.007	0.007	0.002	0.000	0.001	0.000	0.000	0.001	0.002	0.004	0.006	0.026	0.052	0.045	1.33
Oct-21	0.006	0.004	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.003	0.015	0.029	0.024	1.53
Nov-21	0.006	0.004	0.005	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.016	0.031	0.025	1.51
Dec-21	0.008	0.006	0.006	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.003	0.004	0.022	0.042	0.032	1.41
Jan-22	0.005	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.012	0.023	0.017	1.61
Feb-22	0.005	0.003	0.004	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.013	0.024	0.017	1.6
Mar-22	0.004	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.010	0.018	0.013	1.69
Apr-22	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.004	1.99
May-22	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.008	0.006	1.92

SUM* excludes the shaded region

Sum 0.339

START* is equal to ALL adjusted for the risk of a recession starting earlier

Table 4 Five Different Probit Models

Dependent Variable: **Year Before Recession**
Method: ML - Binary Probit (Newton-Raphson / Marquardt steps)
Sample: 1955M07 2020M02 IF RECESSION=0 AND RECOVERY=0
Included observations: 455

Estimates	(1)	(2)	(3)	(4)	(5)
C	0.143	-1.012	-1.648	-0.719	-0.694
T10Y3M	-1.328	-1.072	-1.190	-1.189	-1.180
T10Y3M-T10Y3M(-1)			1.360	1.209	1.186
TB3MS		0.164	0.237	0.160	0.160
TB3MS-TB3MS(-1)			-0.003		
UNRATE		0.052	0.044		
UNRATE-UNRATE(-1)			1.016	0.897	
INFLATION		0.041	-0.032		
INFLATION-INFLATION(-1)			0.601	0.541	
HOUST		-0.0002	0.000		
HOUST-HOUST(-1)			-0.001		

Z-values	>2 or <-2				
	(1)	(2)	(3)	(4)	(5)
C	1.297	-1.630	**-2.386**	**-2.591**	**-2.539**
T10Y3M	**-9.080**	**-5.795**	**-5.884**	**-7.642**	**-7.857**
T10Y3M-T10Y3M(-1)			**2.370**	**3.012**	**3.031**
TB3MS		**2.034**	**2.587**	**3.456**	**3.483**
TB3MS-TB3MS(-1)			-0.007		
UNRATE		0.388	0.314		
UNRATE-UNRATE(-1)			1.628	**1.659**	
INFLATION		0.560	-0.384		
INFLATION-INFLATION(-1)			2.000	**2.034**	
HOUST		-0.574	0.557		
HOUST-HOUST(-1)			-0.660		

	(1)	(2)	(3)	(4)	(5)
McFadden R-squared	0.352	0.408	0.446	0.407	0.393
S.E. of regression	0.331	0.305	0.295	0.315	0.319

(4) and (5) are Stepwise estimates based on lowest Z-values

T10Y3M is the difference between the 10-year yield and the 3-month yield
TB3MS is the yield on the 3-month Treasury
UNRATE is the unemployment rate
INFLATION is 100*log(cpiaucsl/cpiaucsl(-12))
HOUST is housing starts

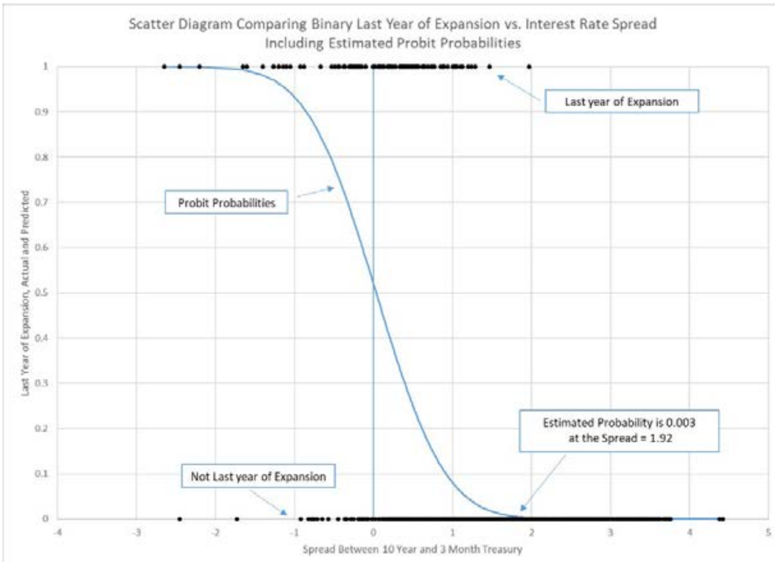
Table 5 Spread between the 10-year and 3-month Treasury rates, Recoveries in Green, Seven Complete Episodes

	1	3	4	5	7	8	9				
	1957M08	1969M12	1973M11	1980M01	1990M07	2001M03	2007M12	Mean	Std. Dev.	M.L. St. Dev.	Forecast St. Dev
36	1.37	-0.14	1.52	2.72	2.72	0.69	1.89	1.54	0.96	0.73	0.78
35	1.45	0.07	1.8	2.86	3.02	0.65	1.63	1.64	0.99	0.74	0.79
34	1.55	0.28	2.41	2.83	3.39	0.52	1.76	1.82	1.07	0.79	0.85
33	1.36	0.75	2.32	2.50	3.17	0.5	1.56	1.74	0.90	0.69	0.73
32	1.39	1.25	1.97	2.26	3.22	0.44	1.3	1.69	0.82	0.65	0.69
31	1.48	1.48	2.25	2.14	2.86	0.2	1.03	1.63	0.81	0.65	0.69
30	1.40	0.95	1.77	1.91	2.55	0.57	0.96	1.44	0.63	0.50	0.53
29	1.16	1.01	1.33	1.53	2.67	0.42	0.82	1.28	0.66	0.50	0.54
28	1.31	0.88	1.64	1.36	2.81	0.26	0.78	1.29	0.75	0.56	0.59
27	1.37	0.92	1.45	1.48	2.83	0.38	0.75	1.31	0.73	0.54	0.58
26	1.30	1.02	1.47	1.62	2.46	0.56	0.66	1.30	0.60	0.46	0.49
25	1.07	0.73	1.59	1.52	2.33	0.79	0.58	1.23	0.58	0.47	0.50
24	0.90	0.53	1.92	1.58	2.2	0.89	0.18	1.17	0.69	0.58	0.62
23	0.65	0.58	2.57	1.75	1.74	1.04	0.14	1.21	0.78	0.66	0.70
22	0.65	0.57	2.88	1.86	1.45	1.33	0.21	1.28	0.84	0.67	0.72
21	0.42	0.26	2.34	1.94	1.2	1.24	0.39	1.11	0.75	0.57	0.61
20	0.49	0.21	2.48	1.73	1.04	1.22	0.39	1.08	0.75	0.56	0.60
19	0.52	0.20	2.44	1.63	0.82	1.24	0.32	1.02	0.75	0.55	0.59
18	0.71	0.19	2.2	1.33	0.64	1.25	0.14	0.92	0.67	0.53	0.56
17	0.58	0.33	2.13	0.57	0.54	0.96	-0.08	0.72	0.65	0.51	0.55
16	0.46	0.27	2.19	0.65	0.53	1.08	-0.09	0.73	0.68	0.55	0.59
15	0.51	0.23	1.89	0.17	0.43	1.34	-0.19	0.63	0.68	0.56	0.60
14	0.80	0.25	1.74	-0.07	0.13	0.97	-0.34	0.50	0.66	0.55	0.59
13	0.73	0.07	1.5	-0.25	0.14	0.57	-0.29	0.35	0.59	0.50	0.53
12	0.54	-0.10	1.29	-0.22	0.21	0.33	-0.22	0.26	0.50	0.45	0.48
11	0.44	0.07	1.05	-0.36	0.44	0.65	-0.31	0.28	0.48	0.47	0.50
10	0.50	0.28	1.04	-0.28	0.37	0.41	-0.38	0.28	0.45	0.48	0.51
9	0.38	0.06	0.62	-0.36	0.18	0.09	-0.18	0.11	0.30	0.38	0.41
8	0.35	0.28	0.41	-0.15	0.21	-0.26	0.02	0.12	0.24	0.32	0.34
7	0.24	0.13	0.49	-0.29	0.57	-0.2	0.49	0.20	0.32	0.43	0.46
6	0.33	-0.28	-0.29	-0.49	0.73	-0.37	0.18	-0.03	0.42	0.55	0.59
5	0.41	-0.29	-0.88	-0.93	0.69	-0.45	0.47	-0.14	0.62	0.69	0.74
4	0.54	0.07	-1.27	-1.40	1.02	-0.53	0.63	-0.13	0.88	0.93	0.99
3	0.51	0.10	-1.2	-1.14	1.02	0.01	0.63	-0.01	0.80	0.86	0.92
2	0.77	-0.10	-0.43	-1.65	0.75	0.22	0.88	0.06	0.83	0.94	1.00
1	0.56	-0.17	-1.10	-1.20	0.85	0.47	1.10	0.07	0.85	0.95	1.02

9. Figures

Probit Image

Figure 1 Scatter Diagram



Spread Images

Figure 2 Interest Spread During Last 36 Months of 7 Expansions that Lasted at Least three years.

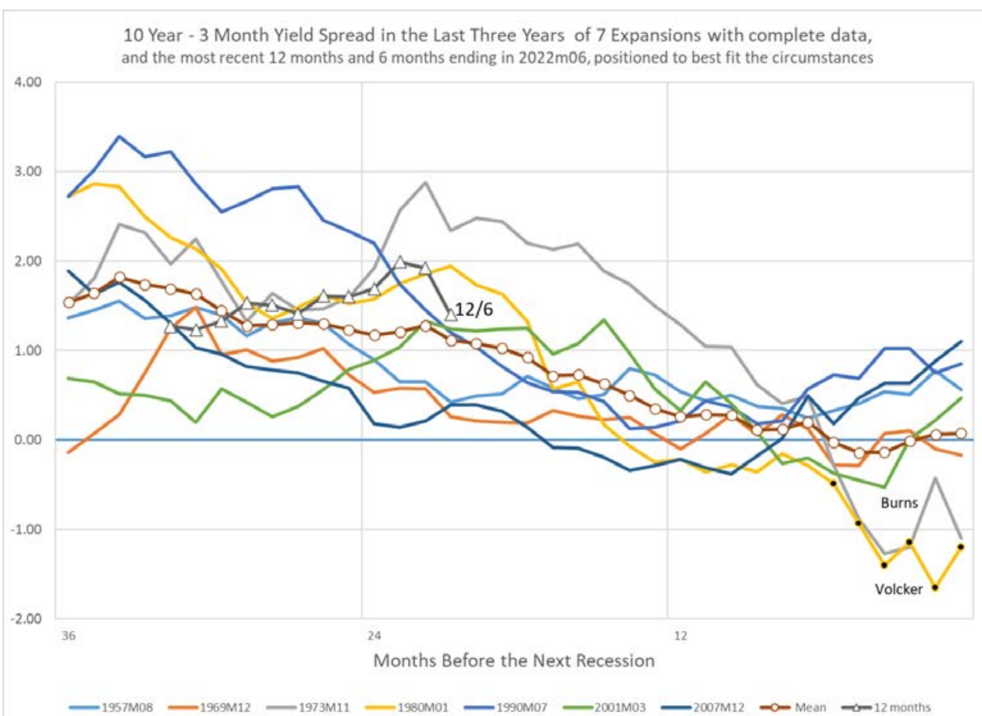


Figure 3   Log Likelihood for Rho

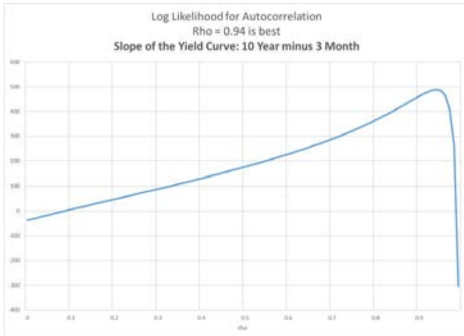


Figure 4   Estimated Standard Errors For Each of the 36 Months Before Recessions

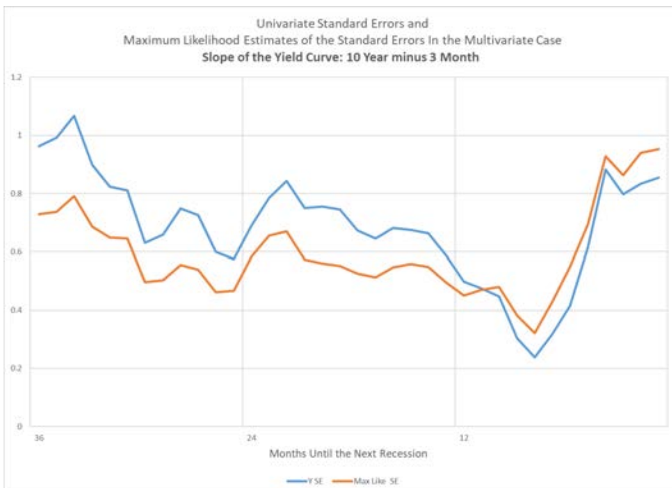


Figure 5   Univariate Error Bands

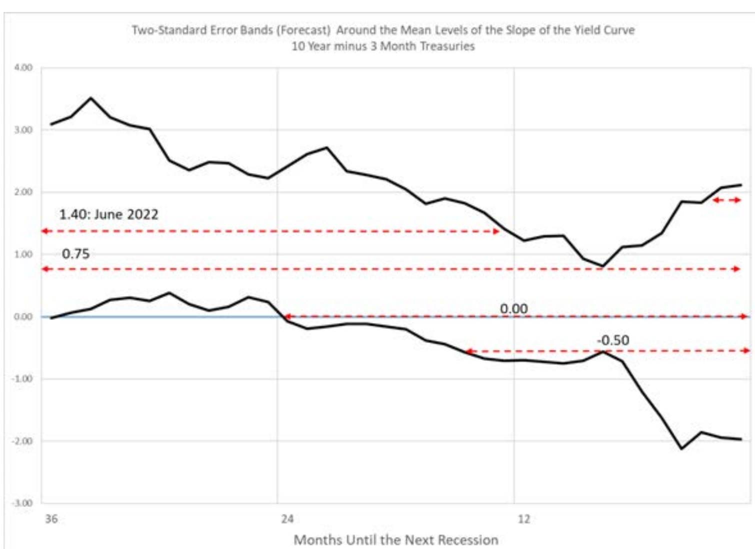


Figure 6 "Posterior" Probabilities of the 36 Months for Four Values of the Spread (1 month only)

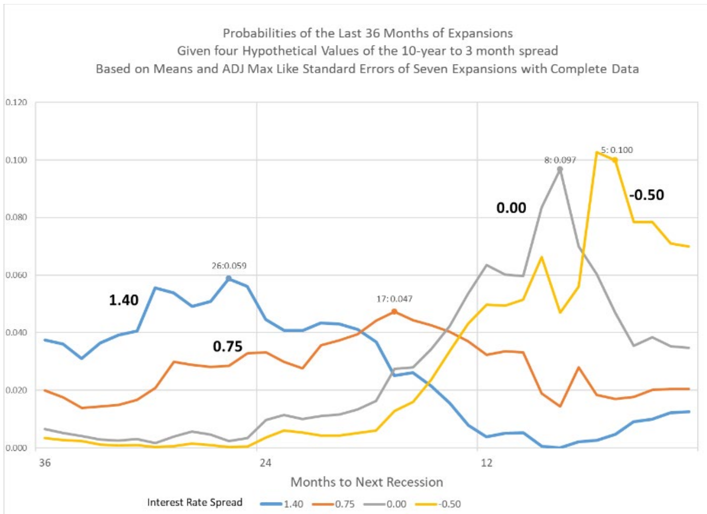


Figure 7 Probababilities accumulated over each of the three years, Univariate Study

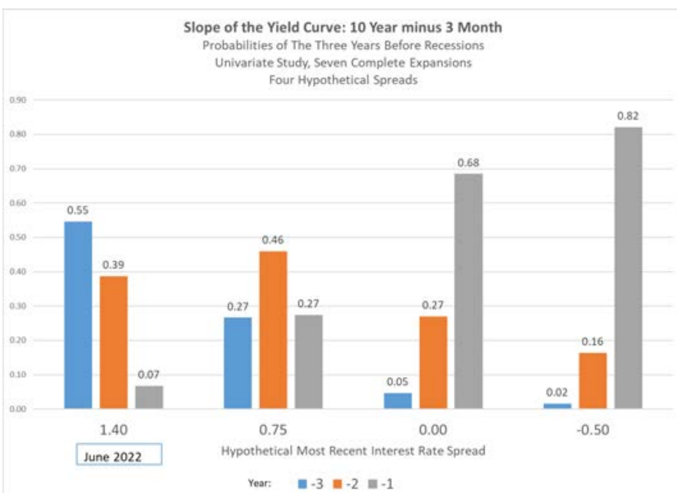


Figure 8   Probabilistic Placement of Spread Data Ending in May 2022

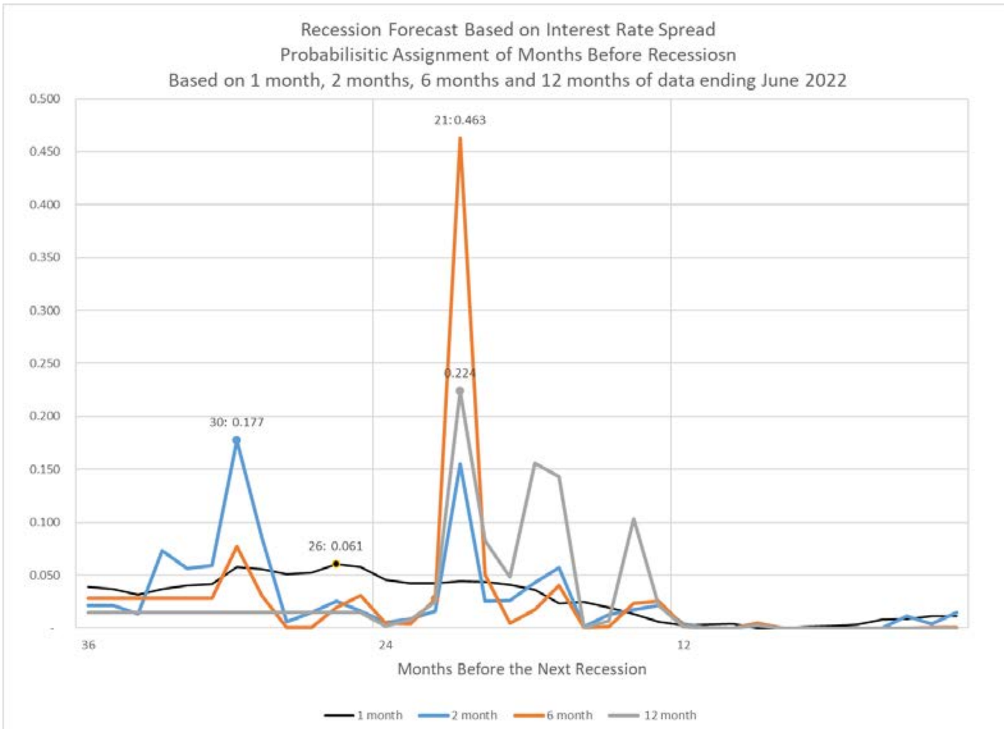
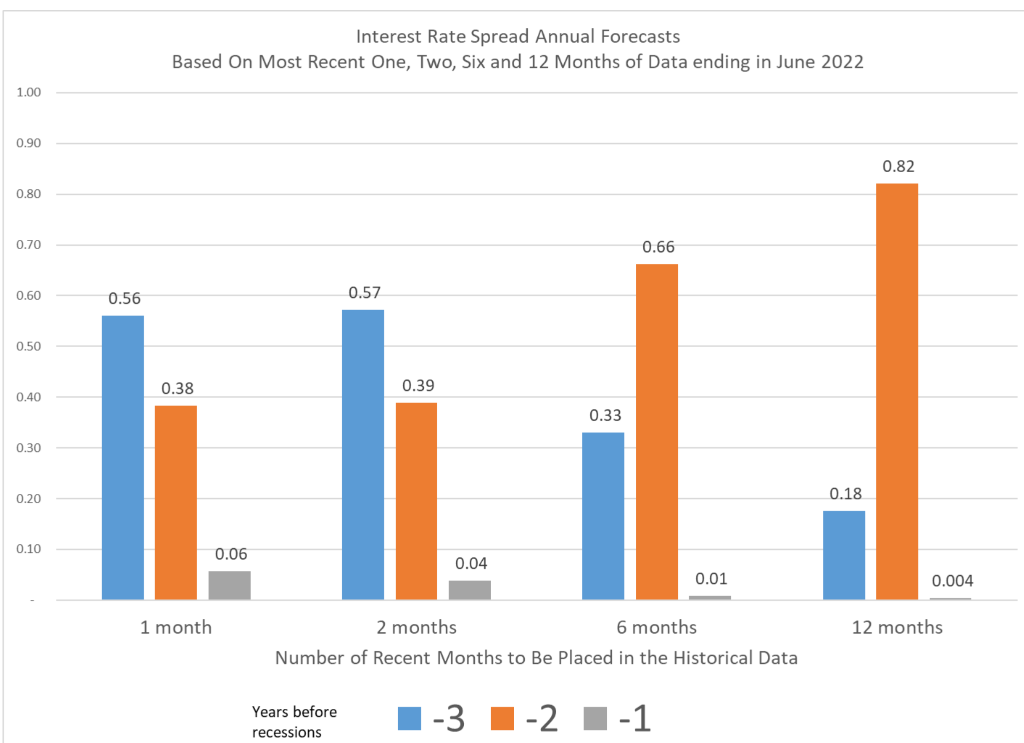


Figure 9   Spread Placement Probabilities summed over each of the three years, Multivariate Study



Yield on the 3-Month Treasury Images

Figure 10 Yield on the 3-month Treasury, Seven Complete Episodes

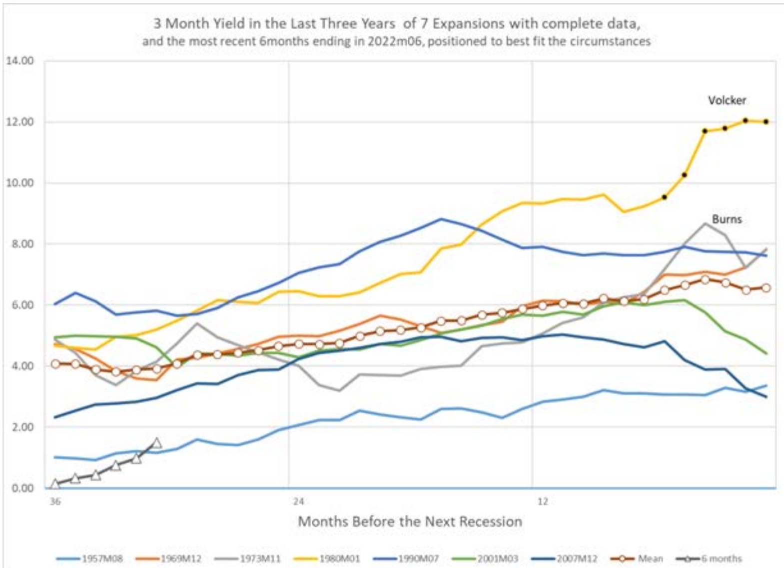


Figure 11 Probabilistic placement of 3-Month Treasury yield into historical data

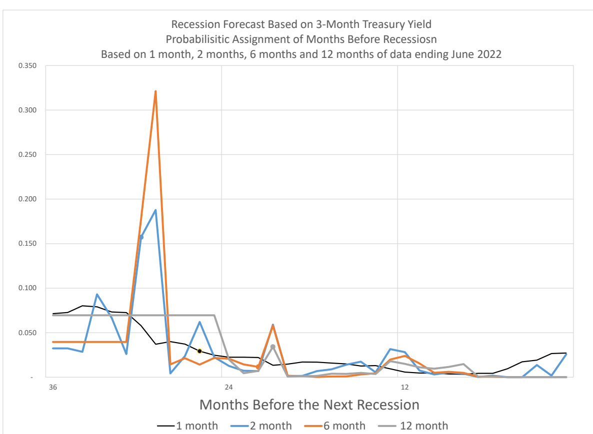
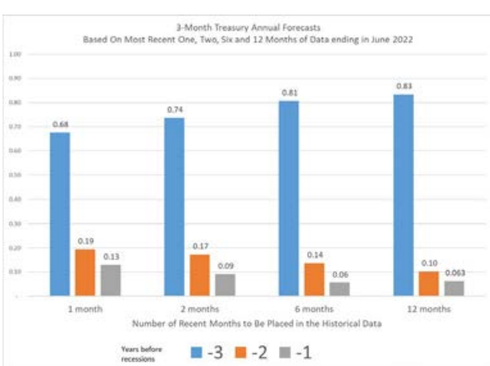


Figure 12 3-Month Treasury Yield Placement Probabilities summed across years



Inflation Images

Figure 13 YOY CPI Inflation, Seven Complete Episodes

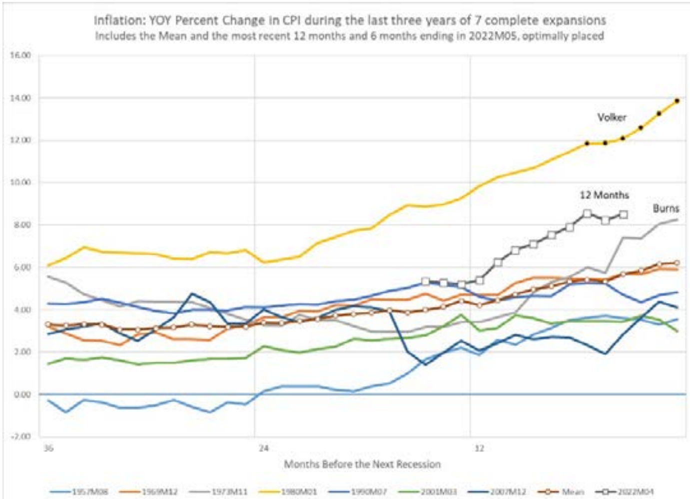


Figure 14 Probabilistic placement of recent inflation data into historical data

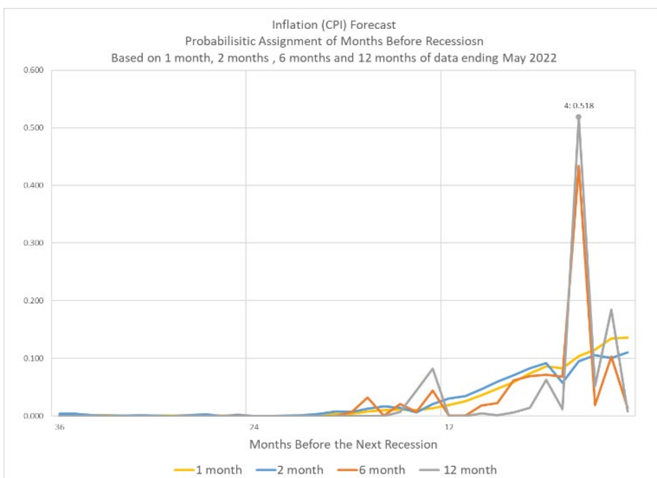
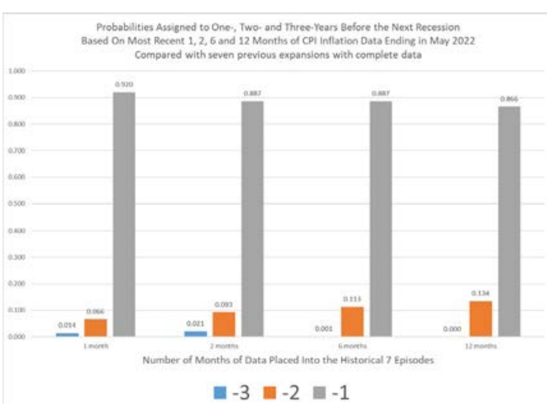


Figure 15 Inflation Placement Probabilities summed across years



Unemployment Images

Figure 16 Unemployment Rate, Seven Complete Episodes

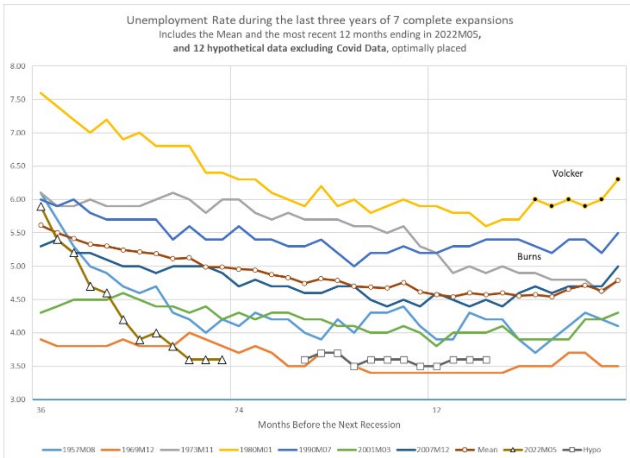


Figure 17 Probabilistic placement of recent hypothetical unemployment data into historical data

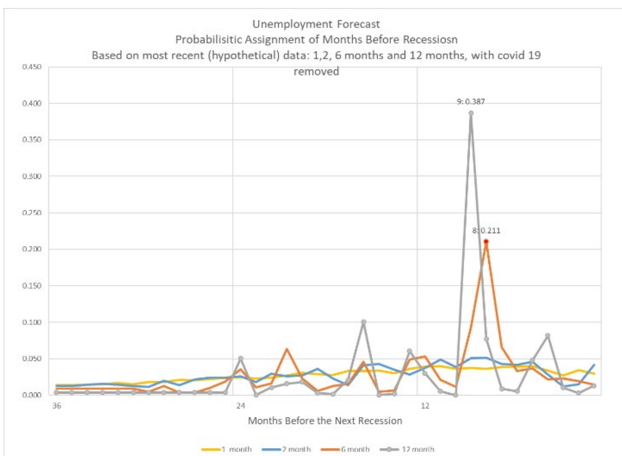
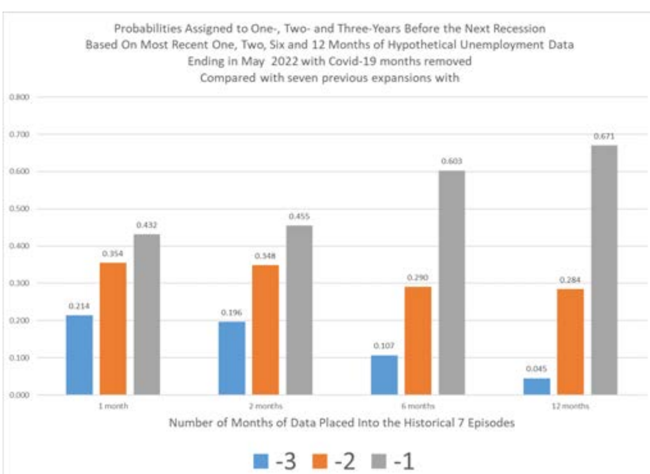


Figure 18 Unemployment Placement Probabilities summed across years



Housing Starts Images

Figure 19 Housing Starts, Seven Complete Episodes

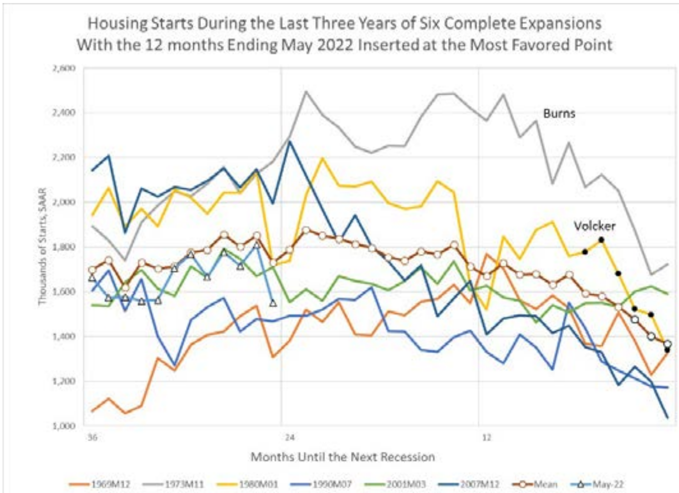


Figure 20 Probabilistic placement of recent housing starts data into historical data

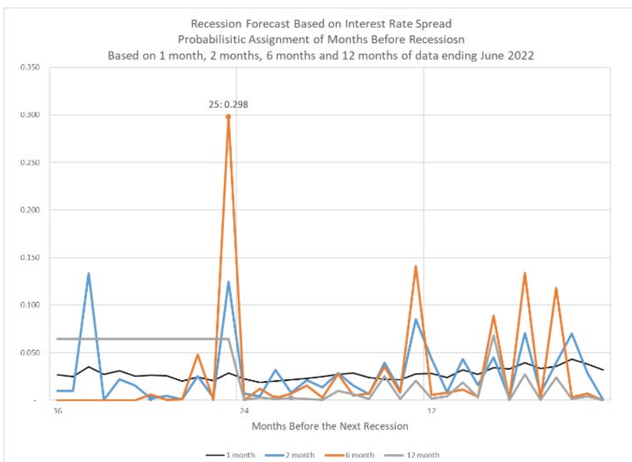
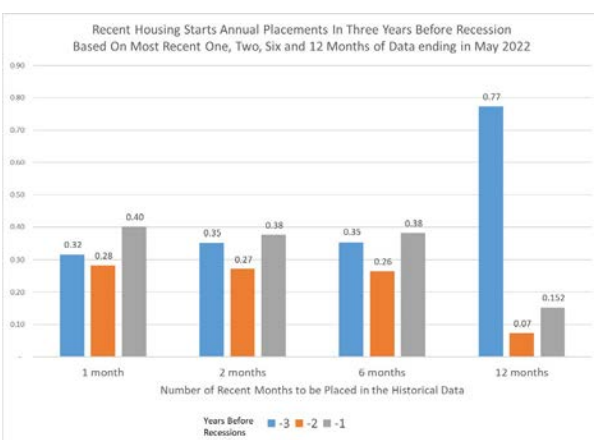


Figure 21 Housing Starts Placement Probabilities summed across years



The Phillips Curve

Figure 22 The Phillips Curve in the 1960s, 1970s and 1980s