

Economic Research Note

Quantifying risks to the US growth outlook

- We test a variety of econometric and machine learning methods for predicting the distribution of GDP growth
- No methods are clear winners, and averaging predictions from several methods may be the best approach
- Based on these results, we put the probability that GDP grows faster than 3% in 2018 at about 30%

Our [baseline forecast](#) continues to look for the US economy to grow above its trend in 2018, pulling the unemployment rate further down and pushing inflation up. But we know well that the chance of 2018 unfolding exactly as our forecast envisions is quite small, and thus we also spend considerable time weighing the likelihood of alternative outcomes. Notably, we have written extensively on our efforts to [quantify the risk of a recession](#) beginning within different time horizons. Despite the market volatility in recent days, our preferred model based on macroeconomic data still puts the probability of recession beginning within one year [just above 20%](#).

In this note, we take a new approach and experiment with multiple methods for forecasting the distribution of GDP growth over the upcoming year—including potential upside scenarios. We conduct a “horserace” among several econometric and machine learning techniques to test which perform best in predicting the likelihood of different GDP outcomes in out-of-sample forecasting backtests. Focusing on the models’ ability to predict the probability of growth above 3%, we find that various models’ predictions are often similar, and no techniques are clear winners. An average of several techniques seems likely to provide the best estimates. Based on these results, we put the probability of 2018 GDP growth (4Q/4Q) being greater than 3% at about 30%. Results also suggest a risk of GDP growth below 1% at about 20%, although we still consider our recession model our preferred method of thinking about downside risks.

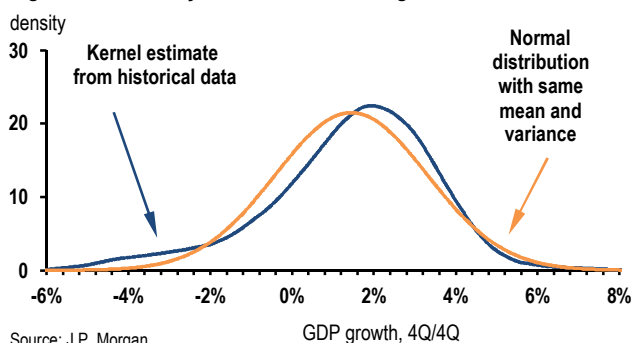
Opening up the playbook

In this note we use historical data to inform our views on questions like the probability of GDP growing above or below certain rates. In this day and age, of course, there exists a vast menagerie of statistical, econometric, machine learning, or artificial intelligence techniques that one might use to perform this task. We do not attempt to evaluate all possible techniques (let alone all possible combinations of techniques), but instead choose a few different options that will provide some representation across a few different families of methods. We

first briefly list and define the techniques we will consider before discussing their theoretical pros and cons and ultimately our empirical results.

1. OLS. The simplest method we use is an ordinary least squares (OLS) regression of a dummy variable for GDP growth above a given threshold on a set of predictor variables.
2. Probit. Also part of the standard econometrics toolbox, the probit model fits the same threshold dummy to a nonlinear function of the predictor variables.
3. Kernel density. We first fit an OLS regression of GDP growth itself (not the threshold dummy) on the predictor variables, then we fit a kernel density estimator to the residuals from this regression. The current estimate of this density is illustrated in Figure 1. The modal, or most likely, growth outcome is a bit above 2%, not far from our own forecast. But the estimated density illustrates that a wide range of other outcomes are possible. The estimated density also has a notably fatter tail of downside risk than a normal distribution with the same mean and variance.

Figure 1: Probability distribution for GDP growth in 2018



4. Quantile regression. We use quantile regressions to estimate, for example, the 90th percentile of GDP growth based on the predictor variables. We run many such quantile regressions and assign the relevant threshold probability to the quantile regression with the result nearest the threshold. For example, if the 72nd quantile regression predicted GDP growth at 3%, we would assign a 28% probability to growth at 3% or above.
5. Random forest classifier. Regression trees divide the space of predictor variables into regions based on combinations of the predictors. For example, all observations where lagged GDP growth is above some threshold while the output gap is below another threshold might be predicted to forecast the same probability of GDP growth above 3%. Random forests average together many different such trees, where there is some randomness in the estimation of the individual trees.

6. Boosted regression trees. Boosted trees are also based on the underlying idea of a regression tree, but additional layers of trees are estimated on the residuals of higher-level trees.

Thinking a bit about potential pros and cons, we note that all of the methods in our list will allow considerable flexibility for the estimates to fit the shape of the tails of the distribution of the data, and none impose a particular distributional form (like normality). We note that the kernel density approach in number 3 has the potential drawback of not allowing the predictor variables to have different effects on probabilities at different thresholds, but all other methods would allow a given predictor variable to have different effects on the probability of GDP growth above 3% and below 1%, for example. Methods 1 through 4 only allow the predictor variables to affect the probabilities through a particular functional form (which is predominantly linear) while methods 5 and 6 could allow the predictors and their interactions to affect the probabilities in quite flexible ways.

Taking some shots downfield

We use each of these methods to perform one-step-ahead, out-of-sample forecasts of the probability of GDP growth over the coming year being above a set of thresholds, in the data from 2000 to present. That is, we use data potentially observable as of 1999q4 to predict the distribution of average GDP growth from 2000q1 to 2000q4, then we use all the data through 2000q1 to predict the distribution of average GDP growth from 2000q2 to 2001q1, etc.

Our aim in this exercise is to test the effectiveness of the probability forecasting techniques while holding other aspects of the estimation constant, so we use the same set of predictor variables with each method and a 40-year rolling sample window. The predictor variables are working-age population growth over the prior two years (meant to capture shifts in potential growth in a way that could be observable in real time), the first principal component of a group of monthly indicators from our nowcaster growth model (meant to capture current growth momentum), and the level of the unemployment rate (which attempts to measure the stage of the business cycle in a manner similar to the “background risk” factor in our recession models). In regressions in data from recent decades, all variables enter the regression with the expected signs and are statistically significant at conventional levels.

We illustrate the results by evaluating the models’ success in predicting GDP growth greater than 3%, which has occurred 25% of the time in the data since 2000 (Figure 2). Figure 3 shows the one-step-ahead model-predicted probabilities of GDP growing above 3%. Overall the various methods we use for predicting the probabilities tend to produce similar results

at a given time, which should not be surprising, as they are all based on the same data. We note that the models generally detect a decline in the probability of growth greater than 3% between the mid-2000s and today, a period over which the growth rate of the working-age population has declined by almost 1%-pt, contributing significantly to our long-held view that [potential growth has slowed](#). Many of the models also saw a notable rise in the probability of 3% growth exiting the Great Recession, when the high unemployment rate suggested an economy with lots of open field ahead.

Figure 2: GDP growth and the 3% threshold

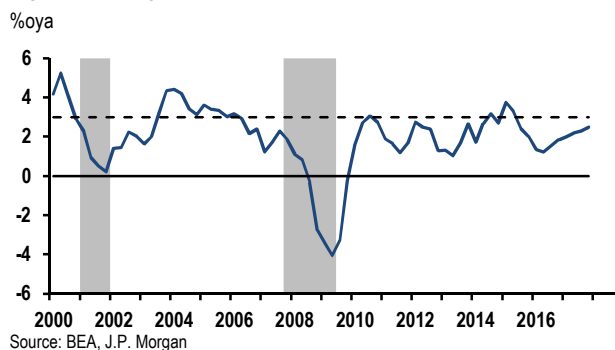
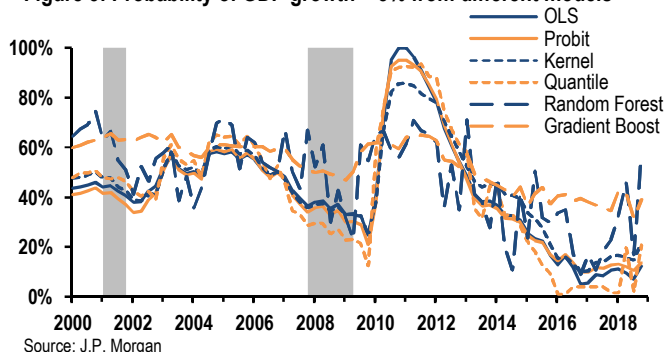


Figure 3: Probability of GDP growth > 3% from different models



Win some, lose some

But in general, the models appear to have had only limited success in picking out the 25% of years when GDP growth would run above 3%oya with much precision. Table 1 evaluates their performance more precisely by calculating their out-of-sample root-mean-squared-errors (RMSEs) in predicting whether GDP growth would run above 3% or below 1%. All the models do considerably better than a coin flip (which somewhat counterintuitively would have a RMSE of 0.71, the square root of 0.5), but they only narrowly outperform a rolling historical average. And differences across the models are slight—there is little indication that more complex, nonlinear models systematically outperform the simplest linear models. We do note that for both thresholds, the average across the several models does at least as well as any individual model, echoing a result commonly found in the forecasting literature.

At the moment, the average across these models would put the probability of 2018 4Q/4Q GDP growth running above 3% at 27%. We suspect the models may not fully capture the positive tone visible in many near-term data series right now and the likely effects of oncoming fiscal stimulus, so we round this figure up and conclude that the probability of GDP growth above 3% in 2018 is about 30%.

Table 1: RMSE in predicting GDP growth probabilities, 2000-2017

Model	> 3%	<1%
OLS	0.48	0.39
Probit	0.47	0.39
Kernel density	0.47	0.39
Quantile regression	0.47	0.41
Random forest	0.49	0.39
Boosted tree	0.52	0.41
Average of methods	0.47	0.39
Historical average	0.53	0.40
Coin flip	0.71	0.71

Source: J.P. Morgan

We could also use these models to take views on downside risks to our forecast; the model average would currently put the probability of GDP growth below 1% at about 20%. This is probably a mildly more optimistic view than our preferred recession model, which puts the probability of recession starting within one year at just above 20%. But in fact, we suspect that the recession model will still be our preferred tool for thinking about recession risks. In a sense, the recession model abstracts from the difficult problem of forecasting potential growth and focuses only on predicting large downside deviations from potential, while the growth-based models developed here must struggle to capture the factors that drive potential growth as well. In any case, we will continue to work on improving our understanding of these issues in future research.

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