INSTITUTIONAL ADVISORY & SOLUTIONS

Executive Summary

THE PROBABILITY OF RECESSION

A Critique of a New Forecasting Technique

June 2020

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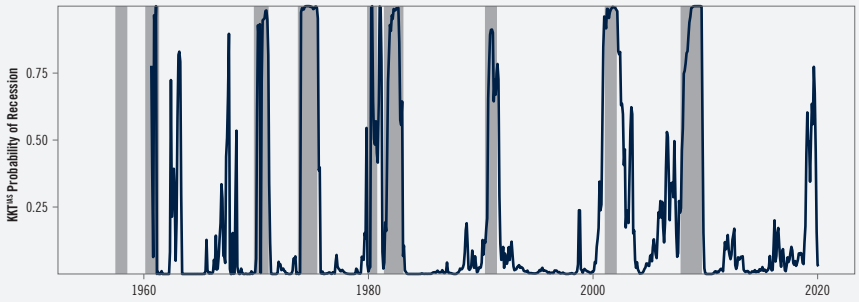
A recent research publication by Kinlaw, Kritzman and Turkington (KKT)[1] develops a new business cycle forecasting technique using a metric called "Mahalanobis distance." This measure is intuitive, is based on a straightforward set of computations, is able to identify post-war US recession with few false positives, and has a reasonable forward hit rate.

In late 2019, KKT concluded that the probability of a US recession had climbed above 75%, a prediction that was at odds with many other models. But by early 2020, the probability of recession had retreated, falling below 3% (see Figure 1). The high degree of volatility prompted a need to learn more about the strengths and weaknesses of this new method. We also examine its potential as a market timing tool.

Figure 1: KKT^{IAS} Probability of Recession
(Out-of-sample estimate, 12m start up data set, expanding window)



Note: Gray bars represent periods of NBER recessions.
Source: BLS, Federal Reserve Board, Haver Analytics, NBER, Standard and Poor's, and PGIM IAS.
For illustrative purposes .

To facilitate a more detailed analysis, we replicate the KKT measure,which we label KKT^{IAS}.

We have five observations on KKT:

(1) **Mahalanobis distance and a Bayesian path to recession probability.** KKT employs a statistic, the **"Mahalanobis distance,"** to the problem of business cycle forecasting. The idea underlying the Mahalanobis distance is

1 "A New Index of the Business Cycle" by W. Kinlaw, M. Kritzman and D. Turkington, MIT Sloan School Working Paper 5908-20, 15 January 2020.

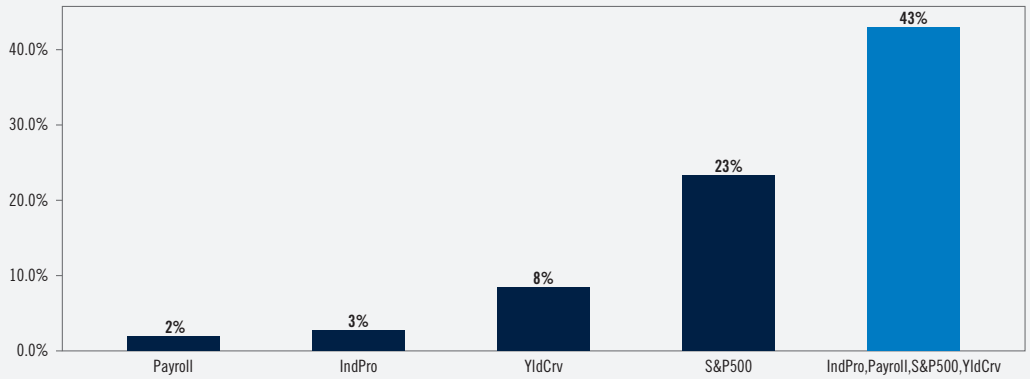
that, at a point-in-time, a set of economic data can be described in terms of its "proximity" to, or "distance away" from, economic data that are typically observed during recessionary periods. This similarity score is essentially the likelihood that a given draw of data is from a recessionary distribution. The next step is to transform this likelihood into *the probability of a recession given a draw of data*, a far more relevant metric for market participants. As we make explicit, the Mahalanobis distance can be transformed into a recession probability. We are able to replicate KKT's measure (to avoid confusion below we label our replication as KKT^{IAS}) and show that it is very sensitive to the many technical details that go into the estimation of the parameters that govern the data's distribution (namely the means and variance-covariance matrices).

(2) **Which inputs matter?** One drawback of the KTT methodology is that it does not lend itself to direct tests of statistical significance of the input variables the way, say, a regression model would allow. The KKT US recession probability measure is based on four input variables: US industrial production growth, US employment growth, trailing-twelve-month (TTM) equity returns and the yield curve. But the authors of the original paper do not discuss their choice of input variables, nor do they subject their index to any sensitivity analysis. We find that, historically, all four candidate explanatory variables do, in fact, seem to matter. We do not explore alternative specifications.

(3) **Equity returns and the yield curve drive the 2019-2020 moves in recession probability.** As illustrated in Figure 1, in late 2019 the KKT^{IAS} index climbed 43 percentage points to 77%; it then subsequently fell to less than 3% by January 2020. In large part, market variables – S&P 500 returns and the yield curve – drove these sharp moves; the S&P 500, *when taken alone*, led to a 23ppt increase in the probability of recession (relative to a 43ppt decline for the full four-variable model) and the yield curve, *when taken alone*, led to an 8ppt increase (see Figure 2). Subsequently, the probability of recession fell by 74ppt (to a 3% probability of recession). Market variables were, again, dominant, with the S&P (*taken alone*) lowering the probability of recession by 43ppt, and the yield curve (*alone*) lowering the probability of recession by 10ppt (see Figure 3). Although employment growth on its own actually had little impact on the probability of recession, and industrial production actually led to a further increase in the probability of recession, when combined with market inputs (the yield curve and equity returns), the four variables, *taken together*, lowered the probability of recession by nearly 75ppt. This illustrates the importance of interaction effects among the input data series, one of the key strengths of the methodology, and underscores the importance in proper estimation of the VCV matrix which governs such interaction effects.

(4) **Is an elevated probability of recession a risk-on signal for markets? Perhaps.** From the perspective of an investment practitioner, one important potential use of a measure such as KKT^{IAS} is as an indicator of forward market conditions, in terms of expected returns, volatility and risk considerations, and the implications for portfolio construction and allocation decisions. Given that trailing market data play a significant (though not exclusive) role in driving the KKT^{IAS} measure, does KKT^{IAS} provide *forward* market information? We analyze how an investor could use the KKT^{IAS} index as a market timing signal. As Figure 4 illustrates, relative to times when KKT^{IAS} climbs to 80% and higher, (we identify 13 such episodes using data from 1954 to present) average S&P 500 returns are negative in the 12-month window before such an event and are positive in the 12 months afterwards. This preliminary analysis suggests that a good deal of market damage has already been inflicted by the time KKT^{IAS} climbs and warrants further exploration.

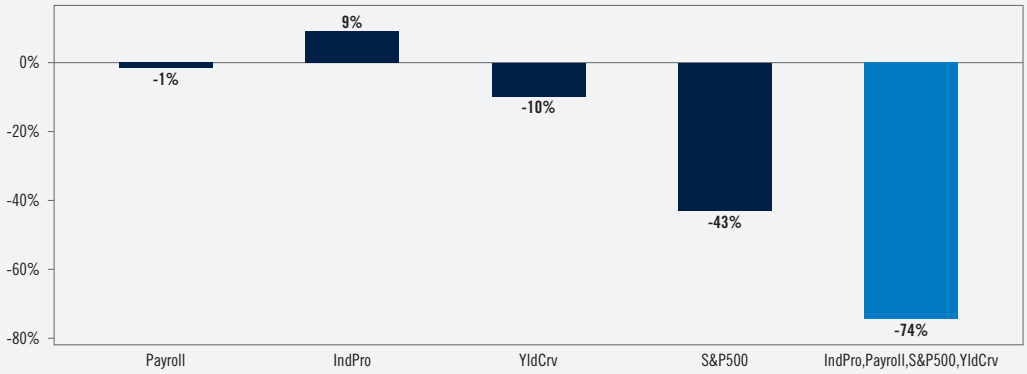
Figure 2: Decomposing the Changes in KKT^{IAS}, April 2019-August 2019



Note: Navy bars represent the change in recession probability from April 2019 to August 2019 using a KKT^{IAS} model based on only a single input. The blue bar represents the change in recession probability from April 2019 to August 2019 using a KKT^{IAS} model based on all four inputs.
Source: Federal Reserve Board, Haver Analytics, NBER, Standard and Poor's, and PGIM IAS. For illustrative purposes only.

(5) **Technical details: Estimating the variance-covariance matrix.** From a technical/statistical perspective, the KKT^{IAS} measure is sensitive to some choices in how to treat the data and estimate some of the key parameters. In particular, we focus on the role of the variance-covariance matrix (VCV) of the four input variables in calculating the probability of recession. We highlight three important facts in this context: (1) The role of the VCV matrix and its impact of weighting the input data is critical; when we try alternative specifications (using either a diagonal matrix – weighting by variances alone) or simple averaging of the data, the resulting probability measure changes substantially. (2) However, the estimated VCV is unstable over time. In particular, recessionary covariance terms do not seem to converge over time, with each recessionary period seemingly associated with its "own" set of covariances (among the four explanatory variables). (3) Finally, although market variables play an outsized role, there does seem to be a tendency for their variances to converge at a higher level, while macroeconomic variable variances seem to be converging to a lower level. This would make market variables relatively less important now relative to the past, and macroeconomic data relatively more important relative to the past (given that the weighting scheme is the inverse of the VCV matrix).

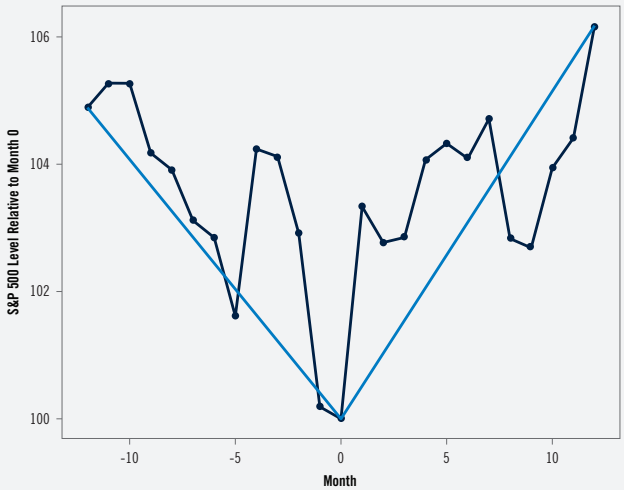
Figure 3: Decomposing the Changes in KKT^{IAS}, August 2019-January 2020



Note: Navy bars represent the change in recession probability from August 2019 to January 2020 using a KKT^{IAS} model based on only a single input. The blue bar represents the change in recession probability from August 2019 to January 2020 using a KKT^{IAS} model based on all four inputs.
Source: Federal Reserve Board, Haver Analytics, NBER, Standard and Poor's, and PGIM IAS. For illustrative purposes only.

Figure 4: S&P 500 Performance Before and After the Probability of Recession Climbs to 80%

24m window, indexed to month 0, 13 episodes from 1954 to 2020
(Month 0 is the first month when $KKT^{IAS} \geq 80\%$)



Source: Haver Analytics, NBER, Standard & Poor's, and PGIM IAS. For illustrative purposes only.

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IAS 0528-200