TWO SIGMA

Street View

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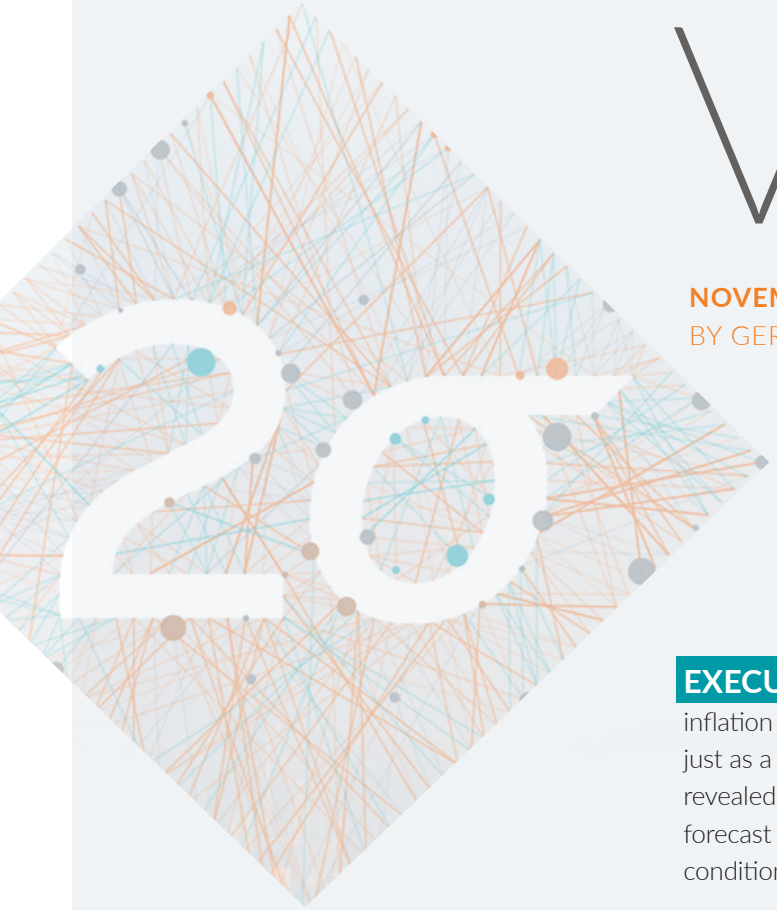

EXECUTIVE SUMMARY One way allocators can improve their inflation forecasts is to analyze it from as many perspectives as possible—just as a data scientist would. Doing so during October would have revealed a surprising and perhaps counter-intuitive result: the median forecast for inflation seems to have fallen recently even as labor market conditions tighten.

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Inside:
Forecasting Inflation like a Data Scientist

Inflation plays a role in almost every important decision that an asset allocator can make, from setting spending targets and managing liabilities to understanding global economic fundamentals and forecasting risk-adjusted returns. Unfortunately, both defining and measuring inflation accurately remain difficult. Janet Yellen, the Chair of the Board of Governors for the US Federal Reserve, described the problem succinctly (at least by Fed-speak-standards) as recently as September 2017: "Our framework for understanding inflation dynamics could be misspecified in some fundamental way."

One way allocators can improve their inflation forecasts is to analyze it from as many perspectives as possible—just as a data scientist would. No single metric comprehensively describes or measures all aspects of inflation, so one should study the sample under many different microscopes. Doing so may not completely solve the challenge the Fed—and others—try to tackle, and the multi-angle approach gives rise to distinct challenges of its own. Still, we believe aggregating and normalizing many different forecasts can help provide more accurate inflation inputs in asset allocation decisions.

CHALLENGES OF A DATA-SCIENCE APPROACH TO FORECASTING INFLATION

Trying to quantify inflation from as many angles as possible—that is, combining different forecasts with different levels of confidence to try to formulate a consolidated view—sounds simple but comes with non-trivial challenges.

One challenge is in the definition of inflation itself. There are many different types of inflation, each of which might have a potentially different market effect for a given horizon and asset. For example, the US Bureau of Labor Statistics publishes both a consumer price index (CPI) and a producer price index (PPI) that includes different baskets of products. Subcategories exist within those broad categories, such as goods vs. services inflation and "core" vs. "non-core." The US Federal Reserve states its goals for inflation in terms of a third metric that the Bureau of Economic Analysis publishes, the Personal Consumption Expenditure (PCE) index. Numerous other definitions of inflation also exist.

Another challenge is the volume of data available. An obvious example includes the proliferation of online prices. Since online prices can change more rapidly than the prices for equivalent goods at brick-and-mortar stores, aligning time stamps to the measurement proves critical (see below). Less obvious, perhaps, is the frequent variation in product specifications. A smartphone today bundles a different set of capabilities than a smartphone last year.

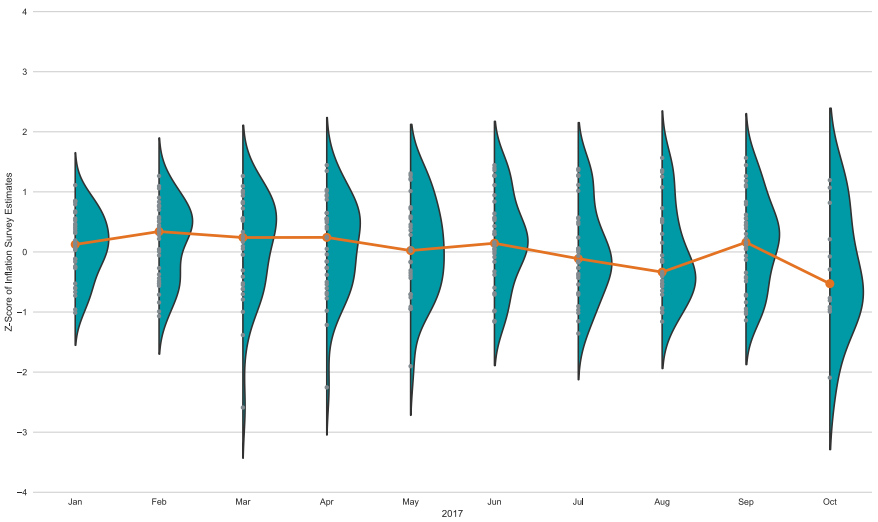
Variation in the time horizon for forecasting inflation presents a third challenge. The US Treasury issues Inflation-Protected Securities (TIPS) with varying maturities, for example. While these instruments may trade continuously, the liquidity varies between on- and off-the-run securities, complicating the estimates for implied inflation forecasts. A similar issue exists for inflation rate swaps.

DISTRIBUTION AND IMPLICATIONS OF 2017 US INFLATION FORECASTS

Figure 1 provides one depiction of these challenges, as well as a potentially better way to understand inflation. The figure plots publicly-available forecasts of future US inflation by month in which the forecast was made. To standardize the estimates, the chart normalizes the mean of each series to zero and the standard deviation to one (based on historical values).

Figure 1 highlights a few main points. First, the inflation forecasts for most months fall in a band of +/- two standard deviations. That band may seem normal (no pun intended), but the important feature is that it affords a relatively varied dataset from which to base inflation forecasts. A data scientist can evaluate which

FIGURE 1 - NORMALIZED AGGREGATE OF PUBLICLY-AVAILABLE FORECASTS OF FUTURE US INFLATION



Note: Chart plots the monthly distribution for expected US inflation forecasts based on a variety of forward-looking (including survey) sources. To normalize the values given different forecast horizons and types of inflation (e.g., CPI vs. PCE), the plot takes a z-score based on the historical mean and standard deviation of each series. Each forecast plotted with grey dot. The orange line connecting the monthly distributions tracks the median forecast.

measures prove the most stable over time and/or test how each forecast affects individual securities. More importantly, it emphasizes the idea that putting undue weight on point estimates risks confusing rather than illuminating the inflation picture.

Second, the median forecast during 2017 has hovered around its long term value (zero), though it dipped materially during the month of October. It seems premature to assume that this one month trend will continue, but it seems inconsistent with the Phillips curve notion that inflation expectations have ticked higher due to tightening labor market conditions. Finally, the distribution of inflation forecasts during 2017 seems to have a negative skew. The Fed professes to have a "symmetric" two percent inflation target, so it tries to manage above- and below-target expectations equivalently. Negatively skewed inflation expectations imply that more market participants believe the Fed has become too hawkish than too dovish on inflation. As a result, the Fed's actions may surprise the market in ways that adversely affect some asset prices.

Chair Yellen summarized the Fed's bewilderment candidly in a September press conference:

> "Now, I recognize and it's important that inflation has been running under our two percent objective for a number of years, and that is a concern, particularly if it were to translate into lower inflation expectations. For a number of years there were very understandable reasons for that shortfall, and they included quite a lot of slack in the labor market—which, my judgment would be, has largely disappeared—very large reductions in energy prices, and a large appreciation of the dollar that lowered import prices starting in mid-2014. This year, the shortfall of inflation from 2 percent, when none of those factors is operative, is more of a mystery, and I will not say that the Committee clearly understands what the causes are of that."

Asset allocators may not know what the causes of it are either, but with proper data they can construct a better, multi-angle picture of how inflation may change. The data-driven approach seems to beat the tried, tested, and frequently failed alternative of relying too heavily on theory.

INTERESTING TECHNOLOGY-RELATED ARTICLES

Two Sigma views itself as a technology company that applies a rigorous, scientific method-based approach to investment management. Our technology is inspired by a diverse set of fields including artificial intelligence and distributed computing. Occasionally, we read articles in the popular press that describe applications of technology that we find interesting, thought-provoking, and relevant for people thinking about improving the investment management process. Below is a subset of the articles we read this month. Please do not view the inclusion of these articles as an endorsement by Two Sigma of their viewpoints or the companies discussed therein. Two Sigma welcomes discussions (and contributions) about these and other such technology-related articles.

"Self-Driving Trucks May Be Closer Than They Appear" by Conor Dougherty

https://www.nytimes.com/2017/11/13/business/self-driving-trucks.html?rref=collection%2Fsectioncollection%2Ftechnology

The $700 billion commercial trucking industry may be approaching a tipping point in its march toward full automation, according to a recent New York Times article. While progress in building autonomous passenger vehicles tends to receive more attention in the press, the race to develop and deploy self-driving tractor-trailers is proceeding with equal vigor, with several prototypes already on the roads. For trucking companies, the benefits of AI-driven fleets potentially include drastically reduced labor costs and lower insurance costs, should autonomous trucks surpass human drivers' safety record. Of course, the ramifications for truck drivers (and associated service providers, like vocational schools) are negative over the long term, but several industry-watchers see opportunities for drivers lasting through perhaps the next couple of decades, including navigating trucks at either end of a trip (the most technically challenging part). An equally crucial but more dubious role for human drivers: training trucks' AI systems to drive—and ultimately take over the entire job.

"You Can Use Aluminum Foil to Strengthen Your Wi-Fi Signal" by Rob Verger

https://www.popsci.com/aluminum-strengthen-wi-fi-signal

Do-it-yourself types once relied on a low-tech solution to augment the most important data network they had available—television signals. These resourceful engineers would wrap their rabbit ears (i.e., television antenna) with aluminum foil to increase signal reception for over-the-air broadcasts. Little seems to have changed. Researchers from Dartmouth College published the specifications for a 3D-fabricated receiver that do-it-yourselfers can cover with aluminum foil to more judiciously aim their WiFi signals. This device can both amplify signal strength in some directions (e.g., poor coverage spots within a house) and shield it from others (e.g., a neighbor's house) to improve their wireless networks. The research raises an important but unresolved question—what advanced communication technology will people cover in tin foil a few decades from now?

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