

# The inflation machine: How it works and where it's going

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- An “inflation scare” of rising consumer prices in 2021 was a central theme of Vanguard’s annual economic outlook. So far in 2021, inflation rates have been stronger than expected, though they are likely to cool later this year. But given a backdrop of highly accommodative monetary and fiscal policies, how likely are persistently higher rates of U.S. inflation for 2022 and beyond?
- We revise and update Vanguard’s state-of-the-art inflation forecast model, our so-called inflation machine first developed in 2007, to project core inflation over the next two years. Our inflation machine accounts for interdependencies and feedback loops from the various drivers of inflation, including cyclical factors (growth, slack), secular forces (technology, globalization), and the fiscal and monetary policy stance. Importantly, unlike conventional approaches, our approach allows for inflation expectations to be affected by the same forces as actual inflation.
- Our inflation machine expects U.S. core Consumer Price Index inflation to settle down later this year after a transitory run-up—an outcome widely anticipated by the markets. Should \$1 trillion or more in additional U.S. fiscal spending be enacted this year, however, core inflation would pick up again more sustainably toward the end of 2022 or in early 2023, perhaps even reapproaching 3%. This upside risk to inflation for 2022 is not fully anticipated by either the financial markets or Federal Reserve forecasts, suggesting that the risk is a slightly sooner-than-expected Fed liftoff.

### The inflation scare of 2021: How transitory?

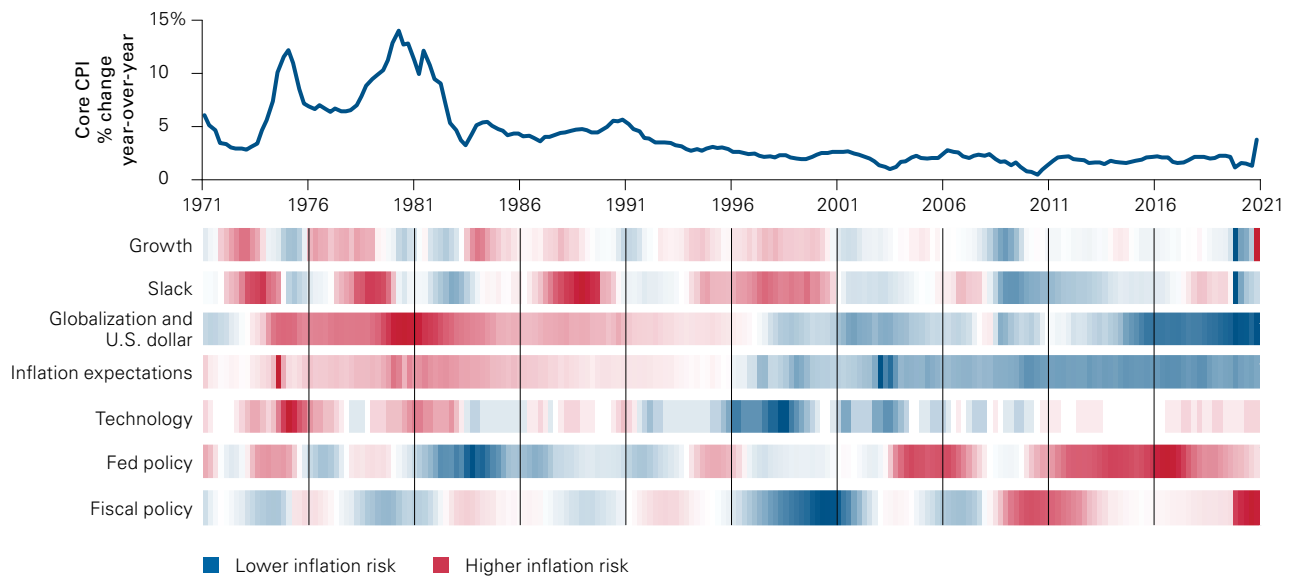
A central theme of Vanguard’s annual economic outlook for 2021 was that inflation would pick up temporarily this year for two reasons. First, the combination of rising COVID-19 vaccination rates and strong policy responses would lead to a strong economic rebound in the U.S., creating some supply-and-demand imbalances. Second, a so-called base effect would amplify this “inflation scare,” with prices returning closer to pre-pandemic levels in sectors that contracted the most sharply, such as leisure and hospitality.

The run-up in inflation rates in 2021 has been stronger than we anticipated, with supply constraints helping prices ranging from used cars to lumber to rise rapidly. As of July 2021, the U.S. Consumer Price Index was up 5.3% over the prior 12 months, the highest such increase since August 2008. Excluding food and energy prices, the so-called core Consumer Price Index (CPI) rate of inflation was 4.5%, above the Fed’s long-term goal of 2%. Nevertheless, most economists (including us) believe that currently high inflation readings will prove transitory, with core inflation beginning to fall back toward 2% by the end of 2021.

Yet with the global COVID-19 crisis having engendered historic monetary and fiscal stimulus and a rapid economic recovery now under way, how likely is persistently higher U.S. inflation for 2022 and beyond? As **Figure 1** shows, the many drivers of inflation show a mixed picture. The economic growth rate is high, but unemployment rates are still elevated. Fiscal and monetary policies are highly stimulative, yet the secular disinflationary forces such as technology have not disappeared.<sup>1</sup> Measures of expected inflation (what consumers and business expect inflation rates to be farther into the future) are stable and support the transitory view. Yet if higher inflation bleeds into expectations, that could trigger a self-fulfilling prophecy and lead to higher future inflation.

So, what are the risks to inflation, and what would it take for the transitory run-up in inflation to become more persistent?

Figure 1. The key drivers of U.S. inflation are sending mixed signals



Note: Data cover the 50 years ended June 1, 2021.

Sources: U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and Federal Reserve, using information from Refinitiv.

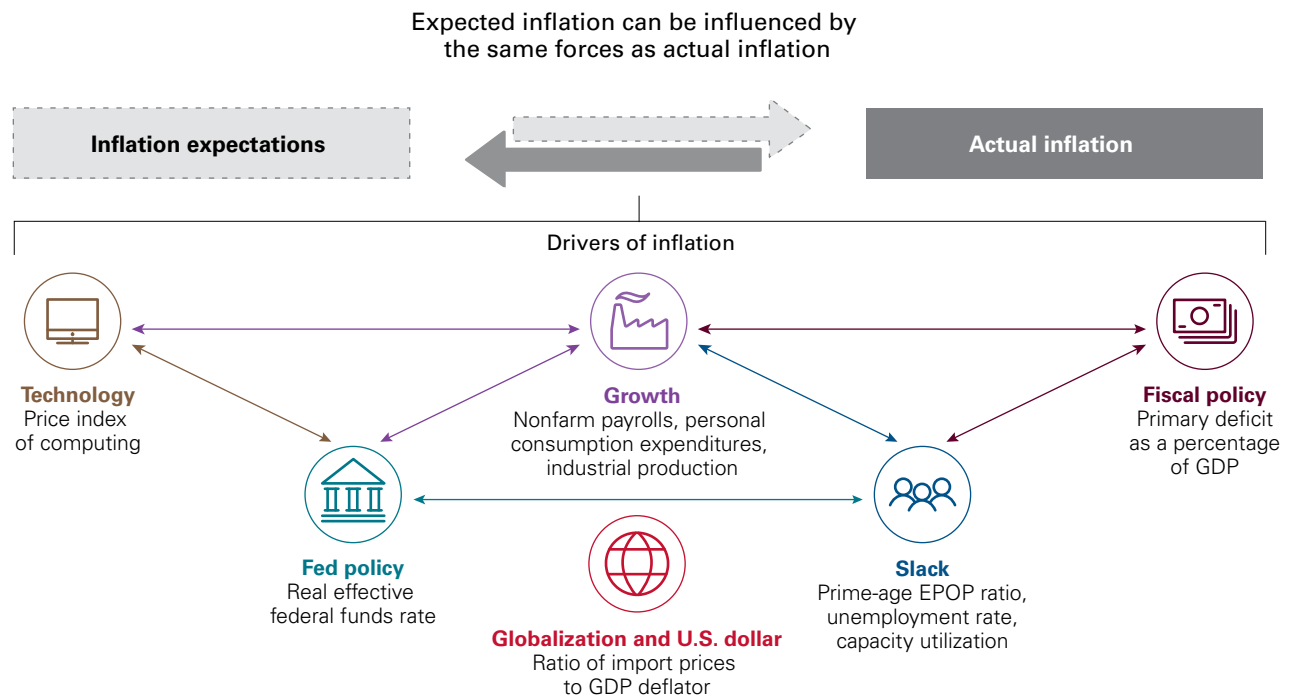
<sup>1</sup> Disinflation is a slowdown in price inflation—that is, when prices are rising but more slowly. This differs from deflation, which is a period of negative inflation or an outright decrease in price levels.

**The details of our inflation machine**

To answer those questions, we’ve revised and updated Vanguard’s state-of-the-art inflation forecast model—our inflation machine first described in Davis (2007)—to project core inflation over the next two years. As **Figure 2** shows, modeling inflation is complex for at least two reasons. First, as documented by academic research such as Stock and Watson (1999), the relative importance of certain drivers of inflation (such as globalization, proxied by commodity prices) can vary over time.

Second, the actual inflation rate *today* (the prices paid by consumers) is in part a function of what inflation is expected to be *tomorrow* (the prices that businesses try to charge and consumers’ willingness to pay them). In a world of “anchored” inflation expectations, any short-term price run-ups should prove transitory. But expected inflation can be influenced by the same forces as actual inflation, so medium-run inflation trends could change.

Figure 2. The inflation machine is complex



**Notes:** The figure is a visual representation of the many drivers of inflation. Nonfarm payrolls are a measure of the number of new jobs created every month in the U.S., excluding farmworkers and a few other job categories. The personal consumption expenditures price index measures what U.S. consumers pay for goods and services. The prime-age EPOP ratio measures the employment-to-population ratio for U.S. workers ages 25 to 54.

Source: Vanguard.

Vanguard's inflation machine explicitly accounts for the interdependencies and feedback loops from the various inflation drivers shown in Figure 2. Specifically, our econometric model accounts for at least seven key factors (excluding actual inflation, which is our variable of interest); those factors include:

- **Distinct cyclical factors for growth and slack.**  
The inflation impacts of stronger growth are more pronounced when an economy's labor market is tight than when it is not, all else being equal.
- **Secular forces such as technology and globalization.**  
Both have served to reduce the costs of production and consumption, which systematically reduce prices in the economy independent of underlying economic conditions.<sup>2</sup>

- **Fiscal and monetary policy stance.** We specify fiscal policy by the trend in deficit spending as a percentage of gross domestic product (GDP). Prior research has found a correlation between fiscal policy and, especially, government spending and inflation, which compels us to include these factors as inflation drivers (Cochrane, 2021).

Importantly, our approach allows for inflation expectations to be affected by the same forces as actual inflation. Expectations play a key role in our model in explaining the endogenous relationships between various inflation drivers. We specify our model as a vector autoregressive (VAR) model estimated since the 1980s. The next section explains the methodology in detail.

<sup>2</sup> Precise definitions of the variables are: for technology, the size-adjusted relative price of technology; for globalization and currency, the ratio of the import price deflator to the overall GDP deflator; and for expectations, adaptive/recursive real-time inflation expectations, derived from the core CPI inflation measure.

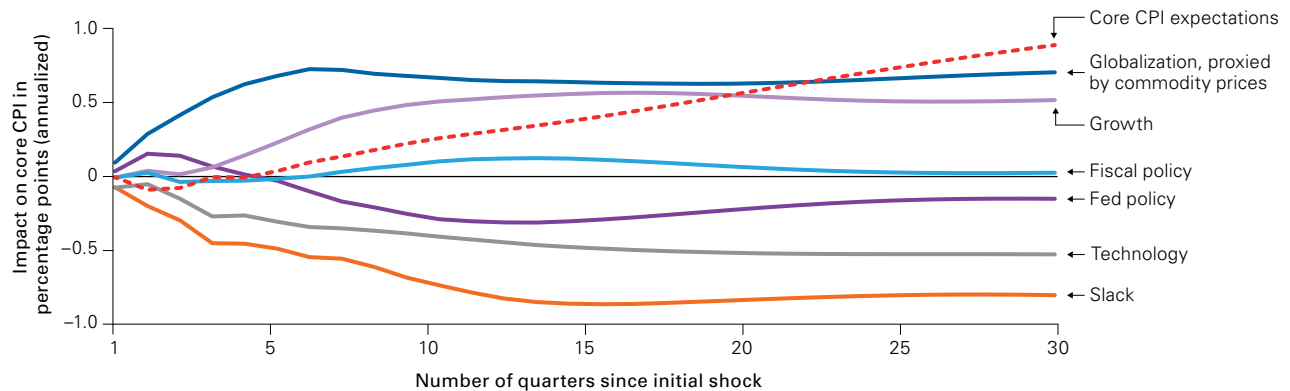
### Our methodology and model specification

Our modeling approach resembles a nonstructural VAR model advocated by Sims (1980), as it brings down the number of economic assumptions to a minimum and allows the model to run free of constraints. Furthermore, the impulse response functions (IRFs) generated from the VAR help us evaluate the impact of alternative fiscal policy assumptions under discussion. Our model helps identify the impact of rising fiscal spending on inflation in the coming months and helps disentangle the dynamic and symbiotic relationship between realized inflation and inflation expectations. We construct our VAR models by combining the drivers of inflation and the core CPI measure of inflation. Each equation includes four lags of all the variables.

The IRFs shown in **Figure 3** summarize the interrelationships between the variables and inflation.<sup>3</sup> The results resemble what we expect in economic theory.<sup>4</sup> Positive shocks to technology, the federal funds short-term interest rate, and slack are disinflationary. Technological improvements have been important secular drivers of disinflation over the past four decades. An increase in the federal funds rate is the Fed’s primary tool for affecting disinflation, and an increase in slack indicates a weaker labor market, reducing inflationary wage pressures. Conversely, a positive shock to the globalization factor, growth, and inflation expectations is inflationary: Higher growth rates boost demand relative to supply, pushing up prices, and commodity price increases boost input prices and thus the inflation rate.

**Figure 3. VAR results point to theoretical relationships between inflation and drivers**

Response of core CPI to a one standard deviation shock in inflation drivers



**Notes:** The figure represents the cumulative impulse response functions from the VAR specification for Vanguard’s inflation machine model. The y-axis represents the cumulative impact on annualized core CPI of a one standard deviation shock to the underlying variables.

**Sources:** Vanguard estimates, using data from Thomson Reuters Datastream, U.S. Bureau of Economic Analysis, and Moody’s Data Buffet, based on Vanguard’s inflation machine model.

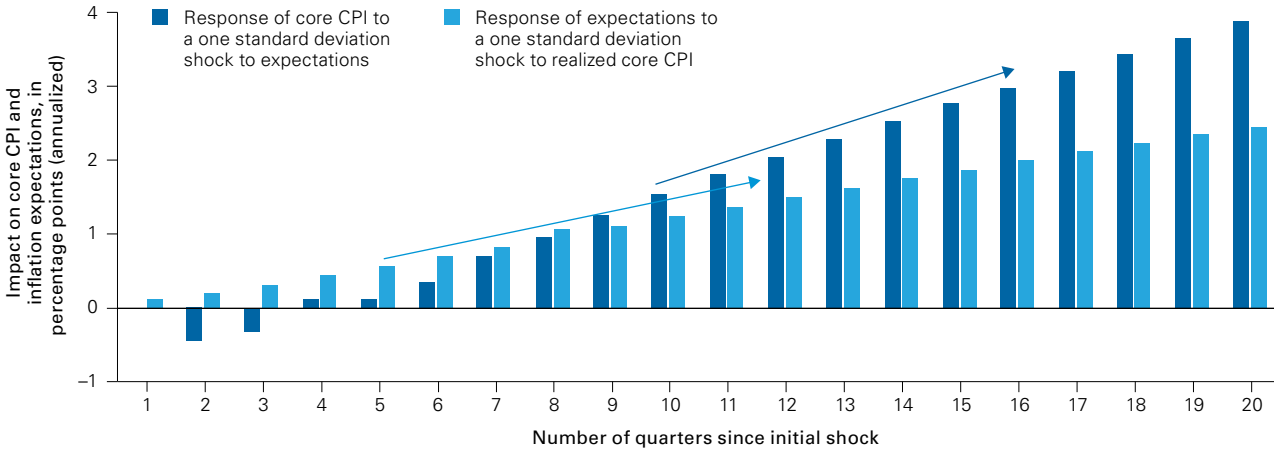
<sup>3</sup> The IRFs represent the cumulative shock to annualized core CPI from a one standard deviation shock in its driver variables, and those IRFs can be scaled up or down to accommodate expected shocks in the driver variables. (For example, if the actual shock to inflation is three times the standard deviation, we can scale the impacts up by multiplying them by three.)

<sup>4</sup> Although an increase in slack and monetary policy variables is deflationary, an increase in growth and fiscal spending variables is inflationary.

The relationship between actual inflation and inflation expectations is an important building block in our understanding of how a change in the markets' and public's perception of the rise in inflation actually affects inflation (Figure 4). Businesses and households both take expectations of future inflation into account when making economic decisions, such as negotiating

wage contracts and setting prices. Focusing on the relationship between core CPI and inflation expectations, we estimate the impact of a shock to one variable on the other using the IRFs. We find that although the relationship extends in both directions, the impact on core CPI of a change in inflation expectations is greater than the other way around.

Figure 4. Expectations and actual inflation are tied together in a feedback loop



Notes: The bars represent the impact on inflation expectations (lighter shade) and core CPI (darker shade) from a one standard deviation shock to the other variable. Sources: Vanguard estimates, using data from Thomson Reuters Datastream, U.S. Bureau of Economic Analysis, and Moody's Data Buffet, based on Vanguard's inflation machine model.

**Our current forecast: Different horizons based on different scenarios**

Another purpose of the VAR model is for evaluating various policy decisions or, as Sims (1980) put it, for use “as a sort of battleground for testing alternatives.” Using the impact values, we can estimate the impact of an increase in fiscal deficit equivalent to the most recent fiscal stimulus package as well as a range of alternative policy packages.<sup>5</sup> For the same time period, we also construct various scenarios of the future path of core CPI if inflation expectations are scaled up. Our scenarios assume that both the policy decisions and inflation expectations shocks originate in the third quarter of 2021.

Our baseline scenario assumes an additional \$500 billion in fiscal stimulus and an increase of 20 basis points (bps) in inflation expectations. (A basis point is one-hundredth of a percentage point.) We estimate that in this scenario, along with the current recovery-driven rebound in inflation, core CPI would rise to a year-over-year rate of 2.9% by the end of 2021. Beyond this year, we estimate that fiscal and inflation expectations shocks would continue to push inflation, offset by stronger base effects in 2021, and by year-end 2022, we could see core CPI touching 2.6% year-over-year (Figure 5).

Figure 5. Reaching 3% core CPI again in 2022 would require even heftier fiscal spending, beyond the \$1.9 trillion already spent

		Scenarios							
		Downside		Baseline		Upside		"Go Big"	
		\$1.9 trillion in enacted fiscal stimulus		\$1.9 trillion in enacted fiscal stimulus + additional \$500 billion		\$1.9 trillion in enacted fiscal stimulus + additional \$1.5 trillion		\$1.9 trillion in enacted fiscal stimulus + additional \$3 trillion	
		BEI up 5 bps		BEI up 20 bps		BEI up 25 bps		BEI up 50 bps + growth upside	
		Core CPI	Inflation expectations	Core CPI	Inflation expectations	Core CPI	Inflation expectations	Core CPI	Inflation expectations
2021	Q1	1.5%	—	1.5%	—	1.5%	—	1.5%	—
	Q2	3.5	1.6%	3.5	1.8%	3.5	1.9%	3.5	2.0%
	Q3	3.4	1.5	3.4	1.8	3.4	1.9	3.5	2.1
	Q4	2.8	1.5	2.9	1.9	2.9	2.0	3.1	2.2
2022	Q1	3.1	1.6	3.2	1.9	3.3	2.0	3.6	2.3
	Q2	1.7	1.6	1.8	1.9	1.9	2.1	2.2	2.4
	Q3	1.7	1.7	1.9	1.9	2.0	2.1	2.4	2.5
	Q4	2.4	1.8	2.6	1.9	2.8	2.2	3.2	2.5

**Notes:** The scenario data for both core CPI and inflation expectations are Vanguard’s inflation machine model estimates for alternative fiscal stimulus spending plans and the magnitude of rise in inflation expectations. Inflation expectations here mean long-term inflation expectations for core CPI. The model estimates are based on a VAR specification in which the globalization factor is treated as exogenous. We use the correlation between break-even inflation (BEI) and long-term inflation expectations to adjust impacts in the model. For all the scenarios shown, the Fed policy stance is unchanged through 2022.

**Sources:** Vanguard estimates, using data from Thomson Reuters Datastream, U.S. Bureau of Economic Analysis, and Moody’s Data Buffet, based on Vanguard’s inflation machine model.

<sup>5</sup> Impact values are derived from IRFs derived from a VAR specification in which the globalization factor is treated as exogenous.

In our upside scenario, additional fiscal stimulus is bumped up to about \$1.5 trillion, and inflation expectations rise by 25 bps. We estimate that in this scenario, core CPI rises to 2.9% year-over-year by the end of 2021. After falling off initially, core CPI could continue to rise to 2.8% year-over-year by the end of 2022. Our downside scenario envisions no additional stimulus and a modest rise in inflation expectations, which we estimate would keep core CPI at 2.8% year-over-year by the end of 2021 and push inflation past 2% only to 2.4% year-over-year by the end of 2022. None of the scenarios outlined thus far, including our upside one, point to a “regime break” in the inflation process, as has been feared recently.

However, if a regime break—a permanent structural shift in inflation trends—does happen, we can imagine that improbable scenario using our framework. What would need to happen to achieve persistently higher core CPI, so much that it pushes above 3% not temporarily but persistently? Asking ourselves that question, we push both our fiscal stimulus and inflation expectations shocks higher. We estimate that core CPI could reach 3% inflation persistently, but that would require substantial net additional fiscal stimulus (about \$3 trillion spent over a year) and a marked jump in inflation expectations (about 50 bps).

### Risks to the model

The predominant near-term risk to inflation involves the significant supply-and-demand dislocations we are seeing in the U.S. economy—particularly in so-called reopening services, such as restaurants and hotels, and in select durable goods categories, such as new and used vehicles. There is a considerable risk, should supply-and-demand disruptions continue in the near term, that core inflation does not dip below 3% by year-end 2021. Once the reopening impulse is behind us, however, the risks to trend inflation into 2022 are well-described by our inflation machine. These risks are strong labor market gains, strong U.S. growth, continued fiscal spending, and inflation expectations. Inflation expectations are especially important as they link near-term risks from supply-and-demand disruptions to longer-term risks of persistent inflation: The longer that today’s inflationary spike lasts, the greater the risk that expectations become dislodged, which could raise the medium- and long-term inflation outlook. As our model shows, inflation is highly responsive to changes in inflation expectations.

Another risk to the forecast arises from changing relationships between variables, such as between realized inflation and inflation expectations. Beginning with Paul Volcker’s tenure as its chair, the Fed has enjoyed strong credibility over the past four decades for its ability and willingness to fight inflation. That strong credibility informs the relationship between expectations and inflation in our model. A change in that credibility—for example, if markets and consumers begin to see today’s Fed as behind the curve on reacting to incipient inflation—would change the relationship between realized inflation and expectations, threatening to more easily dislodge expectations than in the past. This is something to watch as the near-term supply-and-demand mismatches continue.

### Conclusion

A key takeaway from our model is that the consensus is too sanguine about inflation settling into its pre-pandemic trend of 2% in 2022. Our baseline is for a year-end 2022 rate of 2.6%. Thus our model highlights an upside risk to consensus in our base case. Risks to inflation beyond the model’s reach are from current supply-and-demand dislocations proving less transitory than expected, as well as from changes to key relationships between inflation drivers, such as dislodged inflation expectations.

Although proof of any such change in these deeply entrenched economic relationships remains to be seen, the inflation environment will be more volatile in the coming years. The Fed’s raising of rates, while being watchful of higher inflation’s impact on the economy, could prove to be good news for investors as today’s record low rates constrain longer-term portfolio returns. Increased uncertainty about inflation also highlights the importance of constructing a globally diversified portfolio, which gives investors exposure to regions with differing inflation environments.



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