With 20 million trees to a new inflation forecast

Dr. Vincent Stamer

We present a new, powerful inflation model for the euro area. The new model is based, among others, on the machine learning method "Random Forest". It processes a large amount of data and estimates the components of inflation twelve months in advance. For example, the new forecasting model indicates an upward risk for goods prices. Inflation is likely to exceed 2% in the coming year.

A new forecasting model opens up new possibilities

The war in Ukraine and the supply chain crisis caused inflation in the euro area to skyrocket in 2022 – peaking at over 10%. Forecast models had not been able to predict this – partly because there had hardly been any movement in inflation in previous years and models were unable to correctly classify the sharp rise in energy prices and the supply chain problems. Now we have more data and better methods at our disposal. We have therefore developed a new, powerful inflation model that uses machine learning techniques and processes a large amount of data.

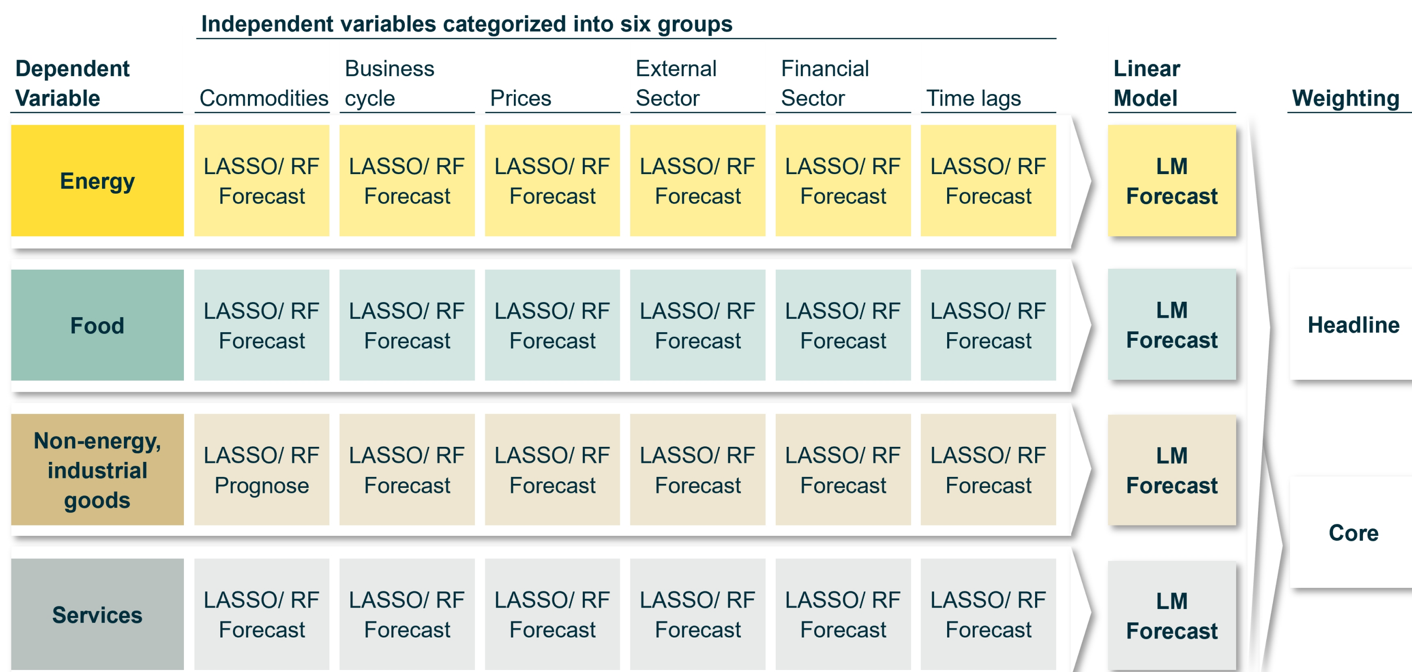
Random forests in the inflation forecast thrive on big data

We have developed a purely data-driven inflation model based on the latest research. While an **Economic Insight** explains all calculation steps in detail, the following section summarizes the most important steps and techniques: At its core, the new forecasting model combines a selection procedure from statistics and a machine learning method that have proven themselves in a similar form in research (see **study**). This combination of techniques allows the processing of a particularly large number of indicators and takes into account unusual movements in the data, such as jumps between inflation levels.

First, a selection procedure (Least Absolute Shrinkage and Selection Operator, LASSO) selects the most important series for the inflation forecast from up to 75 time series and decides what time lags are included in the forecast [1]. The data selected in this way flows into a Random Forest model (RF). This machine learning technique is based on the principle of a decision tree: The months of the last twenty years are sorted into groups in this decision tree according to the independent variables explaining inflation (indicators such as wages or oil prices) and the average inflation of this group is calculated. A new, future month is then sorted into an existing group according to the classification learned. The historical inflation average of this group then serves as a forecast for the new month. The "learning effect" of the machine is that an enormous number of these decision trees are estimated in different combinations of indicators – in our case around 20 million per run. The results of each run are forecasts for the four components of inflation: Energy, food and beverages, non-energy industrial goods and services (rows in Chart 1)[2]. The focus on inflation components allows us to use specific input time series, such as the oil price and producer prices for inputs, to forecast the energy and goods components of inflation in a targeted manner.

Chart 1 - Six groups of independent variables forecast inflation components

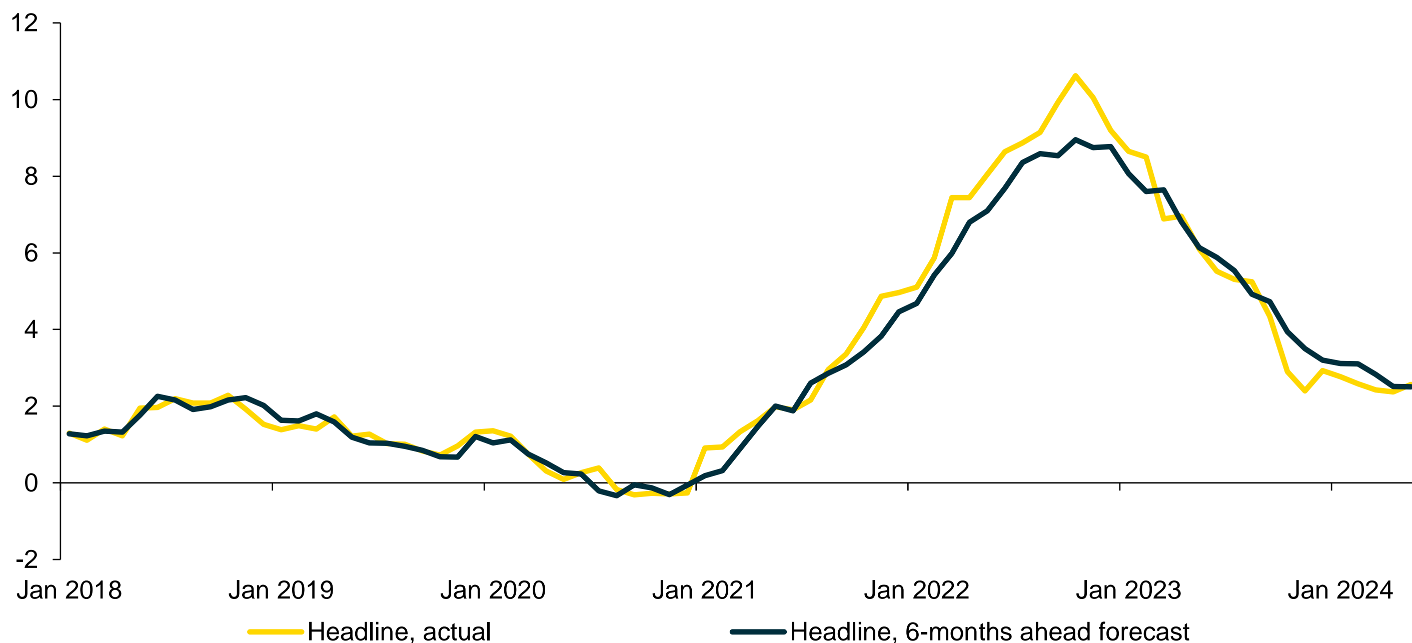
Illustration



The components of inflation are used to produce forecasts for the headline inflation overall and for the core rate excluding energy, food and beverages. After this step, extensive statistical tests check how good the forecast quality of the new methods would have been in the past. As expected, the estimates for the current month are the best (average forecast error of 0.09 percentage points for the month-over-month rate of headline inflation) and the worst for twelve months in advance. Over all time horizons, however, the model beats simple benchmark models such as the historical average or a moving average. We also simulate the forecast for the previous year's inflation rate six months in advance (Chart 2). Despite the enormous deviations in inflation in previous years, the simulated forecast was able to predict well the rise in inflation in 2022 and the subsequent fall in 2023, with certain information from the future being incorporated into this simulation. [3]

Chart 2 - Simulation results promise good fit with inflation

Year-over-year headline consumer price inflation in the euro area; actual values and 6-months ahead forecasts in %



Source: Eurostat, Commerzbank-Research

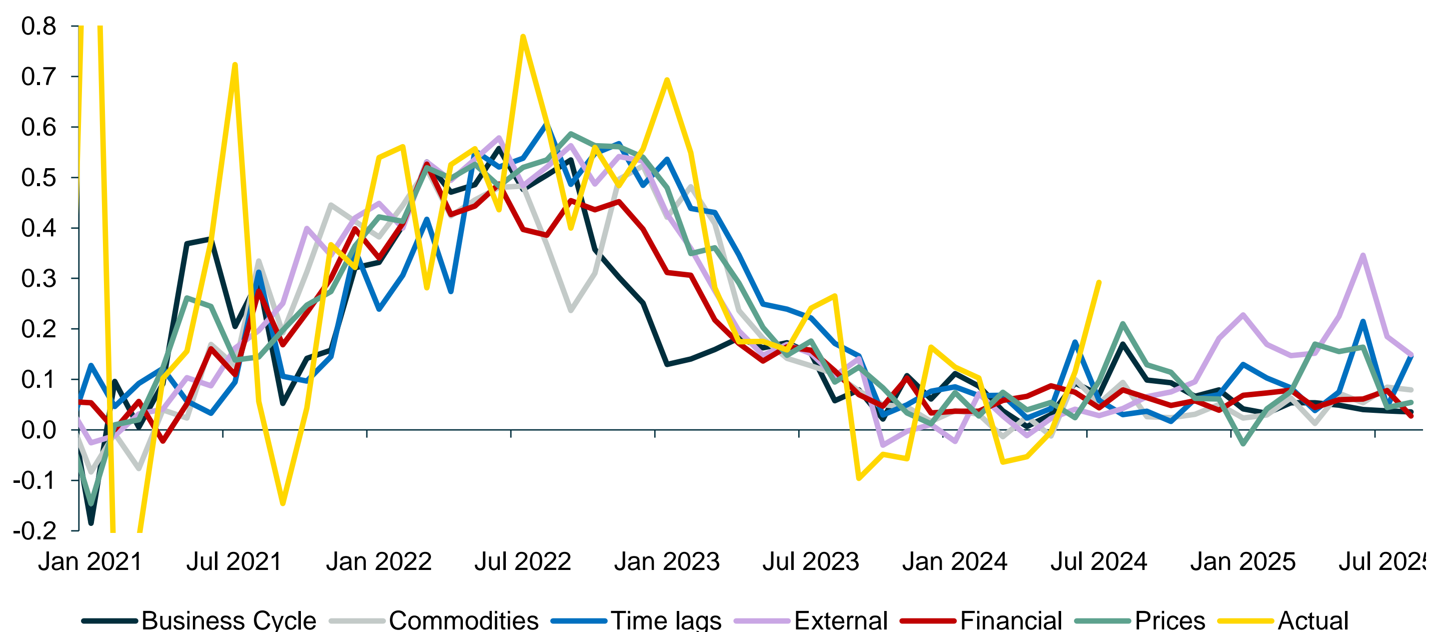
Model sees upside risk for goods prices

To ensure that the model results remain readily interpretable, we do not use all 75 indicators at once, but sort them by groups. For example, one calculation for forecasting goods prices (excluding energy and food) uses only the price developments of exports and imports as well as international transportation costs ("external sector", purple line in Chart 3), while another calculation is based exclusively on past values of the inflation components ("time lags", blue line in Chart 3) [4]. At best, these individual model results produce a narrow corridor for our forecast of goods prices. The simulation of the historical model results paints an interesting picture: In the past, the previous month's rates of goods prices have fluctuated around the six forecasts. This suggests that the high level of goods inflation in July this year of 0.3% compared to June is an outlier. In the coming months, these previous month's rates will likely be below this level.

Falling commodity prices are currently still having a moderating effect on goods price inflation. However, the rising prices of intermediate goods and other inputs ("prices" indicator group) mean that goods price inflation is likely to be higher in the second half of this year than in the first half. The skyrocketing freight rates in the container ship network could then cause goods prices to rise even more starting from December 2024. In a previous **publication**, we had already estimated the effect of the sharp rise in freight rates on the core rate (previous year's rate) to be up to 0.25 percentage points over the next twelve months. The increase in the forecast from the external sector on goods prices supports this calculation.

Chart 3 - Forecast models for goods' prices

Out-of-sample forecasts for monthly changes inf non-energy industrial goods prices, in %; until July 2024 h=0, afterwards increasing in forecst horizon.



Source: ECB, Commerzbank-Research

Service prices slowly falling despite wages

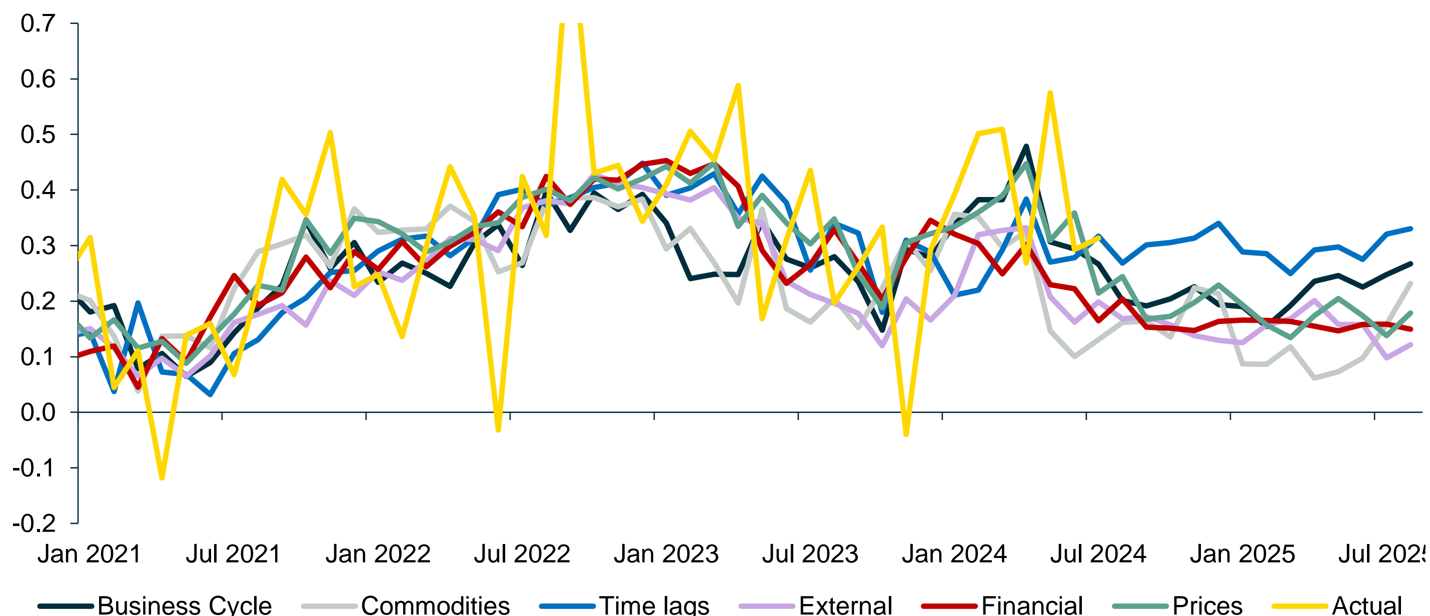
The development of service prices has had a strong impact on inflation in recent quarters due to spikes in package holidays, transportation services and accomodation costs. Services are the most important component of the inflation rate and the average monthly rate since 2021 has been very high at 0.3% (Chart 4). Now, the forecasted trend for the next twelve months is pointing downwards. The slowdown in the rise in food and beverage prices could now also have a dampening effect on restaurant prices. Falling fuel prices in recent weeks could provide relief for transportation services. Overall, the Random Forest model predicts a decline in the core rate to annualized month-over-month rates of around 2%.

These forecasts already take into account the currently high wage increases. In addition to producer prices and surveys on input Prices, the "price time series" indicator group also includes wages, using the ECB's experimental Wage Tracker, among other things. Alongside the output gap, this time series is the only one that is also available for the future and in itself consists of a forecast. This is becasue the wage agreements already available today also determine wage increases in the future.

As also described in the **Economic Insight**, the new Random Forest model is subject to methodological limitations. For example, the Random Forest method could underestimate the effect of wages, as wages have never risen as much in the last twenty years (the training phase of the model) as they are doing now in the application phase.

Chart 4 - Random Forest Forecasts predict easing services inflation

Out-of-sample forecasts for monthly changes in services prices, in %; until July 2024 h=0, afterwards increasing in forecast horizon.



Source: EZB, Commerzbank-Research

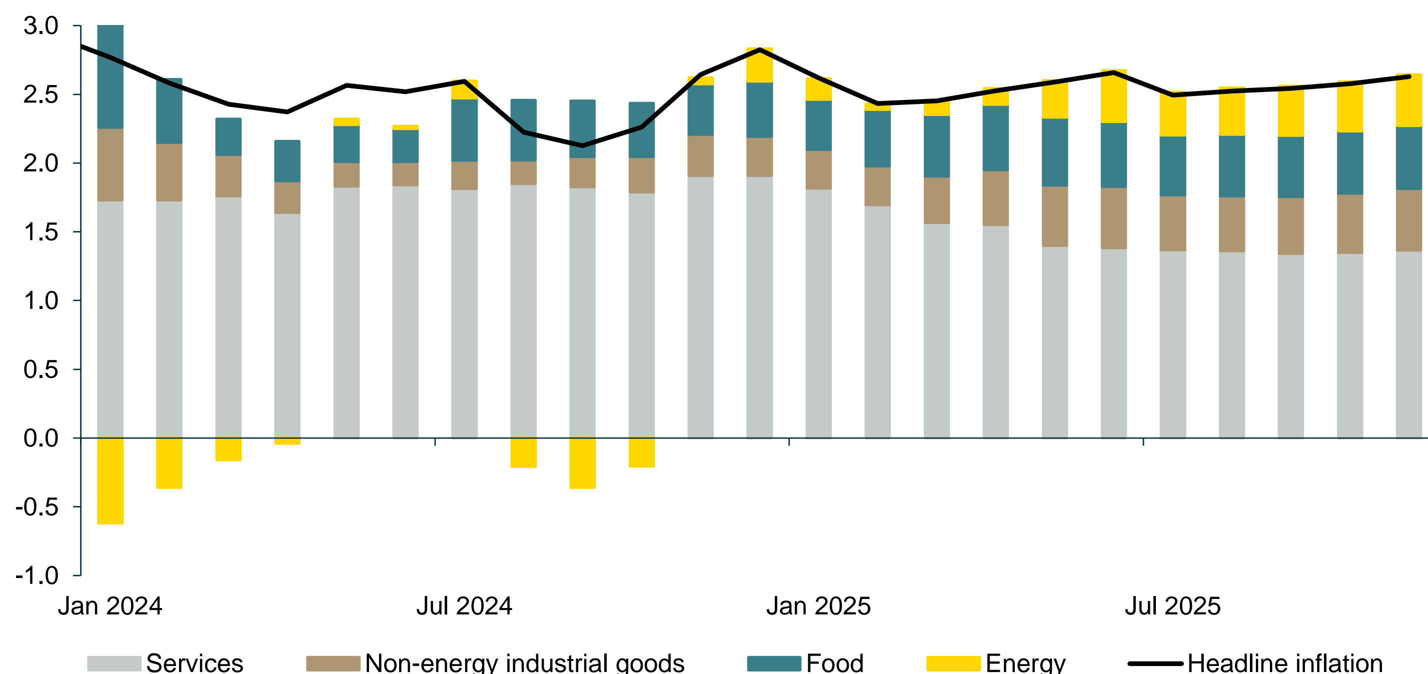
Inflation is likely to remain at 2.5% in the coming year

Due to the limitations mentioned above, we supplement the model forecasts with empirical values and assumptions on structural effects that the Random Forest method cannot yet take into account. We therefore never incorporate the model results into our inflation forecasts without making adjustments. The further into the future the forecast is, the more structural assumptions are incorporated into the calculation. For example, we increase the effect of wages on inflation due to the worsening labor shortage. We also expect higher inflation in the future than calculated by the pure model due to decarbonization and deglobalization. For the second half of 2025, we are continuing the forecast from the last forecast month (in this case August 2025) and incorporate the manual additions to a greater extent.

Overall, the inflation rate is likely to describe a wave-like movement in the coming months: Initially, the inflation rate falls to around 2.0% by September, as energy price increases in late summer 2023 fall out of the year-on-year comparison (Chart 5). The inflation rate will then rise again later this year as service prices continue to rise due to wage increases. Inflation is expected to stabilize at 2.5% during 2025 – also as a result of rising goods and energy prices. At this point, high freight rates are already being factored into the development of goods prices and assumptions about decarbonization effects, for example in energy prices.

Chart 5 - The inflation rate will remain high well until 2025

Contributions to headline inflation by major components; Starting July 2024: Commerzbank Research, in percentage points



Source: Eurostat, Commerzbank-Research

The ECB misses its target

With an average inflation rate of 2.5% next year, the ECB is likely to miss its target of around 2.0%, strictly speaking. However, ECB President Christine Lagarde had already prepared the markets that the inflation rate "will remain elevated well into 2025". As inflation should remain on its expected path to 2%, the central bank could justify further interest rate cuts until spring 2025.

Admittedly, a difference of half a percentage point between the ECB's target and our forecast does not seem high at first glance. But as soon as a further cost shock hits the euro area economy, inflation would soar from an already elevated level well above the ECB's target. With the increasing tensions in the Middle East, a shock to oil and gas prices is not unlikely. This is particularly true if the Strait of Hormuz becomes impassable for tankers due to military intervention by Iran. An escalation in the trade dispute with China cannot be ruled out either.

[1] Least Absolute Shrinkage and Selection Operator (LASSO) goes back to research from the 1990s. Since then, it has been the most widely used method in econometrics for selecting time series in a large amount of data. (Back to the text)

[2] We also categorize the indicators into six groups (columns of Figure 1). Each indicator group is used to forecast the components of inflation (rows of Figure 1). A linear model (LM) combines the forecasts from different indicator groups for the same inflation component. (Back to the text)

[3] Our test procedure corresponds to the "leave-one-out out-of-sample" (LOO) procedure. This is less restrictive than an "expanding window" or "rolling window" version and could underestimate the effect of structural breaks. However, the LOO method has the advantage that the high-inflation phase of previous years can always be used to identify the relevant variables and threshold values. This means that the estimation error of the test phase is also a better indication of the estimation error of the coming months, as the high-inflation phase of recent years is now always available for the estimation (Back to text).

[4] We base this on a **study** by the Dutch central bank and classify the indicator groups as follows:

- Prices of energy sources/commodities and exchange electricity prices (abbreviated here as "C**ommodities**")
- Economic indicators and economic indicators ("**Business cycles**")
- Price indicators and survey results on price trends ("**Prices**")
- Foreign trade prices and international transportation costs ("**External sector**")
- Financial market indicators including the price development of inflation swaps ("**Financial sector**")
- Historical, or time-delayed, dependent time series ("**Time lags**") (Back to text)

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