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Decomposition of the consumer price index into cyclical and acyclical components

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Abstract

The deviation of aggregate demand from its equilibrium level is traditionally considered as an important factor of inflation. However, modern studies increasingly find it difficult to detect a significant connection between the growth of consumer prices and changes in business activity, which raises questions about the efficiency of monetary policy.

One of the most effective ways to solve the problem of the missing relationship between inflation and business activity is to study the components of the price index for the heterogeneity of the influence of business activity on the inflation of individual components. Foreign studies show that the Phillips curve, which has become flat in relation to the aggregate price index, stays steep in relation to individual goods and services.

This paper examines the influence of business activity on the inflation of components of the CPI in the Russian economy. The decomposition of the CPI into cyclical (sensitive to changes in aggregate demand) and acyclical (determined to a greater extent by other factors) components is carried out on the basis of an estimate of the coefficients of the Phillips curve modified for disaggregated price dynamics. The modified Phillips curve takes into account the change in the monetary policy regime, the impact of the exchange rate and relative prices on the inflation of CPI components, as well as the asymmetric response of the growth of prices of individual goods and services to the shock of the general price level growth.

The results obtained confirm the hypothesis of the heterogeneity of the influence of demand on the inflation of individual goods and services in the Russian economy. Cyclical inflation is shown to be much more closely related to business activity than the general price level inflation. The dynamics of cyclical and acyclical inflation in 2021-2024 fully corresponds to the dynamics of aggregate demand. Only the modified Phillips curve made it possible to carry out such a decomposition, the results of which are stable to changes in the proxies for business activity, as well as to the methods of weighting the inflation of the CPI components. The results obtained can be further used in the analysis of price dynamics and the implementation of monetary policy.

Keywords: inflation, business cycle, cyclical inflation, acyclical inflation, Phillips curve

***JEL* codes:** C22, E31

1. Introduction

The process of making decisions on monetary policy is based on the analysis of inflationary processes in the economy. Information on the relationship between aggregate demand and the general price level inflation can be obtained from estimates of the coefficients of the Phillips curve. In contrast to the original paper (Phillips, 1958), which studied the relationship between unemployment and changes in nominal wages, modern interpretations of the Phillips curve use consumer price inflation as the dependent variable and inflation expectations (both the adaptive and rational components) and a measurement of business activity (the output gap, the unemployment gap, or marginal costs) as regressors.

The monetary transmission mechanism assumes that monetary policy affects inflation through aggregate demand. Therefore, the key condition for effective monetary policy is a significant and stable relationship between aggregate demand and inflation. However contemporary research increasingly finds it difficult to find a significant relationship between consumer price inflation and business activity in developed and developing countries (Hazell et al., 2022; Furuoka et al., 2021). It is noted that this relationship weakens over time (Del Negro et al., 2020; Gali and Gambetti, 2019; Stock and Watson, 2020).

In order to find a stable and significant relationship between inflation and demand researchers may replace consumer prices with alternatives such as the producer price index (Sokolova, 2014), the GDP deflator, or the GDP deflator minus exports (Zubarev, 2018). Zubarev (2018) pointes out that this approach has the advantage that the subject of study is inflation which, unlike consumer inflation, depends more on domestic business activity.

However, under an inflation targeting regime, Central Banks choose consumer price inflation as a benchmark in the vast majority of cases. To address the problem of the vanishing Phillips curve and identify a more robust relationship between business activity and consumer prices, a number of studies estimate the Phillips curve on disaggregated data (Shapiro, 2022; Stock and Watson, 2020; Zaman, 2019). The authors of these works find that goods and services have different sensitivities to business activity. This allows them to be divided into 2 groups:

1) Cyclical, that is, goods and services that are positively sensitive to business activity. The inflation of cyclical goods and services accelerates when business activity is high and slows when it is low.

2) Acyclical goods and services, the inflation of which is insensitive or negatively sensitive to business activity.

Accordingly, the inflation of goods and services that are sensitive to business activity is called 'cyclical inflation' (CI), while that of those that are not sensitive is called 'acyclical inflation' (AI).

This approach (the disaggregation of the price index) allows the clarification of the influence of aggregate demand on inflation. Studies (Shapiro, 2022; Stock and Watson, 2020) have demonstrated that a statistically significant relationship between the cyclical components and business activity remains both over the 1988–2007 period and after 2007. Mahedy and Shapiro (2017) disaggregate the core personal consumer expenditure index (core PCE) to answer the question of whether the Fed's accommodative measures between the 2008 and 2020 crises were insufficient to return inflation to 2%. The authors conclude that the Fed's accommodative measures had a significant impact on prices: following the recovery in business activity, cyclical inflation reached and then exceeded the Fed's 2% target. The reason for the low rate of growth of the general price level was the dynamics of the acyclical component, mainly medical care services. Lian and Freitag (2022) analyse the reasons for the decline in inflation in a number of developed countries and come to a similar conclusion that cyclical inflation recovered from 2012 to 2019, but this was offset by a decrease in the acyclical component.

Data on cyclical and acyclical inflation in the United States, obtained using the Shapiro (2022) method, are published on the website of the Federal Reserve Bank of San Francisco and updated once a month. This allows the study of the dynamics of cyclical and acyclical inflation for a period from 2021 to 2024 which is not included in published papers, but which is no less interesting. This period is characterised by high consumer price inflation in the United States, and significant demand and a strong labour market are remarked as its main cause at Fed meetings. Figure 1 shows dynamics of core PCE broken down into cyclical and acyclical inflation. CI is higher than AI over almost the entire period under consideration. This allows the confirmation of the hypothesis that high demand is the main factor of inflation.

Attempts to find a significant link between consumer inflation and business activity in Russia are not always successful. In the work of Averina et al. (2018), the coefficient fore the output gap turns out to be significantly positive, but when the output gap is replaced with unemployment, the coefficient for business activity becomes contradictory from the point of view of economic theory. In the traditional and hybrid Phillips curves, the coefficient is insignificant, while it has a positive sign in the New Keynesian curve. Zubarev (2018) concludes that the coefficient for the output gap is negative if the dependent variable is consumer price inflation. Inozemtsev and Krotova (2024) estimate the Phillips curve on regional data and obtain, depending on the specification used, either a negative or an insignificantly positive coefficient for the output gap. Orlov and Postnikov (2022) confirm the presence of only a weak relationship between the unemployment gap and inflation for a significant part of Russian regions, and no significant estimates are obtained for the Russian Federation as a whole. Sinelnikov-Murylev et al. (2020) note the importance of GRP growth rates for

inflation in Russian regions. Sokolova (2014) concludes that the output gap has a significant impact on inflation, but considers producer prices rather than consumer prices.

Thus, the thesis of the virtual absence of a connection between consumer inflation and business activity (especially if the latter is approximated by the unemployment gap) is quite relevant for the Russian economy. This study attempts to address this issue by decomposing the consumer price index into cyclical and acyclical components. The decomposition of the CPI has not yet been considered in the Russian literature. All of the Russian studies mentioned above apply the Phillips curve to the aggregate price index. If the authors resort to disaggregation, it consists of moving from the country level to the regional level without estimating the coefficients of the Phillips curve for individual goods and services.

In addition, despite the existing layer of foreign papers on the estimation of cyclical and acyclical inflation, some aspects of the decomposition methodology have not been fully studied. This paper thus complements the existing studies by discussing the nuances of the Phillips curve specification for individual components of the CPI.

The paper is structured as follows. Section 2 provides an overview of the standard methodology for decomposing inflation into its components, presents the modification of the methodology, and discusses the data used. Section 3 provides the results of the decomposition and analyses the dynamics of CI and AI in Russia for conformity with changes in aggregate demand. The conclusion contains a brief description of the results of the paper and areas for further research.

2. Methodology and data

Shapiro (2022) proposes a methodology for decomposing inflation into various components using simple regressions. In practice, decomposing the price index into cyclical and acyclical components comes down to estimating the coefficients of the following regression equation:

$$\pi_{i,t} = c + \beta_i^u(u_{t-1}^* - u_{t-1}) + \beta_i^\pi \pi_{t-1} + (1 - \beta_i^\pi)\pi_t^* + \varepsilon_t \quad (1)$$

where:

$\pi_{i,t}$ is the monthly inflation rate of the *i*-th good;

u_{t-1} is the actual unemployment rate in month *t-1*;

u_{t-1}^* is the natural unemployment rate in month *t-1*;

π_t^* is the expected level of headline inflation (long-term inflation expectations obtained from the FRB/US Model).

A good or service falls into the cyclical category only if coefficient β_i^u takes a positive value and is statistically significant. If coefficient β_i^u is insignificant, or significant and negative, then the good or service falls into the acyclical category.

Carrying out such a decomposition of the Russian consumer price index requires changes in the specification of the Phillips curve to take into account both the characteristics of the domestic economy and certain particularities of modelling the relationship between inflation and business activity, which constitute the scientific novelty of this study.

The first feature of this paper is the inclusion of the real effective exchange rate (as a deviation from the trend or as a gap) in the regression equation, since the CPI contains components that directly depend on import conditions. Zubarev and Gorodnov, (2023), Khabibullin (2019) note that the explanatory and predictive power of the Phillips curve increases when it contains the exchange rate.

The authors of Russian studies of the Phillips curve do not reject the unemployment gap as a proxy for the business cycle. The unemployment gap is therefore also used in this paper. However, it is noted that the Russian labour market responds to economic crises primarily by reducing working hours and wages, rather than employment (Kapelyushnikov, 2023). Therefore, researchers often approximate business activity using the output gap rather than the unemployment gap. For this reason, the output gap is additionally considered as an indicator of business activity in this study. It should be noted that the output gap is used by the European Central Bank to estimate its 'Supercore Inflation' indicator, which in essence represents cyclical inflation, as it includes output gap-sensitive goods and services (Ehrmann et al., 2018).

The next point that needs to be discussed is the depended variable in the Phillips curve. Usually, monthly or quarterly rates of inflation are used. However, as noted by Cogley and Sbordone, (2008), the derivation of the Phillips curve equation with inflation rate is carried out within the framework of a model with zero equilibrium inflation. Since this premise is debatable, it is advisable to replace the inflation rate with its deviation from the trend (the inflation gap). This allows not only the abandonment of the assumption of zero inflation in a steady state but also for the possible variability of equilibrium inflation to be taken into account. Cogley and Sbordone (2008) propose a theoretical derivation of the New Keynesian Phillips curve with inflation gaps and show that such a Phillips curve has greater explanatory power. The authors derive the Phillips curve with inflation gaps from the firm's optimization problem and show that demand affects not just inflation, but its deviations from its trend. The inflation trend is determined by the Central Bank’s policy rule and changes in the rule lead to changes in the inflation trend. Monetary policy regime switching, a change in the numerical value of the target and long tolerance for its failure to be achieved may affect the inflation trend. According to Cogley and Sbordone (2008), the Phillips curve with the rate of inflation is only a special case of the Phillips curve with inflation gaps with the assumption of a zero inflation trend. Therefore, the economic interpretation of the coefficient for business activity is the same for both Phillips curves with the inflation rate or gap.

The use of the inflation gap instead of the inflation rate is already quite common in studies. Faust and Wright (2013) deduct the level of trend inflation (which they approximate as the long-term inflation expectations of analysts) from the inflation dynamics when forecasting. Ponomareva (2012) concludes that there are two sources of inflation inertia in the Russian economy. The first is associated with the specific behaviour of agents, and the second is the inflationary trend, which amplifies the effect of increasing prices for individual goods. Zubarev (2018) uses the Phillips curve with the inflation gap (the trend is determined by the Hodrick-Prescott filter) to estimate the relationship between consumer prices and business activity. Sapova and Kharlamova (2023) use the CPI minus its trend (trend determined by the Hodrick-Prescott filter) to estimate the contribution of supply and demand to inflation. Kramkov (2023) uses, among other models, a model with an inflation gaps (in which the inflation trend is the current median inflation) to forecast the CPI by its components.

Thus, the Phillips curve with the inflation gap is used in this study. This helps take into account the transition of the Central Bank of the Russian Federation to inflation targeting. In addition, this method solves the problem of the non-stationarity of the inflation data for certain goods and services.

Another issue is the presence of a forward-looking or rational expectations in the equation. Shapiro (2022) approximates the forward-looking component of each individual good or service by model inflation expectations for the entire price index. Zaman (2019) notes that excluding inflation expectations (the author excludes both the adaptive and rational components) from the Phillips curve does not affect the results of the decomposition, therefore expectations may be dispensed with in the regression. Lian and Freitag (2022), Ehrmann et al. (2018), and Stock and Watson (2020) do not use forward-looking expectations. This paper is also limited to estimating the coefficients of the backward-looking (adaptive) Phillips curve.

So, given the above, the first Phillips curve equation used for decomposition is the following:

$$\hat{\pi}_{it} = c + \beta_1^{\hat{\pi}_i}\hat{\pi}_{it-1} + \beta_2^{\hat{\pi}_i}x_{t-1} + \beta_3^{\hat{\pi}_i}\widehat{reer}_{t-1} + \varepsilon_t^{\hat{\pi}_i} \quad (2)$$

where:

$\hat{\pi}_{it}$ is the inflation gap of the *i*-th good or service in month *t*;

x_{t-1} is the unemployment/output gap in month *t-1*.

$\widehat{reer}_{t-1}$ – is the real effective exchange rate gap in month *t-1*.

Relative price gaps are often used in modelling the dynamics of components of the price index (Kryzhanovsky and Zykov, 2021), but researchers (Shapiro, 2022; Stock and Watson, 2020; Zaman, 2019; Ehrmann et al., 2018) abandon relative prices when decomposing aggregate price indecies. Relative prices are an important factor in the inflation of goods and services. The gap in relative prices helps the inflation of CPI components adjust to one another, even if demand affects only the inflation of cyclical components. Thus, the second specification of the Phillips curve includes the relative price gap, which is defined as the deviation of the level of relative prices from the trend:

$$\hat{\pi}_{it} = c + \beta_1^{\hat{\pi}_i}\hat{\pi}_{it-1} + \beta_2^{\hat{\pi}_i}x_{t-1} + \beta_3^{\hat{\pi}_i}\widehat{reer}_{t-1} + \beta_4^{\hat{\pi}_i}\widehat{rel}_{t-1} + \varepsilon_t^{\hat{\pi}_i} \quad (3)$$

where:

$\widehat{rel}_{t-1}$ is the gap in relative prices of the *i*-th good or service in month *t-1*;

The relative price level is calculated as follows:

$$REL_{it} = \frac{\prod_{t=1}^{n}(1+\pi_{it})}{\prod_{t=1}^{n}(1+cpi_t)} \quad (4)$$

where:

REL_{it} is the level of relative prices for the *i*-th good or service in month *t*;

π_{it} is the price index (monthly seasonal adjusted inflation rate) for the *i*-th good or service in month *t*;

cpi_t is the rate of growth of the CPI (seasonal adjusted inflation rate) in month *t*.

It should also be noted that the Russian inflation data contain a significant number of large shocks. Inflation shocks interfere with the assessment of the relationship between demand and the rate of price change. As a solution to this problem, this study proposes to supplement individual Phillips curves with a variable that reflects the shock of the aggregate price index. We introduce the assumption that the shock of an individual good or service can be represented as the sum of two shocks: 1) a shock that in period t is characteristic not only of this good, but also of the entire price index; 2) a shock that in period t is characteristic only of this good. Also, the shock of an individual component may have its own sensitivity to the CPI shock and reacts differently to positive and negative CPI shocks:

$$\varepsilon_t^{\hat{\pi}_i} = \rho_1^{\hat{\pi}_i} shkcpi_t DP_t + \rho_2^{\hat{\pi}_i} shkcpi_t DN_t + \varepsilon_t' \quad (5)$$

where:

$\varepsilon_t^{\hat{\pi}_i}$ is the shock of the *i*-th good or service;

$shkcpi_t$ is the CPI shock;

DP_t is the dummy variable that takes 1 when the CPI shock is positive and takes 0 in other cases;

DN_t is the dummy variable that takes 1 when the CPI shock is positive and takes 0 in other cases;

ε_t' is the residual shock of the *i*-th good or service.

Replace the shock of the *i*-th good or service in equation 3 with the sum of the CPI shocks and the residual shock (equation 5). Move the CPI shocks to the left-hand side of the equation. Then the following Phillips curve specification will be obtained:

$$\hat{\pi}_{it} - \rho_1^{\hat{\pi}_i} shkcpi_t DP_t - \rho_2^{\hat{\pi}_i} shkcpi_t DN_t = c + \beta_1^{\hat{\pi}_i}\hat{\pi}_{it-1} + \beta_2^{\hat{\pi}_i}x_{t-1} + \beta_3^{\hat{\pi}_i}\widehat{reer}_{t-1} + \beta_4^{\hat{\pi}_i}\widehat{rel}_{t-1} + \varepsilon_t' \quad (6)$$

The CPI shock ($shkcpi$) is the residual of the following equation (with no lags of the depended variable):

$$\widehat{cpi}_t = c + \beta_2^{\widehat{cpi}} x_{t-1} + \beta_3^{\widehat{cpi}} \widehat{reer}_{t-1} + shkcpi_t \quad (7)$$

where:

$\widehat{cpi}_t$ is the CPI gap in month *t*.

The estimates of the coefficients $\rho_1^{\hat{\pi}_i}$ and $\rho_2^{\hat{\pi}_i}$ will be obtained from the following regression equation:

$$\hat{\pi}_{it} = \rho_1^{\hat{\pi}_i} shkcpi_t DP_t + \rho_2^{\hat{\pi}_i} shkcpi_t DN_t + \varepsilon_t \quad (8)$$

As noted earlier, one of the main motivations for moving from the inflation rate to the inflation gap is to account for non-stationarity in the data. However, another approach can be used in order to do this. Consider an equation similar to the one used in Shapiro (2022), with the exchange rate added in:

$$\pi_{it} = c + \left(1 - \beta_1^{\pi_i}\right)\pi_{it-1} + \beta_1^{\pi_i}\pi_t^* + \beta_2^{\pi_i} x_{t-1} + \beta_3^{\pi_i} \widehat{reer}_{t-1} + \varepsilon_t \quad (9)$$

If we expand the brackets before the inflation lag and then move it to the left-hand side of equation 9, we get:

$$\pi_{it} - \pi_{it-1} = c + \beta_1^{\pi_i}(\pi_t^* - \pi_{it-1}) + \beta_2^{\pi_i} x_{t-1} + \beta_3^{\pi_i} \widehat{reer}_{t-1} + \varepsilon_t \quad (10)$$

The variable π_t^* will be approximated by the CPI trend. Thus, in equation 10, unlike other specifications, the inflation data are brought to stationarity not only by subtracting the trend, but also by taking the first difference.

Thus, in this study, the following Phillips curves will be used to perform the decomposition:

1) With the inflation gap (equation 2).

2) With the inflation gap and relative prices (equation 3).

3) With the inflation gap, relative prices and CPI shock (equation 6).

4) With the first difference of inflation and the inflation gap (equation 10).

When the estimates of coefficient β_2 are obtained, goods or services are classified as cyclical if the coefficient is positive and statistically significant (5% level of significance). Otherwise, the goods or services are classified as acyclical. Then, the cyclical and acyclical inflation are calculated using the weighted sum of the monthly inflation rates of goods and services from the corresponding category. Shapiro (2022) relies on the weights of the goods and services in the core PCE. Stock and Watson (2020) weight inflation rates to maximise the relationship between the cyclical inflation and business activity (the authors do not study a measurement of the acyclical inflation, so they do not propose a methodology for weighting the acyclical components). There are also alternatives not considered in the literature on the decomposition. Median weighting could be used, for example.

Another option is to give each component equal weight. Thus, this paper considers different options for weighting the goods and services inflation:

1) Weighting by share in the CPI.

2) Using equal weights (arithmetic mean).

3) Calculating the median level (median weighting).

4) Selecting weights to find the greatest relationship with business activity. In this paper the weights are determined by the following formula:

$$w_i = \frac{|tstat_i|}{\sum|tstat_i|} \tag{11}$$

where:

w_i is the weight of the inflation rate of the *i*-th good or service;

$|tstat_i|$ is the module of t-statistics of the estimate of coefficient β_2 (equations 2, 3, 6 and 10).

Taking into account different business activity proxies and methods of weighting component inflation, there are a total of 8 decomposition options for each of the four Phillips curve specifications. Shapiro (2022), Zaman (2019), and Stock and Watson (2020) do not explore different options for the decomposition, and they therefore do not discuss the question of choosing the best one. To assess the quality of the decomposition performed, this paper estimates the coefficients of the following regression equations:

$$\widehat{ci}_t = c + \beta_1^{\widehat{ci}}\widehat{ci}_{t-1} + \beta_2^{\widehat{ci}}x_{t-1} + \beta_3^{\widehat{ci}}\widehat{reer}_{t-1} + \varepsilon_t \tag{12}$$

$$\widehat{ai}_t = c + \beta_1^{\widehat{ai}}\widehat{ai}_{t-1} + \beta_2^{\widehat{ai}}x_{t-1} + \beta_3^{\widehat{ai}}\widehat{reer}_{t-1} + \varepsilon_t \tag{13}$$

$$ci_t - ai_t = c + \beta_1^{ci-ai}(ci_{t-1} - ai_{t-1}) + \beta_2^{ci-ai}x_{t-1} + \beta_3^{ci-ai}\widehat{reer}_{t-1} + \varepsilon_t \tag{14}$$

$$\widehat{cpi}_t = c + \beta_1^{\widehat{cpi}}\widehat{cpi}_{t-1} + \beta_2^{\widehat{cpi}}x_{t-1} + \beta_3^{\widehat{cpi}}\widehat{reer}_{t-1} + \varepsilon_t \tag{15}$$

where:

$\widehat{ci}_t$ is the cyclical inflation gap in month t;

$\widehat{ai}_t$is the acyclical inflation gap in month t;

ci_t is the cyclical inflation in month t;

ai_t is the acyclical inflation in month t.

The regression of equations 12-14 is carried out on all the time series of the cyclical and acyclical inflation obtained as a result of the decomposition. The interpretation of the estimates of the coefficients of the equations is based on the definition of cyclical and acyclical inflation. Thus, cyclical inflation should be sensitive to changes in business activity. That is, when business activity grows, it is important that the cyclical inflation accelerates, while the reaction of the acyclical inflation is insignificant or opposite to the reaction of the cyclical inflation. In addition, it is important that the difference between the cyclical inflation and the acyclical inflation increases in response to growth

in demand. So, if the decomposition carried out really allows the distribution of the components of the CPI according to their sensitivity to business activity, then the following conditions must be met:

1) The coefficients ${\beta_2}^{\widehat{ci}}$ and ${\beta_2}^{ci-ai}$ are statistically significant, and the signs of the coefficients correspond to economic theory (positive for the output gap and negative for the unemployment gap). In addition, it is necessary that the statistical significance of the coefficients ${\beta_2}^{\widehat{ci}}$ and ${\beta_2}^{ci-ai}$ be higher than the significance of the coefficient ${\beta_2}^{cpi}$.

2) The coefficient ${\beta_2}^{\widehat{ai}}$ is statistically insignificant or is significant with a sign opposite that of the coefficient ${\beta_2}^{\widehat{ci}}$. The only possible exception is the case where the component inflation is weighted proportionally to the t-statistic (equation 11). This weighting gives the largest weight to the components with the closest relationship to business activity. Consequently, the coefficient ${\beta_2}^{\widehat{ai}}$may well be statistically significant. Of course, it is better for the coefficient to remain insignificant. If this does not happen, the attention should be paid to the coefficient ${\beta_2}^{ci-ai}$. The decomposition still should be considered successful when the coefficient ${\beta_2}^{ci-ai}$ is statistically significant.

The significance of the coefficient ${\beta_2}^{ci-ai}$ when weighting the component inflation by its relationship with business activity (equation 11) is itself an important condition for defining the decomposition as successful or unsuccessful. Ultimately, the previously presented modifications to the Phillips curve are aimed at refining the estimate of the coefficient fore business activity. And the best way to check whether the modifications have led to the desired result is to weight the component inflation by its relationship with business activity.

Also, it is desirable that the coefficients ${\beta_2}^{\widehat{ci}}$, ${\beta_2}^{\widehat{ai}}$ and ${\beta_2}^{ci-ai}$ (equations 12-14) are stable. In order to investigate the stability of the relationship between inflation (both cyclical and acyclical) and business activity the Global information criteria breakpoint test is applied. The LWZ criteria is chosen as the selection criterion for the optimum number of breaks after initial testing. The unemployment gap and the output gap are used as the breakpoint variable.

The estimate of the Phillips curve for each component of the CPI is carried out for the period from January 2004 to December 2024. Seasonally adjusted data on the monthly growth rates of the CPI and its components, as well as the growth of the real effective exchange rate, are taken from the Bank of Russia website. A total of 44 components (including other goods and services) are studied, which together make up 100% of CPI. Monthly GDP corresponds to the methodology presented by Zhemkov (2022). Data on the unemployment rate are taken from the Federal State Statistics Service (Rosstat). A seasonal adjusting procedure (Census X-12) is carried out for the unemployment rate. Monthly GDP and exchange rate growth are converted into base indices (compared to December 2003). The level of relative prices (equation 5) is also the base index (compared to December 2003). All the base indices are logarithmised and then multiplied by 100. The trend and

the gap of unemployment, as well as trends and gaps of all the logarithmised base indices are calculated using a one-sided Hodrick–Prescott filter (the λ parameter is 14,400). As in Zubarev (2018), the trend and gap of CPI are also calculated using the Hodrick-Prescott filter. Following Kramkov (2023) and Faust and Wright (2013), the inflation gap of each component (including the CI and AI gaps) is calculated as the difference between its inflation rate and the aggregate price index (CPI) trend. As in Shapiro (2022) OLS estimator with Newey-West error term is applied to estimate the coefficients of all equations. The maximum lag considered for the control of autocorrelation is selected automatically according to the Akaike criterion. A component of the CPI is defined as cyclical only if the coefficient for business or consumer activity is positive and statistically significant at the 5% level. Other goods and services are defined as acyclical.

3. Results of the decomposition

Table 5 presents the estimates of the coefficients $\beta_2^{\widehat{cpi}}$. The consumer price index turns out to be insensitive to the unemployment gap. The coefficient for the output gap is significant only at the 10% level.

The distribution of goods and services is presented in Table 1 for the decomposition by the unemployment gap and in Table 2 for the decomposition by the output gap. The components may be either cyclical or acyclical depending on the specification of the Phillips curve. The following pattern is observed: the more complicated the Phillips curve used for decomposition, the greater the share of CPI components defined as cyclical. This is due to the fact that the modifications made change the estimation of the sensitivity of CPI components to business activity. Thus, when decomposing by the unemployment gap, only the use of the Phillips curve in the form of equation 6 allows us to define furs and fur products, furniture and household services as cyclical components (Table 1). When decomposing by the output gap, only equation 6 allows us to define confectionery products, Electric and other household appliances, TV and radio products, construction materials, passenger cars and other goods and services as cyclical components (Table 2).

According to Table 1 and Table 2, the share of cyclical goods and services in the CPI is much smaller when the decomposition is carried out with the unemployment gap. This is due to the explanatory power of different business activity proxies: the output gap is a significant factor for a much larger number of goods and services than the unemployment gap.

There is no indication in the published literature to date of which components of the aggregate price index must be considered cyclical and acyclical. Common economic sense suggests that the group of cyclical components should include both services and food and non-food products. In the case of decomposition with the output gap, such representativeness is observed regardless of the

Phillips curve specification. However, in the case of decomposition with the unemployment gap, only the Phillips curve with a CPI shock (equation 6) allows at least one component from each category to be included in the group of cyclical ones.

Table 3 presents estimates of the coefficients $\beta_2^{\widehat{ci}}$, $\beta_2^{\widehat{ai}}$ and β_2^{ci-ai} when making decomposition with the unemployment gap. In general, each decomposition variant satisfies the requirements for the coefficients $\beta_2^{\widehat{ci}}$ and β_2^{ci-ai}: their statistical significance is always higher than the statistical significance of the coefficient $\beta_2^{\widehat{cpi}}$.

As noted earlier, the statistical significance of the coefficient β_2^{ci-ai} (when weighting the components inflation rates by their relationship with business activity or by t-stat) is an important condition for recognizing the decomposition as successful. Table 3 shows that the coefficient β_2^{ci-ai} is significant at the 5% level for all decompositions.

Table 4 presents estimates of the coefficients $\beta_2^{\widehat{ci}}$, $\beta_2^{\widehat{ai}}$ and β_2^{ci-ai} when making decomposition with the output gap. Applying the Phillips curve with relative price gap and the CPI shocks (equation 6) makes it possible to carry out the decomposition in which the significance level of the coefficients $\beta_2^{\widehat{ci}}$ and β_2^{ci-ai} is higher than the significance level of the coefficient $\beta_2^{\widehat{cpi}}$ and the highest significance level of the coefficient β_2^{ci-ai} (when weighting components' inflation rates by t-stat) is achieved.

The Global information criteria breakpoint test finds no breaks. Thus, the connection between cyclical and acyclical inflation and business activity is stable regardless the business activity proxy and method of weighing components' inflation rates.

Thus, the Phillips curve that includes relative price gap and the CPI shocks (equation 6) is the most suitable for the decomposition of CPI into cyclical and acyclical components. Unlike other decompositions, it is robust to changes in the business activity proxy and the component weighting method (the requirements for the coefficients $\beta_2^{\widehat{ci}}$, $\beta_2^{\widehat{ai}}$ and β_2^{ci-ai} are always satisfied).

The period from 2021 to 2024 is considered for a narrative analysis (Shapiro and Mahedy, 2017; Lian and Freitag, 2022) of consumer price dynamics using the results of the decomposition. This period is characterised by a succession of periods of high and low demand. Thus, the Bank of Russia's press release for June 2021 notes a rapid expansion of demand compared to the ability to increase output, and the press release for December 2021 cites a labour shortage among the inflationary risks. The September 2022 press release notes subdued dynamics in demand. Domestic demand significantly outstripped the capabilities to expand the supply of goods and services in 2023 and 2024.

Figures 2 and 3 presents the dynamics of median cyclical and median acyclical inflation (the Phillips curve with relative price gap and the CPI shocks is used for the decomposition). The median

inflation is under consideration due to its relatively high stability to outliers. Figure 2 shows the results of the decomposition with the unemployment gap, while Figure 3 presents the results of the decomposition with output gap. Since the output gap better explains the inflation dynamics, more attention should be paid to Figure 3.

Inflation dynamics in 2021 indeed signal strong demand: cyclical inflation exceeded both acyclical inflation and the Bank of Russia target. Cyclical inflation fell below acyclical inflation and the Bank of Russia target in 2022 due to low demand. In 2023, the recovery of demand and the growing deficit in the labor market affected inflation processes: inflation of cyclical goods and services accelerated more than inflation of acyclical goods and services. In 2024, the average gap between the CI and AI remained positive, indicating high aggregate demand.

However, according to Figure 3, there are periods in late 2023 and 2024 when cyclical inflation relative to acyclical inflation slowed down and then accelerated again. These movements in cyclical inflation can show how aggregate demand changed and contributed to price dynamics. The periods of slowdown of the cyclical inflation from November 2023 to March 2024, as well as from June 2024 to September 2024, can be interpreted as evidence of a decrease in pro-inflationary pressure from aggregate demand (which, nevertheless, remained significant). The acceleration of the cyclical inflation from March 2024 to June 2024, as well as from September 2024 to December 2024, may signal an increase in aggregate demand and an increase in the contribution of demand factors to the acceleration of price growth. This conclusion coincides with the one given in the bulletin "Talking trends. Economy and markets" of the Bank of Russia's Research and Forecasting Department[1]. According to the authors' calculations using the Sheremirov (2022) method, the total contribution of positive and negative demand shocks decreased in the fourth quarter of 2023, as well as in the first and third quarters of 2024. And the increase in the contribution of demand shocks to the acceleration of inflation occurred in the second and fourth quarters of 2024.

4. Conclusion

This study confirms the hypothesis of the heterogeneity of the influence of business and consumer activity on the dynamics of various goods and services. In the Russian economy, there are cyclical components of the CPI, the dynamics of which are determined to a greater extent by aggregate demand, and acyclical components, the dynamics of which are determined to a greater

[1] The Bank of Russia. Research and Forecasting Department Bulletin "Talking trends. Economy and markets." March 2025.

extent by other reasons. While estimating the Phillips curve for an aggregate price index does not allow finding significant relationships between inflation and demand, the decomposition technique discussed in this article allows discernment between cyclical inflation, which is sensitive to changes in business and consumer activity, and acyclical inflation, the dynamics of which are largely explained by other factors.

The study proposes changes to the Phillips curve that are designed to take into account the specific features of the Russian economy (dependence of inflation on the exchange rate, change in the monetary policy regime, non-stationarity of data on inflation of some goods and services, the presence of significant inflation shocks) and changes in relative prices. Thus, the effective real exchange rate gap was added to the Phillips curve and the inflation gap is used instead of the inflation rate. Also, the Phillips curve applied to price index components is supplemented with the CPI shocks (taking into account the heterogeneous impact of positive and negative shocks) and relative price gap. The proposed changes made it possible to obtain a decomposition that is robust to changes in the business activity proxy and the method of weighting the inflation of the components. When components' inflation is weighted by t-stat, only the modified Phillips curve allows to estimate the coefficient ${\beta_2}^{ci-ai}$ which is significant at the 1% level.

It is shown that a comparison of the dynamics of CI and AI allows us for reasonable assumptions about the main driver of inflationary processes. The dynamics of median cyclical and acyclical inflation in Russia in 2021-2024 is fully consistent with the hypothesis that the acceleration of the inflation rate is mainly due to high aggregate demand.

This study is limited by certain frameworks and therefore has areas for further development. The approach presented may be extended to the regional level, which will require that the specifics of regional inflation, unemployment and gross regional product be taken into account. In addition, the decomposition should be tested for the predictive power. There is evidence in the literature on the increased accuracy of the disaggregated forecast (Faust and Wright, 2013; Kramkov, 2023), but the forecast accuracy using cyclical and acyclical inflation has not yet been tested. Also, estimates of cyclical inflation and the Phillips curve with relative price gap and the CPI shocks may be useful as an auxiliary tool in studies that assume a significant relationship between inflation and business activity. For example, the comparison of estimates of the non-accelerating inflation rate unemployment (NAIRU) obtained on the basis of regression with the CPI (Orlov and Postnikov, 2022) and cyclical inflation are of interest. The decomposition can be integrated into structural and semi-structural models in order to assess the optimal Central Bank reaction to shocks of CI and AI.

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Appendices

Table 1

Categorization of CPI components based on sensitivity to the unemployment gap

Goods and services	*the Phillips curve equation applied for the CPI decomposition*			
	With the inflation gap (equation 2)	*With the inflation gap and the relative price gap (equation 3)*	*With the inflation gap, relative price gap and the CPI shocks (equation 6)*	*With the first difference of inflation and the inflation gap (equation 10)*
Meat	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Fish	Acyclical	Acyclical	Acyclical	Acyclical
Oil and fats	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Dairy products	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Cheese	Acyclical	Acyclical	Acyclical	Acyclical
Eggs	Acyclical	Acyclical	Acyclical	Acyclical
Sugar	Acyclical	Acyclical	Acyclical	Acyclical
Confectionery products	Acyclical	Acyclical	Acyclical	Acyclical
Tea and coffee	Acyclical	Acyclical	Acyclical	Acyclical
Bread and bakery products	Acyclical	Acyclical	Acyclical	Acyclical
Pasta and cereals	Acyclical	Acyclical	**Cyclical**	**Cyclical**
Fruit and vegetable products, including potatoes	Acyclical	Acyclical	Acyclical	Acyclical
Alcoholic beverages	Acyclical	Acyclical	Acyclical	Acyclical
Food service	Acyclical	Acyclical	Acyclical	Acyclical
Clothing and linen	Acyclical	Acyclical	Acyclical	Acyclical
Furs and fur products	Acyclical	Acyclical	**Cyclical**	Acyclical
Knitwear	Acyclical	Acyclical	Acyclical	Acyclical
Leather, textile and combined footwear	Acyclical	Acyclical	Acyclical	Acyclical
Household detergents and cleaning products	Acyclical	Acyclical	Acyclical	Acyclical
Perfumery and cosmetics	Acyclical	Acyclical	Acyclical	Acyclical
Haberdashery	Acyclical	Acyclical	Acyclical	Acyclical
Tobacco products	Acyclical	Acyclical	Acyclical	Acyclical
Furniture	Acyclical	Acyclical	**Cyclical**	Acyclical
Electric and other household appliances	Acyclical	Acyclical	Acyclical	Acyclical
Printing	Acyclical	Acyclical	Acyclical	Acyclical
TV and radio products	Acyclical	Acyclical	Acyclical	Acyclical
Personal computers	Acyclical	Acyclical	Acyclical	Acyclical
Means of communication	Acyclical	Acyclical	Acyclical	Acyclical
Construction materials	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Passenger cars	Acyclical	Acyclical	Acyclical	Acyclical
Tools and equipment	Acyclical	Acyclical	Acyclical	Acyclical

Goods and services	*the Phillips curve equation applied for the CPI decomposition*			
	With the inflation gap (equation 2)	*With the inflation gap and the relative price gap (equation 3)*	*With the inflation gap, relative price gap and the CPI shocks (equation 6)*	*With the first difference of inflation and the inflation gap (equation 10)*
Petroleum products	Acyclical	Acyclical	Acyclical	Acyclical
Medical products	Acyclical	Acyclical	Acyclical	Acyclical
Household services	Acyclical	Acyclical	**Cyclical**	Acyclical
Passenger transportation services	Acyclical	Acyclical	Acyclical	Acyclical
Telecommunications services	Acyclical	Acyclical	Acyclical	Acyclical
Housing and public utility services	Acyclical	Acyclical	Acyclical	Acyclical
Educational services	Acyclical	Acyclical	Acyclical	Acyclical
Services of cultural institutions	Acyclical	Acyclical	Acyclical	Acyclical
Foreign tourism services	Acyclical	Acyclical	Acyclical	Acyclical
Excursion services	Acyclical	Acyclical	Acyclical	Acyclical
Health resort services	Acyclical	Acyclical	Acyclical	Acyclical
Medical care services	Acyclical	Acyclical	Acyclical	Acyclical
Other goods and services	Acyclical	Acyclical	Acyclical	Acyclical
Share of cyclical components in CPI (2024)	14,37%	14,37%	22,1%	15,5%
Share of acyclical components in CPI (2024)	85,63%	85,63%	77,9%	84,5%

Table 2

Categorization of CPI components based on sensitivity to the output gap

Goods and services	*the Phillips curve equation applied for the CPI decomposition*			
	With the inflation gap (equation 2)	*With the inflation gap and the relative price gap (equation 3)*	*With the inflation gap, relative price gap and the CPI shocks (equation 6)*	*With the first difference of inflation and the inflation gap (equation 10)*
Meat	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Fish	Acyclical	Acyclical	Acyclical	Acyclical
Oil and fats	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Dairy products	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Cheese	Acyclical	Acyclical	Acyclical	**Cyclical**
Eggs	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Sugar	Acyclical	Acyclical	Acyclical	Acyclical
Confectionery products	Acyclical	Acyclical	**Cyclical**	Acyclical
Tea and coffee	Acyclical	Acyclical	Acyclical	Acyclical
Bread and bakery products	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Pasta and cereals	Acyclical	Acyclical	Acyclical	Acyclical
Fruit and vegetable products, including potatoes	Acyclical	Acyclical	Acyclical	Acyclical
Alcoholic beverages	Acyclical	Acyclical	Acyclical	Acyclical
Food service	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Clothing and linen	Acyclical	Acyclical	Acyclical	Acyclical
Furs and fur products	**Cyclical**	**Cyclical**	Acyclical	**Cyclical**
Knitwear	Acyclical	Acyclical	Acyclical	Acyclical
Leather, textile and combined footwear	Acyclical	Acyclical	Acyclical	Acyclical
Household detergents and cleaning products	Acyclical	Acyclical	Acyclical	Acyclical
Perfumery and cosmetics	Acyclical	Acyclical	Acyclical	Acyclical
Haberdashery	Acyclical	Acyclical	Acyclical	Acyclical
Tobacco products	Acyclical	Acyclical	Acyclical	Acyclical
Furniture	**Cyclical**	Acyclical	**Cyclical**	Acyclical
Electric and other household appliances	Acyclical	Acyclical	**Cyclical**	Acyclical
Printing	Acyclical	Acyclical	Acyclical	Acyclical
TV and radio products	Acyclical	Acyclical	**Cyclical**	Acyclical
Personal computers	Acyclical	Acyclical	Acyclical	Acyclical
Means of communication	Acyclical	Acyclical	Acyclical	Acyclical
Construction materials	Acyclical	Acyclical	**Cyclical**	Acyclical
Passenger cars	Acyclical	Acyclical	**Cyclical**	Acyclical
Tools and equipment	Acyclical	Acyclical	Acyclical	Acyclical
Petroleum products	Acyclical	**Cyclical**	**Cyclical**	Acyclical

Goods and services	*the Phillips curve equation applied for the CPI decomposition*			
	With the inflation gap (equation 2)	*With the inflation gap and the relative price gap (equation 3)*	*With the inflation gap, relative price gap and the CPI shocks (equation 6)*	*With the first difference of inflation and the inflation gap (equation 10)*
Medical products	Acyclical	Acyclical	Acyclical	Acyclical
Household services	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Passenger transportation services	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Telecommunications services	Acyclical	Acyclical	Acyclical	Acyclical
Housing and public utility services	Acyclical	Acyclical	Acyclical	Acyclical
Educational services	**Cyclical**	Acyclical	Acyclical	**Cyclical**
Services of cultural institutions	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Foreign tourism services	Acyclical	Acyclical	Acyclical	Acyclical
Excursion services	Acyclical	Acyclical	Acyclical	Acyclical
Health resort services	**Cyclical**	**Cyclical**	**Cyclical**	**Cyclical**
Medical care services	Acyclical	Acyclical	Acyclical	Acyclical
Other goods and services	Acyclical	Acyclical	**Cyclical**	Acyclical
Share of cyclical components in CPI (2024)	29,09%	30,68%	51,75%	28,9%
Share of acyclical components in CPI (2024)	70,91%	69,32%	48,25%	71,1%

Table 3

Testing decompositions (estimation of coefficients $\beta_2^{\widehat{ci}}$, $\beta_2^{\widehat{ai}}$ и β_2^{ci-ai} for the unemployment gap)

Method of weighing components' inflation rates	*Coefficients and equations*	*the Phillips curve equation applied for the CPI decomposition*			
		Equation 2	*Equation 3*	*Equation 6*	*Equation 10*
By share in CPI	$\beta_2^{\widehat{ci}}$ (equation 12)	-0,18***	-0,18***	-0,16***	-0,19***
	$\beta_2^{\widehat{ai}}$ (equation 13)	-0,112	-0,112	-0,108	-0,108
	β_2^{ci-ai} (equation 14)	-0,169***	-0,169***	-0,149***	-0,18***
By t-stat	$\beta_2^{\widehat{ci}}$ (equation 12)	-0,224***	-0,228***	-0,19**	-0,23**
	$\beta_2^{\widehat{ai}}$ (equation 13)	-0,201*	-0,19*	-0,203	-0,19*
	β_2^{ci-ai} (equation 14)	-0,179**	-0,18**	-0,16**	-0,21**
Median weighting	$\beta_2^{\widehat{ci}}$ (equation 12)	-0,173***	-0,173***	-0,135*	-0,202**
	$\beta_2^{\widehat{ai}}$ (equation 13)	-0,046	-0,046	-0,031	-0,042
	β_2^{ci-ai} (equation 14)	-0,154***	-0,153***	-0,087**	-0,187**
Equal weights	$\beta_2^{\widehat{ci}}$ (equation 12)	-0,229**	-0,229***	-0,186**	-0,24**
	$\beta_2^{\widehat{ai}}$ (equation 13)	-0,125	-0,125	-0,115	-0,116
	β_2^{ci-ai} (equation 14)	-0,23**	-0,23**	-0,202**	-0,25**
The significance level of all coefficients $\beta_2^{\widehat{ci}}$ and β_2^{ci-ai} is higher than the significance level of the coefficient $\beta_2^{\widehat{cpi}}$		Yes	Yes	Yes	Yes
All coefficients $\beta_2^{\widehat{ai}}$ are statistically insignificant or significant with the opposite sign of coefficients $\beta_2^{\widehat{ci}}$		No	No	Yes	No
The coefficient β_2^{ci-ai} shows relatively high significance when components' inflation rates are weighed by t-stat		Yes (5% significance level)	Yes (5% significance level)	Yes (5% significance level)	Yes (5% significance level)

Note: Asterisks indicate the significance levels: *** is 1%, ** is 5%, * is 10%.

Table 4

Testing decompositions (estimation of coefficients $\beta_2^{\widehat{ci}}$, $\beta_2^{\widehat{ai}}$ и β_2^{ci-ai} for the output gap)

Method of weighing components' inflation rates	*Coefficients and equations*	*the Phillips curve equation applied for the CPI decomposition*			
		Equation 2	*Equation 3*	*Equation 6*	*Equation 10*
By share in CPI	$\beta_2^{\widehat{ci}}$ (equation 12)	0,044***	0,044***	0,063**	0,042***
	$\beta_2^{\widehat{ai}}$ (equation 13)	0,036	0,033	0,021	0,037
	β_2^{ci-ai} (equation 14)	0,025*	0,033***	0,028***	0,025*
By t-stat	$\beta_2^{\widehat{ci}}$ (equation 12)	0,068***	0,073***	0,073***	0,063***
	$\beta_2^{\widehat{ai}}$ (equation 13)	0,042	0,034	0,024	0,042
	β_2^{ci-ai} (equation 14)	0,031*	0,048*	0,031***	0,032*
Median weighting	$\beta_2^{\widehat{ci}}$ (equation 12)	0,033**	0,036***	0,042**	0,032***
	$\beta_2^{\widehat{ai}}$ (equation 13)	0,021	0,0225	0,013	0,024
	β_2^{ci-ai} (equation 14)	0,028***	0,038***	0,028***	0,0298*
Equal weights	$\beta_2^{\widehat{ci}}$ (equation 12)	0,061***	0,068***	0,077***	0,057***
	$\beta_2^{\widehat{ai}}$ (equation 13)	0,027	0,024	0,015	0,027
	β_2^{ci-ai} (equation 14)	0,045**	0,058***	0,039***	0,046**
The significance level of all coefficients $\beta_2^{\widehat{ci}}$ and β_2^{ci-ai} is higher than the significance level of the coefficient $\beta_2^{\widehat{cpi}}$		No	No	Yes	No
All coefficients $\beta_2^{\widehat{ai}}$ are statistically insignificant or significant with the opposite sign of coefficients $\beta_2^{\widehat{ci}}$		Yes	Yes	Yes	Yes
The coefficient β_2^{ci-ai} shows relatively high significance when components' inflation rates are weighed by t-stat		No (10% significance level)	No (10% significance level)	Yes (1% significance level)	No (10% significance level)

Note: Asterisks indicate the significance levels: *** is 1%, ** is 5%, * is 10%.

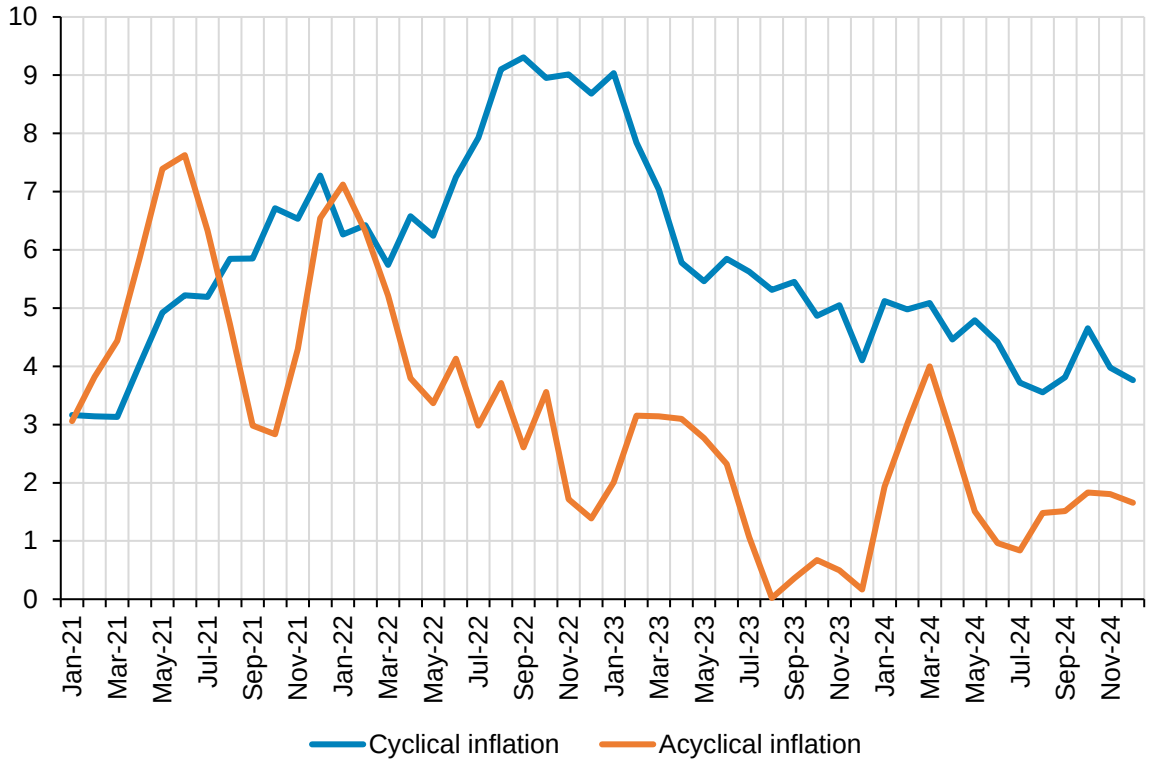
Table 5

Estimation of the coefficient $\beta_2^{\widehat{cpi}}$ (equation 15)

Aggregate demand proxy	*The coefficient $\beta_2^{\widehat{cpi}}$ estimation*
The unemployment gap	-0,137
The output gap	0,043*

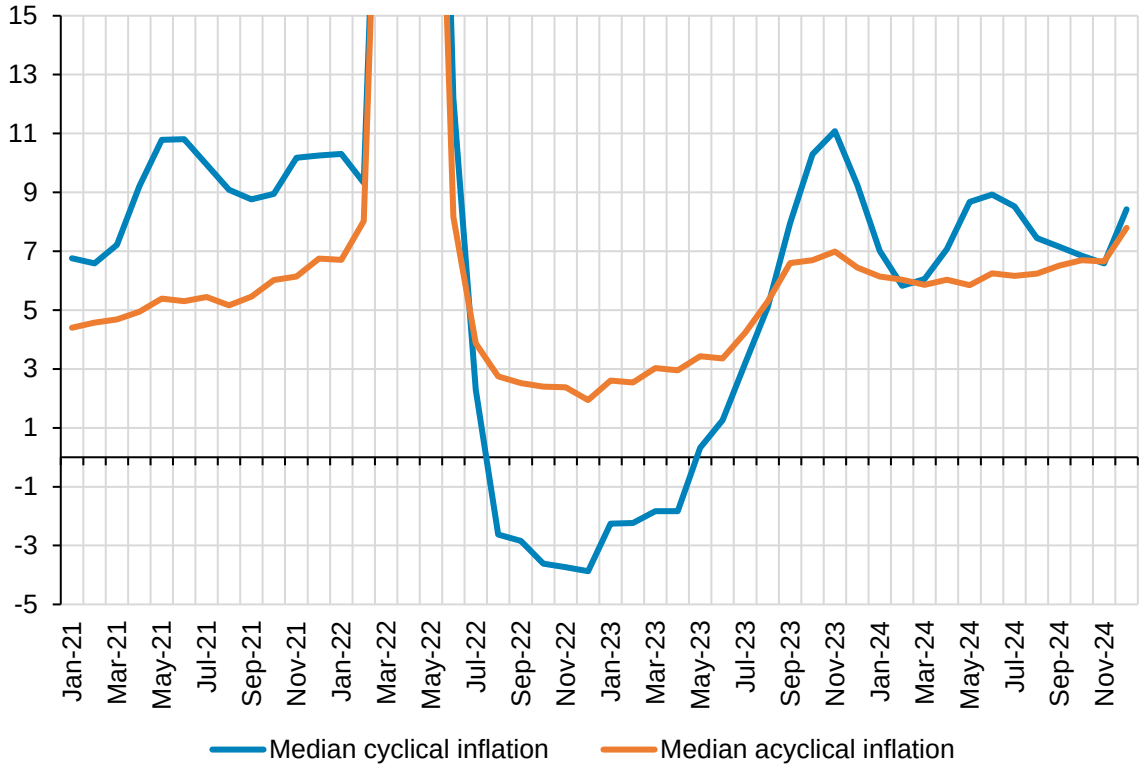
Note: Asterisks indicate the significance levels: *** is 1%, ** is 5%, * is 10%.

Figure 1: Dynamics of cyclical and acyclical inflation in the USA (% 3mma SAAR)



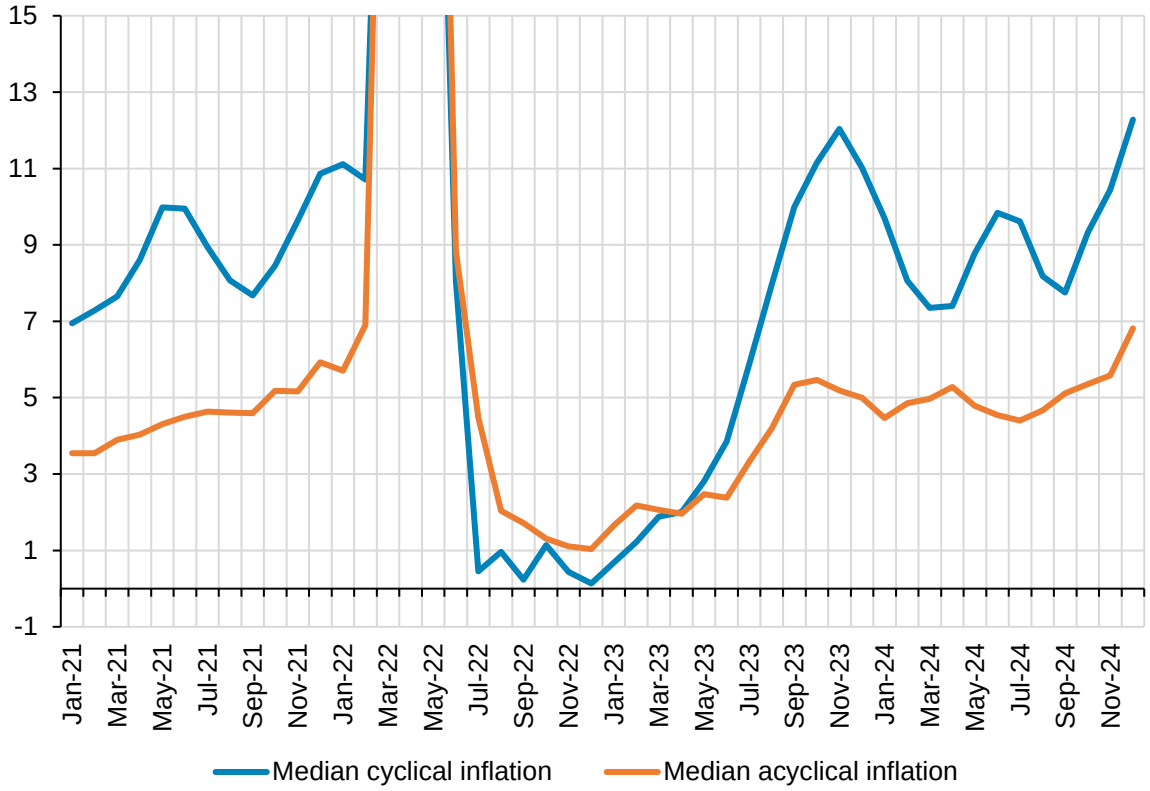
Source: the Federal Reserve Bank of San Francisco

Figure 2: Dynamics of cyclical and acyclical inflation in Russia (% 3mma SAAR), the decomposition is based on the unemployment gap



Source: Author's own calculation

Figure 3: Dynamics of cyclical and acyclical inflation in Russia (% 3mma SAAR), the decomposition is based on the output gap



Source: Author's own calculation