THE CHANGING DYNAMICS OF ALBANIAN INFLATION: A QUANTILE REGRESSION APPROACH

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THE CHANGING DYNAMICS OF ALBANIAN INFLATION: A QUANTILE REGRESSION APPROACH

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1. INTRODUCTION

Discussion of inflation risks - perceived as the conditional distribution of inflation - especially whether risks to future inflation are balanced or tilted to the upside or downside, often take centre stage in central bank policy debate. It is necessary for policymakers to consider not only the most likely future path of inflation, but also the distribution of outcomes around that path, based on the given paths of its explanatory indicators, in order to be able to propose the appropriate policies accordingly. The central bank's assessment of inflation risks, and how this is communicated to the public, may potentially influence private agents 'expectations and hence their decisions, thus contributing to actual outcomes.

A significant amount of literature has investigated the variance of inflation or symmetric uncertainty, while only a few recent empirical studies have investigated the shape of the entire inflation distribution, including tail risks (e.g. Andrade et al (2015); Lopez-Salido and Loria (2019)). Particularly, these papers have focused on advanced economies where inflation has generally been less volatile and tail risks – especially those on the upside – less prominent than in emerging market economies.

In this light, this article aims at investigating inflation risks (the conditional forecast distribution) in Albania. Contrasting the tails and the median of inflation distribution gives a more comprehensive picture of the effects of real and financial shocks on inflation. Since inflation has a changing behaviour over time, illustrated in Figure 1, estimating linear parameters that assume symmetry may be inappropriate; under such conditions we suggest the use of quantile regression. Similar methodology is used by Manzan & Zerom (2013), Tillmann & Wolters (2014), Gaglianone & Lima (2014).

The conditional distribution of macroeconomic indicators for the Albanian economy has been analysed by Tanku & Ceca (2013) and Tanku & Ceca (2018). Our contribution to the literature is twofold, first we introduce the use of quantile regression approach for estimating the conditional distribution; and second we enrich the conditional distribution by the time dimension, as a feature of QR. Our results reveal significant time variation in the shape of the distribution of inflation. On average, the inflation distribution results skewed

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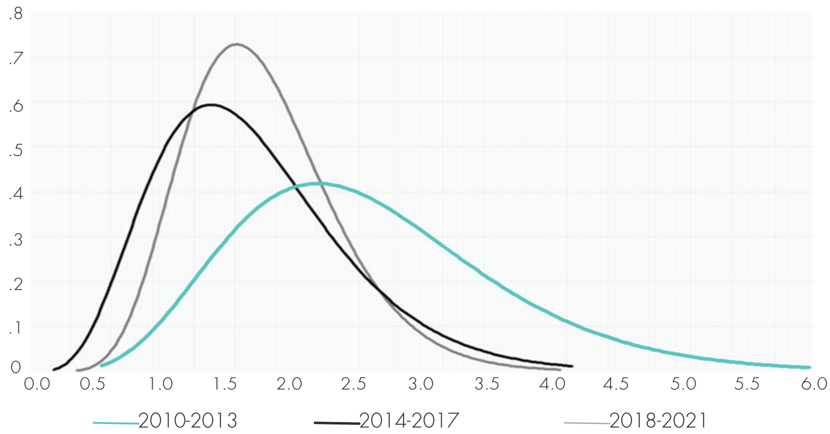
on the positive side.

The article continues as follows. Section 2 describes the quantile regression specification for the Albanian economy, the selected economic indicators and the estimation procedure. Section 3 discusses the results obtained by the empirical analysis and their interpretation, while Section 4 presents some final remarks.

Chart 1 Inflation distribution over three sub-periods: 2010-2013, 2014-2017 and 2018-2021.



Source: Authors' calculations.

2. METHODOLOGY AND DATA DESCRIPTION

The starting point of the analysis is an open-economy Phillips curve that explains the future inflation distribution to current inflation, unemployment, exchange rate and foreign prices and a constant (the explanatory variables, collectively denoted as χ_t) expressed as follows:

$$(1) \quad \pi_{t+h} = \alpha + \chi_t' \beta + [(\delta + \chi_t' \gamma)\ U_t]$$

where π_{t+h} is the *h*-month ahead year-on-year CPI inflation. The vector $\chi_t = (\pi_t, un_t, \Delta er_t, \pi_t^{EA})$ in (1) comprises the explanatory variables in an open-economy *Phillips* curve: un_t is the unemployment gap, π_t is current annual inflation rate, Δer_t is the annual change in the nominal exchange rate ALL/EUR and π_t^{EA} represents inflation in the Euro Area. The term in square bracket represent the stochastic error.

The conditional quantiles for 3-month ahead inflation introduced by Koenker & Bassett (1978) and Koenker (2005) are computed as:

$$(2) \quad Q_\pi (\tau | X_t) = (\alpha + \delta_i\, q(\tau)) + \chi_t' \beta + \chi_t' \gamma q(\tau)$$

We estimate coefficients for five quantiles: 10, 25, 50, 75 and 90 percent quantiles. The confidence intervals are computed by bootstrapping with 500 replications.

Each predicted quantile in the equation above corresponds to a point in the cumulative distribution function (CDF) F(.) of the 3-month ahead inflation forecast for each period[2]. A sequence of probability density functions (PDFs) is then computed by mapping the estimated discrete quantiles at each point in time. These points are interpolated afterwards to obtain a smooth distribution which allows us to perform inflation risk analysis. Smoothing is also necessary because the projected quantile are often noisy, given the error accompanying the estimation. The projected quantiles are interpolated non-parametrically using Epanechnikov Kernel[3].

The methodology has several advantages over the conventional counterparts. In contrast to ordinary least squares (OLS) regression, which estimates the conditional mean of the dependent variable, quantile regression estimates the entire conditional distribution of the dependent variable, as a function of variables set with changing effects along the distribution. Basically, this estimation framework yields the entire distribution of future inflation for the "risk" factors. We thus examine important risk asymmetries and the average effects of the risk factors.

The information sources used to get these data are: Bank of Albania (BoA), the National Institute of Statistics (INSTAT) and Eurostat. The dataset includes monthly time series for the period 2010M1-2021M12. Inflation rate is the annual change of monthly price level measured by the Consumer Price Index (CPI) published by INSTAT. Nominal exchange rate ALL/EUR is the daily official rate of Bank of Albania. Monthly frequency is the simple average of the daily observations and year on year growth rate is applied to exchange rate series. Unemployment gap is calculated as the ratio of unemployment rate to the NAIRU, under the aim of capturing the so called 'speed effect'. Unemployment rate is taken from INSTAT and NAIRU is generated according to the methodology described in Çela and Skufi (2018). The linear interpolation is applied to unemployment rate and NAIRU to convert the data from quarterly to monthly frequency. Harmonized Consumer Price Index (HICP) in EA are obtained from Eurostat as an annual change of monthly data.

3 ESTIMATION RESULTS

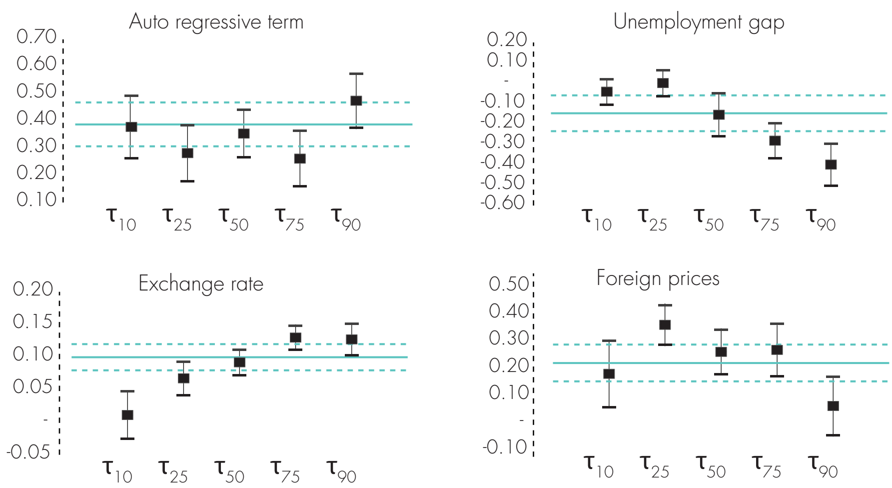
This section presents the results of quantile regression (QR), for five quantiles τ = {10, 25, 50, 75, 90}. Figure 2 shows the estimated coefficients and 95% confidence interval bands (boxplots). Horizontal green lines indicate the least squares estimations (LS) for the same variable set. All the coefficients in the Phillips Curve have the expected signs along the quantiles. The unemployment gap results with a negative effect on inflation, while current

2 The QR model perform well for h=1, .., 6; we choose to illustrate for h=3-month ahead horizon, due to the fact that labour market data [illegible]equency.

3 Epanechnikov Kernel CDF is given by $P(X < k|\mu, r) = \frac{-\left(\frac{k-\mu}{r}\right)^3 + 3\left(\frac{k-\mu}{r}\right) + 2}{4}$, *where k ∈ (μ - r; μ + r). The Epanechnikov "distribution" is simply a concave polynomial of second degree. As such the distribution entails some desirable properties. The Epanechnikov distribution is controlled by two parameters: μ and r: μ represents the mean, mode and median, which all coincide since the distribution is symmetrical; r represents the spread and corresponds to the distance between the mean and the smallest/largest possible value supported by the distribution, i.e. half the range.*

inflation, exchange rate change and foreign prices result with a positive effect on the 3-month ahead inflation.

Chart 2 Estimated QR and LS coefficients



Source: Authors' calculations.

Note: LS coefficients in green and QR coefficients in black, shown with the 90% confidence interval bands.

The results demonstrate economical and statistical asymmetries between inflation and explanatory variables. In particular, unemployment gap and exchange rate affect more inflation in the right tail, while the foreign prices effects are higher at the 25th quantile. This insight would be lost if we would have focused solely on the central tendency. The exchange rate effect tends to increase in the upper quantiles, implying that a depreciation of the domestic currency tends to increase more inflationary pressures in times of high inflation. Inflation persistence is higher in the tails of the distribution. Similar results are found by Busetti et al. (2015) for conditional distribution of inflation in euro area.

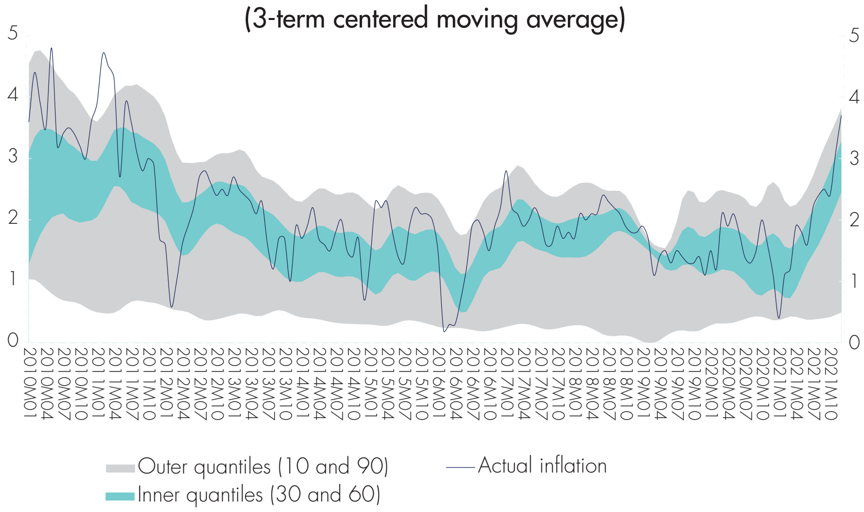
The asymmetry of the coefficients is tested further by the Wald slope equality test. The results on the coefficients equality for the median against those estimated at the upper and lower quartile, not surprisingly are statistically significant at 1% (p-value = 0.0091), concluding that coefficients differ across quantile values and that the conditional quantiles are not identical. These results are also supported by the distribution symmetry measure ($\xi = Q_{10} + Q_{90} - 2Q_{50}$) displayed in Figure 3. A value greater than zero indicates positive skewness, meaning that the right tail is longer than the left one. The conditional distribution of 3-month inflation generated by the quantile regression model tends to be negatively skewed during the first part of the sample period (2010-2014), turning into positive afterwards and remaining such till the end of the estimation period (2015-2021).

Chart 3 Skewness test results: the symmetry of inflation's conditional distribution (centered moving average of three terms).

Source: Authors' calculations.

The estimated coefficients and the corresponding fitted values of the QR model are used to generate the sequence of continuous probability density functions and estimates of upside risks to inflation. Figure 4 shows the realized values of inflation (black line) together with the estimated 30–60 and 10–90 quantile ranges for the fitted values of inflation. The results show significant time variation in the shape of inflation conditional distribution. Large swings of the explanatory variables are associated with inflation falling in the upper or in the lower distribution. As an example, the drop of inflation in 2016 is related to the currency appreciation[4] and labour market developments characterized by a higher unemployment gap.

Chart 4 Conditional distribution and realized inflation (3-term centered moving average)



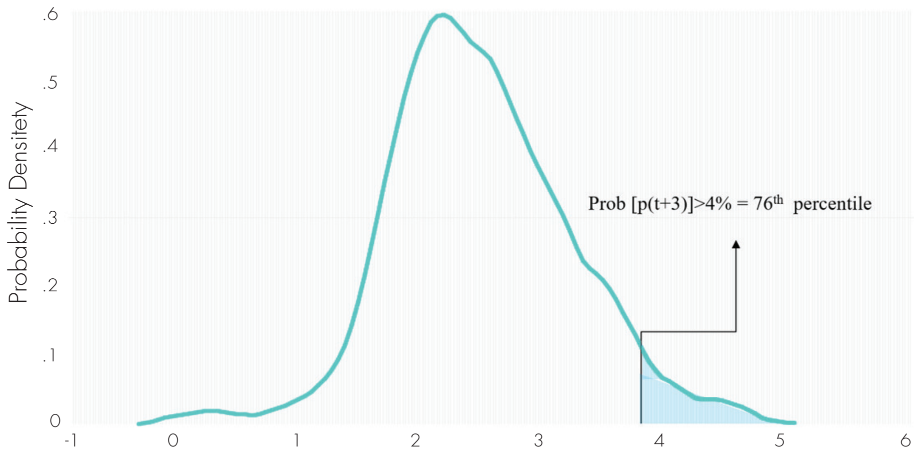
Source: Authors' calculations.

In a decade of relatively marginal upside risks, the conditional distribution of inflation tells that average 3-month ahead inflation above 4 percent has a

[4] *See Monetary Policy Report 2016 (BSH, 2016) for a detailed description of Lek appreciation during 2016.*

low probability. In other words the upside (tail) risk associated with "excessive inflation" is 7.4%. Figure 5 illustrates the link between inflation risks and the quantiles of the inflation distribution. Upside risks to inflation can be characterized by the probability mass to the right tail of the distribution. The blue shaded area indicates that a 4% (or higher) inflation rate corresponds to the 76th quantile of the inflation distribution.

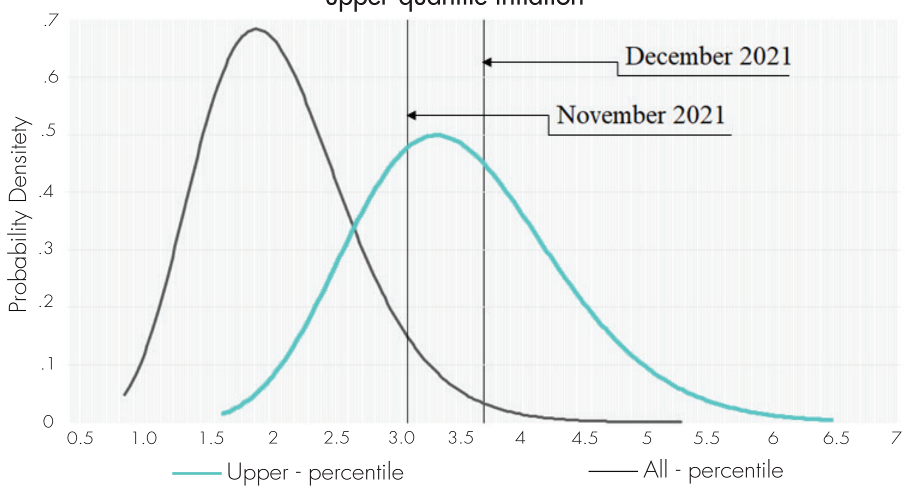
Chart 5 Probability density of average 3-month ahead inflation



Source: Authors' calculations.

Following the same logic, an inflation rate above 3% has a 40% probability to occur. Figure 6 illustrates the inflation average conditional distribution over the estimation sample. The average conditional distribution of full percentiles is represented by the grey line. While the average conditional distribution of upper percentiles related to inflation rate above the target of 3% is indicated by the green line. The results indicate that once inflation overshoots the target, it will probability fluctuates around an average of 3.5%, and there is a high probability to return to target. This bodes well with the realised value of 3.7% of headline inflation in December 2021, once the latter moved above target the month prior. The full conditional distribution would have suggested a headline inflation rate of 1.9%.

Chart 6 Probability density of estimated quantile-inflation and upper-quantile inflation



Source: Authors' calculations.

4. CONCLUDING REMARKS

Inflation in Albania dropped below the central bank's target of 3% in 2012 and has fluctuated below target until end-2021. In this article we investigate the evolution of inflation risks in Albania and its main drivers. We use quantile regressions to estimate the three-month-ahead density forecast of inflation, derived from a Phillips curve for a small open economy. This methodology provides a measure to quantify the uncertainty surrounding the main estimation. At the same time QRs analyse the relation among the variables in the different areas of the distribution producing estimations for the probability of events away from the conditional mean.

The in-sample results reveal significant time variation in the shape of the distribution of inflation and considerable nonlinearities in the effects of the explanatory variables, beyond the volatility. On average the inflation distribution results skewed on the positive side. We find that inflation react more to cyclical conditions and exchange rate movements in the right tail of the distribution.

Lastly, the analysis described in this article is mostly an illustration on how quantile regression models can be used for generating time varying conditional distributions. It can be further altered according to the specific needs of the policymakers.

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