

# Inflation expectations in Poland, 2001-2013

## Measurement and macroeconomic testing

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### Abstract

This paper presents survey-based direct measures of inflation expectations of consumers, enterprises and financial sector analysts in Poland. It then goes on to provide the results of testing those features of inflation expectations that seem the most important from the point of view of monetary policy and its transmission mechanism. The study updates the results described in Łyziak (2012) – it uses new measures of consumer inflation expectations and covers the updated sample (2001-2013). Characteristics of inflation expectations in Poland are diversified across the analysed groups of economic agents. Inflation expectations of financial sector analysts and enterprises outperform those of consumers in terms of their accuracy and information content, although consumer inflation expectations are also to some extent forward-looking.

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# Introduction

Inflation expectations constitute an important reference point in monetary policy making and a key variable in the monetary transmission mechanism. Three features of inflation expectations are especially important in this context: firstly, the degree of their forward-lookingness, especially the fulfilment of the rational expectations hypothesis; secondly, the degree to which they are anchored, i.e. consistent with the inflation target and insensitive to changes in current inflation; thirdly, the role of inflation expectations in affecting actual price dynamics in the economy.

The degree of forward-lookingness of inflation expectations has important consequences for macroeconomic performance and monetary policy. More forward-looking expectations make monetary policy more efficient and less costly, shortening the disinflation process and reducing the sacrifice ratio. If there are no constraints and asymmetries in collecting and processing information by economic agents, inflation expectations formed in a forward-looking manner are consistent with the rational expectations hypothesis – they reflect the true model of the economy and are characterized by a lack of systematic errors.<sup>1</sup>

Formation of inflation expectations is in the centre of theoretical debates and empirical research. General conclusions from the literature can be summarized in the following manner: Firstly, inflation expectations seem highly diversified in terms of their formation model and information content across various groups of economic agents; i.e. heterogeneity of expectations is observed (e.g. Trehan 2010). Secondly, inflation expectations of different groups of economic agents are not independent of each other. Empirical studies often show that inflation forecasts of professional economists influence expectations of those agents who are not experienced in macroeconomic forecasting, such as consumers (e.g. Carroll 2003, 2006; Döepke et al. 2008). Thirdly, even if inflation expectations of various groups of economic agents usually appear as a biased estimator of future inflation, they are not formed on the basis of past information only (e.g. Mehra 2002; Forsells and Kenny 2010). Fourthly, independently of the fact that model forecasts in many cases outperform direct measures of inflation expectations in terms of the forecasting accuracy, including those measures in forecasting models usually reduces their forecast errors (e.g. Mestre 2007). Fifthly, direct measures of inflation expectations are useful in estimating different versions of the Phillips curve (e.g. Henzel and Wollmershäuser 2006).

The aim of the paper is twofold: first, to construct direct measures of inflation expectations of consumers, enterprises and financial sector analysts in Poland that would be internally consistent and comparable with each other; second, to use those measures in testing the formation of inflation expectations and compare their characteristics across the analysed groups of economic agents. All the measures of inflation expectations

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<sup>1</sup>In the environment of incomplete information, expectations of fully forward-looking agents can be characterized by inertia. There are different theoretical concepts supporting this observation, i.e. signal extraction problem (Lucas 1972), information stickiness (Mankiw and Reis 2002) and rational inattention (Sims 2003).

used in the paper are survey-based and their horizon is 12 months. In the case of consumers and enterprises, qualitative type of the survey questions results in the need to quantify survey data.

The structure of the paper is the following. Section 1 describes conclusions from the existing literature on inflation expectations in Poland. Section 2 describes data sources and inflation expectations measures used in the study. Section 3 presents the results of empirical tests, in which we verify the degree of forward-lookingness of inflation expectations, the fulfilment of the principal requirements of the rational expectations hypothesis, the impact of the National Bank of Poland inflation target on inflation expectations, the relationship between inflation expectations of different groups of economic agents and their role in affecting actual price dynamics in the Polish economy. The final section concludes.

## 1 What do we know about inflation expectations in Poland?

Existing empirical studies on inflation expectations in the Polish economy usually have not been of comparative nature; rather they have been focused on expectations of a particular group of economic agents. Conclusions from those studies provide both a context and a reference point for testing performed in this paper.

Results from previous research suggest a limited degree of forward-lookingness of inflation expectations in Poland. Early studies, covering years 1992-2001, show that inflation expectations of Polish consumers and commercial bank analysts display positive errors. In the case of commercial bank analysts they are significantly lower than in the case of consumers and outperform naive forecasts (Łyziak 2003). Different studies suggest that the requirements of the rational expectations hypothesis, particularly unbiasedness and orthogonality of expectations with respect to available information, are not fulfilled in the Polish economy. This observation refers both to consumer (Łyziak 2005, Kokoszcyński et al. 2010) and enterprise inflation expectations (Tomczyk 2004, 2005).<sup>2</sup>

Inflation expectations of Polish consumers depend heavily on current inflation and its perception (Łyziak 2010b), which is affected by changes in prices of frequently purchased goods even if the overall CPI inflation is relatively stable (Łyziak 2009).<sup>3</sup> There exist also causality between the actual future inflation and inflation expectations currently formed (Łyziak and Stanisławska 2006), which suggests a certain role of forward-looking determinants of expectations. It is however relatively low – even if higher than the EU-average, yet lower than in some of the old members of the EU (Łyziak 2010b). Inflation expectations of Polish consumers

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<sup>2</sup>The results we report here are based on inflation expectations of Polish enterprises for the next 3-4 months based on survey data from the Research Institute for Economic Development of the Warsaw School of Economics. Features of those measures of expectations have been tested in a number of studies (e.g. Tomczyk 2004, 2005, 2007, 2008).

<sup>3</sup>Consumer inflation expectations in Poland are also influenced by changes in consumer sentiment, anticipated changes in the unemployment and consumers' current financial situation (Stanisławska 2010).

seem to be efficient with respect to some macroeconomic variables (especially: exchange rates), which is another sign of partially anticipative nature of those expectations (e.g. Łyziak 2005).

It seems that Polish enterprises find it more difficult to forecast inflation than predict changes in output and employment, which is reflected in positive bias of inflation expectations (Tomczyk 2005). Inconsistency of enterprises' inflation expectations with the requirements of the rational expectations hypothesis is also confirmed on the basis of contingency tables (Tomczyk 2007).

Inflation expectations of Polish consumers and commercial bank analysts have also been used to test the model of adaptive learning, in which it is assumed that economic agents learn the model of economic relationships gradually, by estimating their fore-casting rule every period (see: Evans and Honkapohja 2001, Bullard and Mitra 2002). Stanisławska (2008) shows that there are no large differences between consumers and bank analysts in the learning process with regard to the speed of learning or variables taken into consideration in formulating expectations. However, commercial bank analysts seem to employ information on the inflation target of the National Bank of Poland and future price changes to a greater degree than consumers. So we can conclude that both groups of economic agents form their expectations differently from each other: there are different degrees of forward-lookingness and expectation anchoring.

Central bank credibility and anchoring of inflation expectations has been tested in a separate study (Łyziak et al. 2007). Polish consumers do not seem to pay attention to the NBP inflation target while forming inflation expectations or – as can be seen from recent evidence – consider it to a small extent (NBP 2010), while commercial bank analysts perceive inflation target as credible and its weight in the formation of their inflation forecasts exceeds 80%.

Research studies concerning the impact of inflation expectations on price dynamics in Poland have used direct measures of consumer inflation expectations only – so far there have been no studies using expectations of other groups of economic agents in this context. Measures of consumer inflation expectations quantified on the basis of survey data proved to be useful while estimating the hybrid New Keynesian Phillips curve (Kokoszcyński et al. 2010) and modelling the monetary transmission mechanism in Poland (Łyziak 2002, Łyziak 2004).

## 2 Data

In this section we present the details of the measurement of inflation expectations of consumers, enterprises and financial sector analysts in Poland and data sources used.

## 2.1 Consumer inflation expectations

We use consumer survey data from the Central Statistical Office (GUS) survey, conducted with monthly frequency.<sup>4</sup> Its qualitative question on expected price changes has the following form:

“By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will... (1) increase more rapidly, (2) increase at the same rate, (3) increase at a slower rate, (4) stay about the same, (5) fall, (6) don’t know”.

There is an additional qualitative question in the GUS survey that concerns the perception of price changes over last 12 months:

“In your opinion, is the price level now compared to that 12 months ago: (1) much higher; (2) moderately higher; (3) a little higher; (4) about the same; (5) lower; (6) don’t know”.

Its results are used in our analysis of the degree of forward-lookingness of inflation expectations in Poland.

Balance statistics offer the easiest way to summarize the responses to survey questions of this kind. They are defined as the differences between weighted or unweighted proportions of respondents selecting individual response categories. They do not measure expected or perceived inflation directly, but at the same time they are not influenced by the assumptions imposed in quantification methods (Łyziak 2010a). Calculating the balance statistics of expected and perceived inflation to be used in this paper, the subsequent percentages of respondents – starting from the most pessimistic one – are weighted with the following numbers: 1,  $\frac{1}{2}$ , 0,  $-\frac{1}{2}$  and -1.

In the empirical part of the paper we use not only balance statistics, but mainly two measures of inflation expectations quantified with the probability method assuming normal distribution of expected inflation in the population.<sup>5</sup> In quantifying the first measure – called ‘objectified’ – it is assumed that the current CPI inflation constitutes the reference point for consumers in selecting the response option to the question on predicted price changes. In the case of the second measure of inflation expectations – called ‘subjectified’ – we refer to subjectively perceived price dynamics, so-called Consumer Perceived Price Index (CPPI) (Halka and Łyziak 2013). It exceeds CPI inflation significantly (5.0% vs. 3.0% on average in 2001-2013) due to the fact that in their perceptions of price developments Polish consumers focus on prices of frequently purchased

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<sup>4</sup>GUS survey data on consumer opinions on future price developments start in January 2004. To obtain a longer time series of inflation expectations we extrapolate the balance statistic of GUS survey responses that is used in the quantification of inflation expectations, exploiting the relationship between GUS survey data and Ipsos survey data, covering a longer sample period.

<sup>5</sup>The probability quantification method was proposed by Carlson and Parkin (1975). We use its extended version (e.g. Batchelor and Orr 1988, Łyziak 2010b).

goods and services and seem to pay no attention to price reductions of these items.<sup>6</sup> Detailed description of probability methods used to quantify the above measures of consumer inflation expectations in Poland can be found in Lyziak (2010a).

## 2.2 Enterprise inflation expectations

Inflation expectations of Polish enterprises are measured on the basis of quarterly surveys conducted by the National Bank of Poland (NBP's Quick Monitoring). Similarly as in the case of consumers, except balance statistic we use quantified measures of enterprises' inflation expectations. The survey question provides the respondents with the most recent CPI inflation figure, so we treat it as a scaling factor in the quantification of enterprises' inflation expectations.

Since the 3rd quarter of 2008 the survey question concerning expected price changes has the following qualitative nature:

„In ... [*here: the month with the most recent CPI index available*] CPI inflation was ... % in annual terms. In your opinion during next 12 months prices will: (1) rise faster than at present, (2) rise at the same rate, (3) rise more slowly, (4) stay at their present level, (5) go down, (6) difficult to say”.

Earlier, i.e. since the 1st quarter of 2001 till the 2nd quarter of 2008, survey question on expected price changes was quantitative.<sup>7</sup> Both time series of enterprises' inflation expectations (quantitative and quantified on the basis of qualitative data) seem similar<sup>8</sup>, so we integrated them into a single measure. However, there are doubts whether combining survey data in this way is coherent. It is not only due to the fact that the nature of survey questions is different (qualitative vs. quantitative), but also due to the fact that in the qualitative question the current CPI inflation is referred to, which can anchor the opinions on future price changes. Assessment of the impact of changes in the method of collecting data on the resulting measures of enterprise inflation expectations is complicated by a time coincidence of changes in survey questions and the beginning of the global financial crisis – it is not possible to isolate both effects.

To take into account the uncertainty of measurement related to the change in the survey question we use two measures of enterprise inflation expectations. Except for the main measure, being a combination of the results from the quantitative question (2001Q1-2008Q2) and expectations quantified on the basis of

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<sup>6</sup>It should be noted however that they take into consideration a relatively broad basket of goods and services, including food and non-alcoholic beverages, tobacco, housing and energy carriers, medical products, fuels, communication services, newspapers and articles and products for personal care (see Halka and Lyziak 2013 for details).

<sup>7</sup>The question then had the following form: „In the opinion of the enterprise, the increase of CPI during the next 12 months will be ... %”.

<sup>8</sup>The average quantitative measure in 2008Q2 is similar to the average of the probability measure of expectations in 2008Q3. Moreover, the volatility of both time series, as assessed with the coefficient of variation, is similar (for the period with quantitative question – 35.5% on average; for the period with quantified measures of inflation expectations – 38.8% on average).



qualitative survey data (since 2008Q3), we calculate an alternative measure, different from the main one in the first sub-period. Having quantitative expectations of individual enterprises we translate them into implied (individual) responses to the qualitative survey question, and then we aggregate them and use to quantify inflation expectations with the probability method. Details concerning the construction of this measure are presented in the Annex.

## 2.3 Inflation expectations of financial sector analysts

Financial sector analysts are the third group of agents, whose inflation expectations we analyse in this study. We use monthly data on 12-month inflation expectations obtained from the surveys by Reuters.<sup>9</sup>

## 2.4 Inflation expectations in Poland, 2001-2013

Table 1 presents selected features of inflation expectations of consumers, enterprises and financial sector analysts since the 1st quarter of 2001 till the 2nd/3rd quarter of 2013. In terms of their averages, the subjectified measure of consumer inflation expectations in the analysed period was significantly higher than the current inflation and expectations of remaining groups of economic agents. Even if the objectified measure of consumer inflation expectations was the lowest one, both measures of consumer inflation expectations were more volatile than predictions of enterprises and financial sector analysts. The comparable volatility of consumer inflation expectations and current inflation suggests a relatively weak anchoring of those expectations.

Table 1: Selected features of inflation expectations and CPI inflation in Poland

Category	Data source, measure	Average (%)	Standard dev. (p.p.)	Coefficient of variation (%)
Consumer inflation expectations [1]	GUS, objectified	2.8	1.6	59.1
	GUS, subjectified	4.7	2.0	43.6
Enterprise inflation expectations [2]	NBP, main	3.1	1.2	38.7
	NBP, alternative	2.9	1.2	41.4
Financial sector agents infl. expectations [1]	Reuters	2.9	1.0	34.5
Current inflation	GUS	3.0	1.7	56.7

Notes: [1] – monthly data, sample: 2001:01-2013:08; [2] – quarterly data, sample: 2001:Q1-2013:Q2.

Source: own calculations on the basis of GUS, NBP and Reuters data.

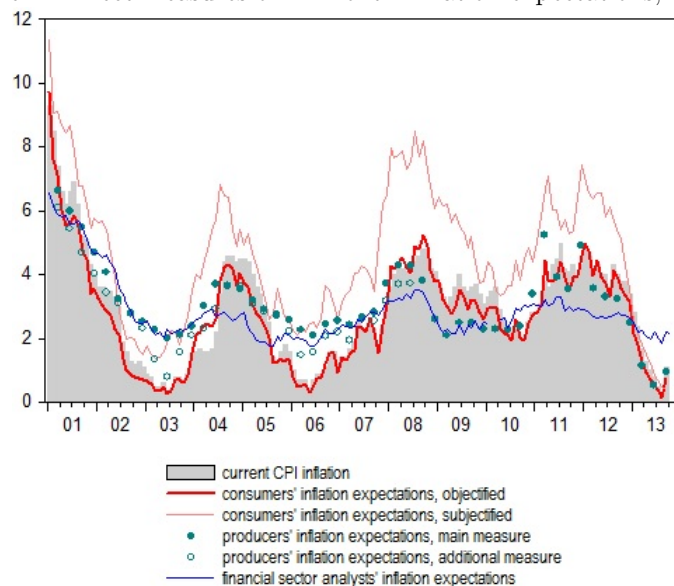
Below we presents time series of inflation expectations of analysed groups of economic agents – direct measures of expected price change (Figure 1) and balance statistics of consumer and enterprise opinions on future price changes (Figure 2). Both the measures of consumer inflation in Poland follow developments of current CPI inflation closely<sup>10</sup>, more closely than expectations of enterprises and financial sector analysts do. Also the

<sup>9</sup>Since November 2000 till December 2010 and in March 2011 the Reuters survey question concerned 11-month horizon.

<sup>10</sup>In the case of the objectified measure of inflation expectations it is to some extent caused by the assumptions of the quantification method, in the case of the subjectified ones the quantification method does not impose so close relationship (see Lyziak 2010a).

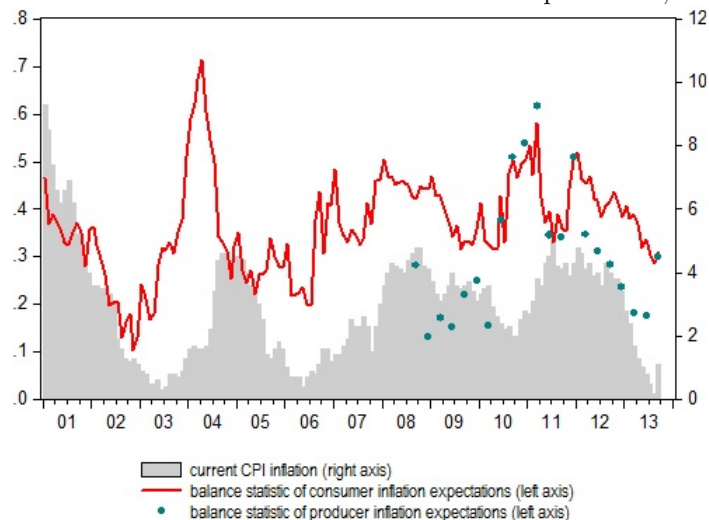
balance statistic of consumer opinions on future price changes confirms that in the periods of rising inflation consumers' opinions on expected price changes tend to worsen and vice versa. It contradicts the behaviour of enterprises, whose opinions on future inflation were becoming more pessimistic in 2008-2010, in spite of the fact that inflation in this period was declining.

Figure 1: Direct measures of 12-month inflation expectations, 2001-2013



Source: own calculations on the basis of GUS, NBP and Reuters data.

Figure 2: Balance statistics of 12-month inflation expectations, 2001-2013



Source: own calculations on the basis of GUS, NBP and Reuters data.

## 3 Testing selected features of inflation expectations in Poland

### 3.1 Rationality of inflation expectations

While analysing the fulfilment of the rational expectations hypothesis<sup>11</sup> its two principal requirements are usually tested, i.e. unbiasedness and macroeconomic efficiency. Expectations are unbiased if they are free from systematic errors, being equal to actual future inflation on average, and to actual future inflation plus a random forecast error period by period. Expectations fulfil the macroeconomic efficiency requirement if economic agents efficiently process available information while setting their expectations, i.e. expectational errors are orthogonal to available information.

Literature distinguishes two degrees of macroeconomic efficiency of inflation expectations. The weak-form efficiency requires expectational errors to be orthogonal to an information set that includes only past values of inflation. The strong-form efficiency requires expectational errors to be orthogonal with respect to a much wider information set, encompassing a range of macroeconomic variables that influence price dynamics. In other words, agents are supposed to effectively incorporate information about all the variables that a state-of-the-art model of inflation would include (Lloyd 1999).

As far as inflation expectations of economic agents in Poland are concerned, it appears that in the case of enterprises and financial sector analysts expectational errors have been, in absolute terms (MAE), lower than the errors of naive forecasts (Table 2).<sup>12</sup> All the groups of economic agents, especially consumers, have tended to overestimate future inflation. Inflation expectations of consumers display the highest mean absolute error, while inflation expectations of financial sector analysts – the lowest one. It should be noted that inflation expectations of enterprises are only slightly less accurate than financial sector analysts' inflation expectations.<sup>13</sup>

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<sup>11</sup>Rational expectations were introduced to the Phillips curve by Lucas (1972); however the concept of rational expectations had been proposed even before (Tinbergen 1932, Muth 1961).

<sup>12</sup>In terms of the mean absolute error (MAE), only the subjectified measure of consumer inflation expectations is less accurate than the naive forecast.

<sup>13</sup>Analysis of expectational errors is conducted with the complete sets of observations available for each of the groups of economic agents considered in the analysis. In the case of consumers and financial sector analysts, the monthly frequency of survey data makes the number of observations three times larger than in the case of enterprises, whose expectations are available once a quarter. As a cross check we compared expectational errors taking into account quarterly time series of expectations of all groups of economic agents and the results (available on request from the author) were similar to those presented in Table 2. In the subsequent parts of the paper, for efficiency of performed tests we use complete sets of observations for each of groups of agents, ignoring differences in the number of observations at the disposal.

Table 2: Inflation expectation errors

Category	Data source, measure	ME	MAE	MAPE
Consumer inflation expectations [1]	GUS, objectified	0.18	1.80	125.4
	GUS, subjectified	2.15	2.60	206.6
Enterprise inflation expectations [2]	NBP, main	0.60	1.63	147.3
	NBP, alternative	0.32	1.61	139.9
Financial sector agents infl. expectations [1]	Reuters	0.29	1.41	118.7
Naive forecast	-	0.40	1.96	146.9

Notes: [1] – monthly data, sample: 2001:01-2013:08; [2] – quarterly data, sample: 2001:Q1-2013:Q2.

Source: own calculations on the basis of GUS, NBP and Reuters data.

To verify the unbiasedness property of inflation expectations in Poland we estimate the following equation:

$$\pi_{t|t-12}^e = \alpha + \beta \cdot \pi_t + \varepsilon_t \quad (1)$$

where  $\pi_{t|t-12}^e$  is the expectation of inflation at time  $t$  formed 12 months before,  $\pi_t$  denotes the actual inflation in period  $t$ , while  $\varepsilon_t$  is a white-noise error. In line with the unbiasedness requirement of the rational expectations hypothesis, the coefficients  $\alpha$  and  $\beta$  in the equation 1 should be equal to zero and one, respectively. Estimation results (Table 3) show that none of the groups of economic agents under consideration forms unbiased expectations, moreover actual future inflation, with respect to which inflation expectations are formed, is statistically insignificant in all the estimated equations.

Table 3: Unbiasedness of inflation expectations – estimation results of eq. (1)

Category	Data source, measure	$R_{adj.}^2$	$\alpha$	$\beta$	F-prob $H_0 : (\alpha, \beta) = (0, 1)$
Consumer inflation expectations [1]	GUS, objectified	0.92	0.026 (0.006)	-0.084 (0.090)	0.000
	GUS, subjectified	0.92	0.045 (0.009)	-0.109 (0.123)	0.000
Enterprise inflation expectations [2]	NBP, main	0.67	0.032 (0.005)	-0.079 (0.090)	0.000
	NBP, alternative	0.64	0.029 (0.003)	-0.078 (0.099)	0.000
Financial sector agents infl. expectations [1]	Reuters	0.97	0.031 (0.004)	-0.084 (0.113)	0.000

Notes: [1] – monthly data, sample: 2001:01-2013:08; [2] – quarterly data, sample: 2001:Q1-2013:Q2. Standard errors in parentheses.

Source: own calculations on the basis of GUS, NBP and Reuters data.

In the above analysis we use measures of consumers' and enterprises' inflation expectations quantified on the basis of survey data. In order to cross-check the results concerning expectational errors, we compare qualitative opinions on future inflation proxied by balance statistics with actual future inflation expressed in a similar way.<sup>14</sup> To derive the qualitative measure of actual future inflation, we translate the official CPI

<sup>14</sup>The idea of conducting the analysis of expectational errors in this (qualitative) way was inspired by Nolte et al. (2010), among others.

inflation ( $\pi$ ) into the measure  $\pi^{BS}$ , consistent with the construction of balance statistics used in this paper, i.e.:

$$\pi_t^{BS} = \begin{cases} 1 & \text{if } \pi > \pi_{t-12} \\ 0.5 & \text{if } \pi_t = \pi_{t-12} \\ 0 & \text{if } 0 < \pi_t < \pi_{t-12} \\ -0.5 & \text{if } \pi_t = 0 \\ -1 & \text{if } \pi_t < 0 \end{cases} \quad (2)$$

A comparison of balance statistics of inflation expectations and actual future inflation (Table 4) indicates that Polish consumers in the analysed period used to form their opinions in excessively optimistic manner, while qualitative opinions of enterprises on expected price changes were accurate on average.

Table 4: Average balance statistics of inflation expectations and actual future inflation

Agents	Data source, measure	Average inflation expectations	Average actual inflation	Difference (in % of actual future inflation)
Consumers [1]	GUS, balance statistics	0.37	0.44	-15.9
Enterprises [2]	NBP, balance statistics	0.49	0.49	1.3

Notes: [1] – monthly data, sample: 2001:01-2013:08; [2] – quarterly data, sample: 2001:Q1-2013:Q2; in 2001:Q2-2008:Q2 the balance statistic is calculated using implied fractions of respondents obtained on the basis of individual data, in line with the method described in detail in Annex.

Source: own calculations on the basis of GUS and NBP data.

In testing macroeconomic efficiency of inflation expectations we verify if expectational errors ( $e_t = \pi_{t|t-12}^e - \pi_t$ ) are caused by ignoring available information on macroeconomic variables affecting inflation ( $\Omega_t$ ). Two versions of the test equations are used<sup>15</sup>, i.e.:

$$\begin{aligned} e_t &= \alpha_0 + \alpha_1 \cdot \Omega_t + \varepsilon_t & [I] \\ e_t &= \alpha_0 + \alpha_1 \cdot \Omega_t + \alpha_2 \cdot e_{t-1} + \varepsilon_t & [II] \end{aligned} \quad (3)$$

Due to possible problems with multi-collinearity, which could appear while estimating equations (3<sup>[I]</sup>) and (3<sup>[II]</sup>) in a multivariate context, univariate regressions are run, in which the dependent variable is the year-on-year change in the information variable at the time that the expectations were formed (publication lags taken into account). A statistically significant  $\alpha_1$  suggests that agents failed to take account of the selected information variable in an optimal way in assessing future price developments.

Different categories of macroeconomic indicators are considered in testing orthogonality of inflation expectational errors to available information – short-term interest rates (WIBOR 1M and WIBOR 3M), exchange rates (PLN/USD, PLN/EUR), demand variables (industrial output, unemployment rate) as well as price

<sup>15</sup>In the literature the equation (3<sup>[I]</sup>) is usually used alone while testing macroeconomic efficiency of expectations (e.g. Forsells and Kenny 2010). Due to strong autocorrelation of forecast errors – which does not contradict the rational expectations hypothesis given that the horizon of analysed expectations is longer than the frequency of the data – we use in addition an extended version of the test equation (3<sup>[II]</sup>), with the lagged expectational error on its right-hand side. This substantially improves the statistical properties of estimation results.

and cost variables (oil price, CPI inflation). Table 5 presents the results and provides the assessment of the degree of macroeconomic efficiency.

The degree of macroeconomic efficiency seems diversified across different groups of economic agents, although the differences in this respect are rather small. Efficiency of Polish consumers' inflation expectations is relatively weak. Even if the exchange rates, oil price and industrial output do not lead to expectational errors, the remaining variables – i.e. interest rates, unemployment rate and CPI inflation – are not interpreted by consumers in an adequate manner.<sup>16</sup> Inflation expectations of financial sector analysts and enterprises display higher degree of macroeconomic efficiency. It is to some extent surprising that Polish enterprises outperform financial sector analysts in processing available information on current inflation, which means that weak macroeconomic efficiency condition is fulfilled in the case of enterprise inflation expectations.

Table 5: Macroeconomic efficiency of inflation expectations estimates of  $\alpha_1$  in eq. (3)

Agents	Data source, measure	Model	Information variables [1]							
			WIBOR 1M	WIBOR 3M	PLN/EUR	PLN/USD	Ind. output	Unemployment	Oil price	CPI inflation
Consumers	GUS, objectified	(3 <sup>[I]</sup> )	0.000 (0.001)	0.002 (0.002)	-0.012 (0.016)	0.003 (0.009)	-0.011 (0.008)	-0.001 (0.001)	0.002 (0.004)	0.454* (0.055)
		(3 <sup>[II]</sup> )	0.001* (0.000)	0.001* (0.000)	0.002 (0.006)	0.002 (0.003)	0.011 (0.010)	0.000 (0.000)	0.001 (0.002)	0.082* (0.023)
		(3 <sup>[I]</sup> )	0.000 (0.002)	0.001 (0.002)	-0.002 (0.020)	0.014 (0.013)	-0.005 (0.009)	-0.003* (0.001)	0.0026 (0.005)	0.153* (0.075)
		(3 <sup>[II]</sup> )	0.001* (0.000)	0.001* (0.000)	0.002 (0.007)	0.002 (0.0034)	0.026* (0.012)	-0.001* (0.000)	0.002 (0.002)	0.054* (0.027)
	<b>Assessment [2]</b>		-	-	++	++	+	-	++	--
	GUS, subjectified	(3 <sup>[I]</sup> )	0.000 (0.002)	0.001 (0.002)	-0.002 (0.031)	0.014 (0.017)	-0.005 (0.075)	-0.003* (0.002)	0.0026 (0.010)	0.153* (0.194)
		(3 <sup>[II]</sup> )	0.001* (0.000)	0.001* (0.000)	0.002 (0.015)	0.007 (0.006)	0.016 (0.028)	0.000 (0.001)	-0.003 (0.002)	0.083 (0.061)
		(3 <sup>[I]</sup> )	0.001 (0.002)	0.000 (0.002)	-0.039 (0.032)	0.011 (0.018)	-0.100 (0.069)	0.004* (0.002)	-0.005 (0.010)	-0.095 (0.197)
		(3 <sup>[II]</sup> )	0.001* (0.000)	0.001* (0.000)	-0.001 (0.015)	0.007 (0.005)	0.021 (0.033)	0.000 (0.001)	-0.003 (0.0023)	0.107 (0.067)
	<b>Assessment [2]</b>		-	-	++	++	++	+	++	++
Enterprises	NBP, main	(3 <sup>[I]</sup> )	0.000 (0.002)	0.000 (0.002)	-0.039 (0.031)	0.006 (0.017)	-0.093 (0.075)	0.003* (0.002)	-0.004 (0.010)	-0.154 (0.194)
		(3 <sup>[II]</sup> )	0.001* (0.000)	0.001* (0.000)	-0.002 (0.015)	0.007 (0.006)	0.016 (0.028)	0.000 (0.001)	-0.003 (0.002)	0.083 (0.061)
	NBP, alternative	(3 <sup>[I]</sup> )	0.001 (0.002)	0.000 (0.002)	-0.039 (0.032)	0.011 (0.018)	-0.100 (0.069)	0.004* (0.002)	-0.005 (0.010)	-0.095 (0.197)
		(3 <sup>[II]</sup> )	0.001* (0.000)	0.001* (0.000)	-0.001 (0.015)	0.007 (0.005)	0.021 (0.033)	0.000 (0.001)	-0.003 (0.0023)	0.107 (0.067)
	<b>Assessment [2]</b>		-	-	++	++	++	+	++	++
Financial sector agents	Reuters	(3 <sup>[I]</sup> )	0.000 (0.000)	0.000 (0.001)	-0.006 (0.011)	0.007 (0.007)	-0.008 (0.005)	0.000 (0.001)	0.002 (0.004)	0.086* (0.038)
		(3 <sup>[II]</sup> )	0.000* (0.000)	0.000* (0.000)	-0.002 (0.004)	0.002 (0.002)	0.002 (0.007)	0.000 (0.000)	0.000 (0.001)	0.032* (0.019)
	<b>Assessment [2]</b>		-	-	++	++	++	++	++	--
	<b>Assessment [2]</b>		-	-	++	++	++	++	++	--

Notes: [1] – red colour denotes parameters that are not statistically different from zero, while \* – parameters statistically different from zero with 10% significance; [2] – the following symbols are used: „++” – given variable used efficiently while forming inflation expectations, „+” – given variable used rather efficiently while forming inflation expectations, „-” – given variable used inefficiently while forming inflation expectations, „--” – given variable used rather efficiently while forming inflation expectations. Standard errors in parentheses.

Source: own calculations on the basis of GUS, NBP and Reuters data.

<sup>16</sup>In the light of presented result the degree of macroeconomic efficiency of Polish consumers' inflation expectations seems smaller than in developed economies, such as the euro area (e.g. Forsells and Kenny 2010) or US (e.g. Mehra 2002).

### 3.2 The degree of forward-lookingness of inflation expectations

Rejecting the fully rational model of the formation of inflation expectations in Poland makes it legitimate to consider hybrid models of expectations formation, in which expectations are to some extent forward-looking (rational) and to some extent backward-looking. In order to assess the formation of inflation expectations in Poland, for each of the measures we estimate two equations. Both of them assume that inflation expectations are of a hybrid nature. The difference between both specifications concerns the applied model of backward-looking expectations – it is either adaptive (equation (4)) or static (equation (5)):

$$\pi_{t+12|t}^e = \alpha_1 + \alpha_2 \cdot \pi_{t+12} + (1 - \alpha_2) \left[ \pi_{t-2|t-14}^e + \alpha_3 \cdot \left( \pi_{t-2|t-14}^e - \pi_{t-2} \right) + \alpha_4 \cdot (\pi_{t-2} - \pi_{t-14}) \right] + \varepsilon_t \quad (4)$$

$$\pi_{t+12|t}^e = \alpha_1 + \alpha_2 \cdot \pi_{t+12} + (1 - \alpha_2) \cdot \pi_{t-2} + \varepsilon_t \quad (5)$$

The equation (4) was used in some empirical studies (e.g. Gerberding 2001, Carlson and Valev 2002, Heineman and Ullrich 2006). In its backward-looking part – except standard determinants of adaptive expectations – a possible impact of a change in the current inflation on inflation expectations is additionally taken into account. For subjectified measures of consumer inflation expectations among explanatory variables in both versions of the test equation we also include the difference between current inflation and its perception by consumers.

For the assessment of the formation of inflation expectations we use this version of the test equation that outperforms its alternate in terms of statistical properties. The degree of forward-lookingness of inflation expectations is measured with parameter  $\alpha_2$ . If the hypothesis that the estimated parameter  $\alpha_2$  equals 1 is not rejected, it suggests that inflation expectations are fully forward-looking and meet the unbiasedness requirement of the rational expectations hypothesis. If the estimation results show that  $\alpha_2$  is insignificantly different from zero, inflation expectations are fully backward-looking; either adaptive or static.

Estimation results (Table 6) show that among analysed groups of economic agents, Polish enterprises display the highest degree of forward-lookingness in forming their inflation expectations – the weight of this component is about 35%. Inflation expectations of financial sector analysts are characterised by a lower degree of forward-lookingness (25%). Consumer inflation expectations are mostly backward-looking and the role of the forward-looking component is small (ca. 10%).<sup>17</sup>

<sup>17</sup>According to Lyziak (2010b), the degree of forward-lookingness of Polish consumers' inflation expectations in 2002-2007 (approx. 13%) was slightly higher than the EU-average, but significantly lower than in some old member states of the EU (e.g. Italy – approx. 40%, the Netherlands – approx. 35%, UK and Ireland – approx. 25%).

Table 6: Forward-lookingness of inflation expectations – estimation results of eq. (4)/(5)

Agents	Data source, measure	equation [1], $R^2_{adj.}$	degree of forward- lookingness, $\alpha_2$	degree of backward- lookingness, $1 - \alpha_2$	$\alpha_3$	$\alpha_4$
Consumers	GUS, objectified	(5), 0.95	<b>0.08</b> <b>(0.02)</b>	0.92	x	x
	GUS, subjectified	(4), 0.89	<b>0.10</b> <b>(0.06)</b>	0.90	-1.14 (0.04)	1.10 [2] (0.11)
Enterprises	NBP, main	(5), 0.38	<b>0.36</b> <b>(0.07)</b>	0.64	x	x
	NBP, alternative	(5), 0.57	<b>0.32</b> <b>(0.06)</b>	0.68	x	x
Financial sector agents	Reuters	(4), 0.82	<b>0.25</b> <b>(0.04)</b>	0.75	-0.43 (0.05)	-

Notes: [1] – Estimation technique: Following the usual procedure, actual future inflation is used as a measure of rational expectations. As a consequence, the error term of the estimated equation includes the expectations error of rational expectations (see: Fair 1993). Therefore, two-stage least squares method (2SLS) is used to estimate both versions of the test equation with constant and twelve lags of current inflation being the instruments (in line with Gerberding 2001); [2] – In the case of subjectified measures of inflation expectations, instead of the estimate of the parameter  $\alpha_4$ , which was not significantly different from zero, we present the coefficient of the gap between perceived and official current inflation that was used additionally in the estimated equations.

Source: own calculations on the basis of GUS, NBP and Reuters data.

To cross-check the results based on quantified measures of consumer and enterprise inflation expectations, we compute correlation coefficients between balance statistics of their opinions on price changes during the last 12 months and the next 12 months. A high degree of such correlation would suggest that qualitative opinions on price changes in future depend on the assessment of past price changes, which – indirectly – would indicate a limited forward-lookingness of those opinions. Although such analysis uses qualitative, not quantitative, measures of the opinions on future inflation, it allows avoiding problems caused by quantification methods. These methods impose some degree of correlation between current inflation and quantification outcomes (see: Łyziak 2010a), therefore applying quantified measures of inflation expectations in the estimation of the equations (4) and (5) can bias upwards the assessment of the degree of expectations' backward-lookingness. In the case of enterprises instead of the balance statistic of perceived price changes, which is not available (since there is no survey question concerning perceived price changes), current CPI inflation is used. The analysis of correlation coefficients (Table 7) indicates a medium degree of positive correlation between consumers' opinions on currently perceived and future inflation and a negative correlation between current inflation and enterprises' opinions on price changes in the next 12 months.

Table 7: Correlation between balance statistics of perceived and expected price changes

Agents	Data source, measure	Spearman correlation between balance statistic of expected price changes and balance statistic of perceived price changes (consumers) / current inflation (enterprises)
Consumers [1]	GUS, balance statistics	0.54
Enterprises [2]	NBP, balance statistics	-0.84 [3]

Notes: [1] – monthly data, sample: 2001:01-2013:08; [2] – quarterly data, sample: 2001:Q1-2013:Q2; in 2001:Q2-2008:Q2 the balance statistic is calculated using implied fractions of respondents obtained on the basis of individual data, in line with the method described in detail in Annex; [3] – Spearman correlation with current CPI inflation.

Source: own calculations on the basis of GUS and NBP data.



### 3.3 Central bank inflation target and inflation expectations

If the central bank is perceived as credible, its inflation targets (or forecasts) should influence (anchor) inflation expectations in the economy. Therefore in this section we test the impact of the NBP inflation target on inflation expectations of all analysed groups of economic agents.

There are some problems with defining a continuous measure of the NBP inflation target for the whole period under consideration. In 1998-2003 there were annual NBP inflation targets set for the end of subsequent years<sup>18</sup>, while since February 2003 there has been a continuous target  $2.5\% \pm 1\text{p.p.}$  In order to obtain implicit monthly inflation targets covering the whole period considered in this study (i.e. 2001-2013), three measures of inflation target have been calculated, in line with those proposed in Łyziak et al. (2007): the official target for a given year, a smoothened inflation target computed with the Hodrick-Prescott filter, and a monthly linear interpolation between end-year targets.

In analysing central bank credibility long-term expectations should be considered. Using measures of short-term inflation expectations formed for the next 12 months by Polish consumers, enterprises and financial sector analysts can underestimate the credibility of the NBP. Even if it was high in the sense that long-term inflation expectations in the economy were insensitive to changes in inflationary shocks, such shocks could influence short-term inflation expectations due to natural lags in their absorption. Therefore in our analysis we refer to the adjusted measure of the inflation target ( $\pi_{t+1}^{tar*}$ ). In calculating it we assume that if the current inflation is above the target ( $\pi_{t+1}^{tar}$ ), economic agents setting their 12-month inflation expectations can be aware that in line with the principles of flexible inflation targeting the gap between inflation and the inflation target will be reduced gradually by the central bank.<sup>19</sup> For sufficiently large inflation shocks it can imply that even if the central bank is fully credible and committed to attain the target in the medium-term, inflation expectations for the next 12 months can still stay above the target.

The assessment of the absorption of inflationary shocks used to adjust the NBP inflation target is based on the results of VAR models estimated at the NBP.<sup>20</sup> They show that 12 months after inflation is shocked by 1 percentage point, CPI inflation remains approximately 0.2 percentage point above the baseline. Following this estimate, the adjusted measures of the NBP inflation target, capturing the principle of gradual absorption of inflationary shocks, are calculated in the following way:

$$\pi_{t+12}^{tar*} = \pi_{t+1}^{tar} + 0.2 \cdot (\pi_{t-2} - \pi_{t+1}^{tar}) \quad (6)$$

<sup>18</sup>The NBP inflation target for the end of 2001 was 6-8%. Initially the target for the end of 2002 was  $5.0\% \pm 1\text{pp}$ , but in June 2002 it was changed to  $3.0\% \pm 1\text{pp}$ . The target for the end of 2003 r. was 2-4%.

<sup>19</sup>The strategy of the National Bank of Poland formulates this principle in the following way: "Should some unexpected shocks push inflation outside the permissible volatility band, monetary policy will be aimed at reinstating it and bringing it closer to the target over a medium-term time horizon. In such a time horizon, efforts will be made to attain the monetary policy target in a manner assuring minimum production volatility" (NBP 2003, pp. 12-13).

<sup>20</sup>We refer to results presented in the report of the Bureau of Economic Research, NBP Economic Institute on the monetary transmission mechanism in Poland: Demchuk et al. (2012).

Analysing deviations of inflation expectations in the Polish economy from the NBP inflation target in 2001-2013 (Table 8), it occurs that on average inflation expectations of financial sector analysts were very close to the NBP inflation target, while in the case of the remaining groups of economic agents this assessment depends on the measure of expectations we use. However, all the measures under consideration indicate that the highest absolute deviations from the target were observed in the case of consumer inflation expectations, while the lowest – in the case of financial sector analysts. Absolute deviations of enterprise inflation expectations from the NBP inflation target were slightly larger than deviations of financial sector analysts’ inflation expectations.

Table 8: Deviations of inflation expectations from the NBP inflation target

Category	Data source, measure	Deviation from the target [3]					
		Average			Average in absolute terms		
		TAR_A	TAR_IP	TAR_HP	TAR_A	TAR_IP	TAR_HP
Consumer inflation expectations [1]	GUS, objectified	-0.20	-0.16	-0.18	1.03	0.99	1.04
	GUS, subjectified	1.71	1.76	1.73	1.88	1.92	1.99
Enterprise inflation expectations [2]	NBP, main	0.18	0.23	0.21	0.62	0.56	0.62
	NBP, alternative	-0.07	-0.02	-0.04	0.68	0.61	0.66
Financial sector agents infl. expectations [3]	Reuters	-0.07	-0.03	-0.05	0.31	0.27	0.27

Notes: [1] – monthly data, sample:2001:01-2013:08; [2] – quarterly data, sample: 2001:Q1-2013:Q2; [3] – symbols „TAR\_A”/”TAR\_IP”/”TAR\_HP” denote inflation expectations’ deviations from, respectively: inflation target for a given year / interpolated inflation target/ HP-inflation target.

Source: own calculations on the basis of GUS, NBP and Reuters data.

To assess the weight attached by consumers, enterprises and financial sector analysts to the NBP inflation target in the formation of their inflation expectations, we use the Bomfim and Rudebush (2000) approach, estimating the credibility parameter  $\lambda$  in the following equation:

$$\pi_{t+12|t}^e = \lambda \cdot \pi_{t+12}^{tar*} + (1 - \lambda) \cdot \pi_{t-2} + \varepsilon_t \quad (7)$$

where  $\pi_{t+12|t}^e$  denotes inflation expectations formed in  $t$  for the period  $t + 12$ ,  $\pi_{t+12}^{tar*}$  is a given measure of the inflation target for the period  $t + 12$  adjusted for the short-term nature of inflation expectations, while  $\pi_{t-2}$  is the most recent inflation known in the period  $t$ .

According to the estimation results (Table 9), the degree of the NBP credibility is the highest among financial sector analysts – the weight of the central bank inflation target in setting their inflation expectations is between 0.86 and 0.93, depending on the inflation target measure. Polish enterprises’ inflation expectations display lower degree of anchoring – for different measures of the inflation target and inflation expectations it varies between 0.47 and 0.67. Polish consumers do not treat the NBP inflation target as an important benchmark in setting their inflation expectations – the estimated credibility parameter is approximately 0.12 in the case of the objectified measure of inflation expectations and 0.15 in the case of subjectified measures.

Table 9: Anchoring of inflation expectations - estimation results of eq. (7)

Agents	Data source, measure	inflation target measure, $R^2_{adj.}$	weight of inflation target, $\lambda$	weight of current inflation, $1 - \lambda$
Consumers	GUS, objectified	TAR_A	<b>0.12</b>	0.88
		0.84	<b>(0.04)</b>	
		TAR_IP	<b>0.12</b>	0.88
		0.86	<b>(0.06)</b>	
		TAR_HP	<b>0.11</b>	0.89
		0.86	<b>(0.06)</b>	
	GUS, subjectified	TAR_A	<b>0.15</b>	0.85
		0.77	<b>(0.05)</b>	
		TAR_IP	<b>0.15</b>	0.85
		0.78	<b>(0.05)</b>	
		TAR_HP	<b>0.15</b>	0.85
		0.77	<b>(0.05)</b>	
Enterprises	NBP, main	TAR_A	<b>0.62</b>	0.38
		0.63	<b>(0.13)</b>	
		TAR_IP	<b>0.67</b>	0.33
		0.69	<b>(0.11)</b>	
		TAR_HP	<b>0.62</b>	0.38
		0.67	<b>(0.11)</b>	
	NBP, alternative	TAR_A	<b>0.47</b>	0.53
		0.73	<b>(0.10)</b>	
		TAR_IP	<b>0.53</b>	0.47
		0.73	<b>(0.10)</b>	
		TAR_HP	<b>0.50</b>	0.50
		0.84	<b>(0.08)</b>	
Financial sector agents	Reuters	TAR_A	<b>0.86</b>	0.14
		0.95	<b>(0.11)</b>	
		TAR_IP	<b>0.93</b>	0.07
		0.98	<b>(0.04)</b>	
		TAR_HP	<b>0.92</b>	0.08
		0.97	<b>(0.04)</b>	

Notes: Symbol “\*” denotes the use of a constant in the estimated equation. Symbols “TAR\_A”/ “TAR\_IP”/ “TAR\_HP” denote, respectively: inflation target for a given year / interpolated inflation target/ HP-inflation target; “TAR\_...K” – denotes adjusted measure of the inflation target. In the case of subjectified measures of inflation expectations we use perceived inflation instead of current CPI inflation.

Source: own calculations on the basis of GUS, NBP and Reuters data.

Similarly as in the previous tests, the results obtained with quantified measures of consumers’ and enterprises’ inflation expectations are supplemented with the analysis based on balance statistics. We replicate the approach used while assessing inflation expectations errors, i.e. we compare average values of balance statistics of inflation expectations with average inflation target expressed in terms of balance statistics ( $\pi_t^{tar*BS}$ ), calculated in the following way:

$$\pi_t^{tar*BS} = \begin{cases} 1 & \text{if } \pi_t^{tar*} > \pi_{t-12} \\ 0.5 & \text{if } \pi_t^{tar*} = \pi_{t-12} \\ 0 & \text{if } 0 < \pi_t^{tar*} < \pi_{t-12} \\ -0.5 & \text{if } \pi_t^{tar*} = 0 \\ -1 & \text{if } \pi_t^{tar*} < 0 \end{cases} \quad (8)$$

Comparison of balance statistics of expected price change and the inflation target (Table 10) indicates that qualitative opinions of enterprises on price changes during the next 12 months are nearly equal to the NBP inflation target on average. It confirms a high degree of their anchoring, as found with quantified measures of inflation expectations. Also in the case of consumers, the results based on balance statistics are consistent with the analysis presented above. Consumer opinions on future price changes are more optimistic than would result from the inflation target expressed in the similar qualitative way.

Table 10: Balance statistics of inflation expectations and the NBP inflation target

Agents	Data source, measure	Average balance statistic of expected price change	Average inflation target with short-term adjustment expressed in units of balance statistics
Consumers [1]	GUS, balance statistics	0.37	0.51 [TAR_A] 0.48 [TAR_IP] 0.49 [TAR_HP]
Enterprises [2]	NBP, balance statistics	0.49	0.53 [TAR_A] 0.51 [TAR_IP] 0.51 [TAR_HP]

Notes: [1] – monthly data, sample:2001:01-2013:08; [2] – quarterly data, sample: 2001:Q1-2013:Q2; in 2001:Q2-2008:Q2 the balance statistic is calculated using implied fractions of respondents obtained on the basis of individual data, in line with the method described in detail in Annex.

Source: own calculations on the basis of GUS and NBP data.

### 3.4 Transmission of inflation expectations between groups of economic agents

Another empirical issue we analyse concerns the relationship between expectations of different groups of economic agents. In testing it, we refer to epidemiological models (e.g. Carroll 2003, 2006; Döepke et al. 2009, Nunes 2009) that describe the process of the diffusion of information on the basis of models of disease. Models of epidemiological expectations assume that not all economic agents form their own inflation expectations – agents not experienced in analyzing large data sets and macroeconomic forecasting can base their inflation predictions on information provided by the media, updated with a given frequency. Media news concerning inflation prospects are usually based on inflation forecasts of professional experts. They are absorbed by other agents and gradually transformed in their opinions. In the first step we analyse Granger causality between inflation expectations of consumers, enterprises and financial sector analysts. It indicates several ways of transmission of information between groups of economic agents under consideration (Table 11). Financial sector analysts' and enterprises' inflation expectations are Granger causes of consumer inflation expectations (the objectified measure), while consumers' expectations do not influence expectations of the remaining groups. It seems that there exists two-way causality between inflation expectations of enterprises and financial sector analysts indicated in previous research (Łyziak 2012), although in the case of each of the measures of enterprise inflation expectations under consideration one of these causalities becomes statistically insignificant.

Table 11: Granger causality between inflation expectations of consumers, enterprises and financial sector analysts

Hypothesis	Obs.	F-statistic	Prob.
INFE_P_M does not Granger cause INFE_C_OB	49	19.2019	0.0000
INFE_C_OB does not Granger cause INFE_P_M		0.54689	0.5826
INFE_P_A does not Granger cause INFE_C_OB	49	10.5266	0.0002
INFE_C_OB does not Granger cause INFE_P_A		0.49426	0.6134
INFE_FSA does not Granger cause INFE_C_OB	49	3.89365	0.0277
INFE_C_OB does not Granger cause INFE_FSA		1.36223	0.2667
INFE_P_M does not Granger cause INFE_C_SUB	49	2.30275	0.1119
INFE_C_SUB does not Granger cause INFE_P_M		1.08868	0.3456
INFE_P_A does not Granger cause INFE_C_SUB	49	1.10163	0.3413
INFE_C_SUB does not Granger cause INFE_P_A		2.37769	0.1046
INFE_FSA does not Granger cause INFE_C_SUB	49	0.85505	0.4322
INFE_C_SUB does not Granger cause INFE_FSA		0.90530	0.4118
INFE_FSA does not Granger cause INFE_P_M	49	2.10739	0.1337
INFE_P_M does not Granger cause INFE_FSA		2.61019	0.0849
INFE_FSA does not Granger cause INFE_P_A	49	2.77286	0.0734
INFE_P_A does not Granger cause INFE_FSA		2.16322	0.1270

Notes: INFE\_C\_OB – objectified measure of consumer inflation expectations, INFE\_C\_SUB – subjectified measure of consumer inflation expectations, INFE\_P\_M (INFE\_P\_A) – main (alternative) measure of enterprise inflation expectations, INFE\_FSA – financial sector analysts’ inflation expectations.

Source: own calculations on the basis of GUS, NBP and Reuters data.

The next step in analysing links between inflation expectations of various groups of agents is the application of epidemiology models to assess the strength of the links indicated by Granger causality tests. Using quarterly data, we estimate the following equation proposed by Carroll (2003):

$$\pi_{t+4|t}^{e(i)} = \beta_0 + \beta_1 \pi_{t+3|t-1}^{e(i)} + \beta_2 \pi_{t+4|t}^{e(j)} + \varepsilon_t \quad (9)$$

where  $\pi_{t+4|t}^{e(i)} / \pi_{t+4|t}^{e(j)}$  denotes inflation expectations of the  $i$ -th /  $j$ -th group of economic agents for the next 4 quarters. In the case of inflation expectations of financial sector analysts and enterprises, which are likely to simultaneously depend on each other, the equations are estimated as a system.

Estimation results (Table 12) confirm links between inflation expectations of economic agents identified with Granger causality tests.<sup>21</sup> In majority of cases the hypothesis that there is a complete pass-through between expectations of agents under consideration (i.e. the sum of coefficients  $\beta_1$  and  $\beta_2$  equals 1) is not rejected. Epidemiological models enable the assessment of the speed with which inflation expectations of professional forecasters influence expectations of agents less advanced in macroeconomic forecasting.<sup>22</sup> The results presented below suggest that Polish consumers update information on professional inflation forecasts

<sup>21</sup>It seems that the response of inflation expectations of consumers and enterprises to expectations of the remaining groups of economic agents has become bigger with respect to previous evidence (Łyziak 2012). At the same time we are not able to confirm findings based on the sample ending in 2011 suggesting that consumer inflation expectations become closer to financial sector agents’ ones in the periods when inflation is more frequently analysed in mass media, i.e. in the periods of relatively high inflation.

<sup>22</sup>The frequency of updating information on inflation expectations of another group of economic agents is calculated as  $1/\beta_2$ .

every 13 months on average<sup>23</sup>, while in the case of enterprises such frequency is lower and equals 8-9 months.

Table 12: Epidemiology of inflation expectations – estimation results of of eq. (9)

Measure of expectations $\pi_{t+4 t}^{e(i)}$	Measure of expectations $\pi_{t+4 t}^{e(j)}$	$R_{adj}^2$	$\beta_1$	$\beta_2$	F-prob $\beta_1 + \beta_2 = 1$	Frequency of updating (in months)
INFE_C_OB	INFE_FSA	0.76	0.70 (0.10)	0.24 (0.12)	0.34	12.5
INFE_C_OB	INFE_P_M	0.81	0.60 (0.10)	0.32 (0.09)	0.10	9.4
INFE_C_SUB	INFE_P_M	0.82	0.64 (0.12)	0.50 (0.18)	0.00	6.0
INFE_C_OB	INFE_P_A	0.84	0.53 (0.10)	0.42 (0.10)	0.26	7.1
INFE_P_M	INFE_FSA	0.66	0.61 (0.13)	0.40 (0.15)	0.91	7.5
INFE_FSA	INFE_P_M	0.90	0.64 (0.05)	0.31 (0.05)	0.00	9.7
INFE_P_A	INFE_FSA	0.64	0.63 (0.12)	0.34 (0.13)	0.38	8.8
INFE_FSA	INFE_P_A	0.88	0.71 (0.05)	0.26 (0.05)	0.05	11.5

Notes: INFE\_C\_OB – objectified measure of consumer inflation expectations, INFE\_C\_SUB – subjectified measure of consumer inflation expectations, INFE\_P\_M (INFE\_P\_A) – main (alternative) measure of enterprise inflation expectations, INFE\_FSA – financial sector analysts’ inflation expectations.

Source: own calculations on the basis of GUS, NBP and Reuters data.

### 3.5 Direct measures of inflation expectations in the Phillips curve

There are many empirical studies showing the usefulness of direct measures of inflation expectations of various groups of economic agents in estimating the Phillips curve (e.g. Roberts 1997, Forsells and Kenny 2004, 2006, Gerberding 2001, Paloviita 2006, Gorter 2005, Henzel and Wollmersh euser 2006, Nunes 2010), including those based on Polish data (e.g. Kokoszcz y ski et al. 2010).

Referring to studies of this kind, for each of the measures of inflation expectations we estimate the New Keynesian hybrid Phillips curve (Fuhrer and Moore 1995) of the following form:

$$\pi_t^c = \alpha_0 + \alpha_1 \pi_{t+4|t}^{e(i)} + \alpha_2 \pi_{t-4}^c + \alpha_3 x_{t-m} + \alpha_4 e_{t-n}^r + \varepsilon_t \quad (10)$$

where  $\pi^c$  denotes core inflation,  $x$  – the output gap, while  $e^r$  – the real effective exchange rate gap. The output gap and the real exchange rate gap are estimated with the Hodrick-Prescott filter.

Table 13 and Table 14 present estimation results obtained with two different measures of core inflation: the first one excludes foodstuffs and fuels, the second one – foodstuffs and energy. . Inflation expectations of all

<sup>23</sup>Polish consumers update information on professional forecasts less frequently than consumers in the US, where the analogous frequency equals 11 months (Carroll 2006), but more frequently than in the large economies of the European Union (Germany, France, Italy, UK), where it is approximately 18 months (D e pe et al. 2008).

groups of economic agents under consideration are statistically significant and their impact on core inflation is usually stronger than the impact of past inflation. The dynamics of inflation response to changes in inflation expectations is diversified across the analysed groups of respondents and measures of core inflation. However, in the majority of cases, the Phillips curves estimated with direct measures of inflation expectations of Polish enterprises and financial sector analysts, fulfil the dynamic homogeneity property (i.e. the sum of parameters  $\alpha_1$  and  $\alpha_2$  is not statistically different from 1). It means that in the long run, any change in inflation expectations is reflected in the analogous change in inflation itself.

Table 13: Inflation expectations in the hybrid NKPC – estimation results of eq. (10), core inflation measure excluding foodstuffs and fuels

Agents	Data source, measure, lags	$R_{adj}^2$	$\alpha_1$	$\alpha_2$	$\alpha_3$	$\alpha_4$	F-prob $\alpha_1 + \alpha_2 = 1$
Consumers	GUS, objectified, $m = 1, n = 0$	0.79	0.55 (0.08)	0.35 (0.07)	0.47 (0.13)	-0.05 (0.02)	0.02
	GUS, subjectified, $m = 2, n = 0$	0.84	0.33 (0.04)	0.32 (0.05)	0.42 (0.07)	-0.05 (0.02)	0.00
Enterprises	NBP, main, $m = 2, n = 1$	0.81	0.43 (0.08)	0.41 (0.07)	0.79 (0.14)	-0.05 (0.03)	0.00
	NBP, alternative, $m = 1, n = 0$	0.71	0.33 (0.11)	0.58 (0.08)	1.10 (0.20)	-0.11 (0.03)	0.12
Financial sector agents	Reuters, $m = 1, n = 0$	0.75	0.61 (0.17)	0.33 (0.13)	0.80 (0.20)	-0.08 (0.05)	0.31

Estimation technique: Inflation expectations are measured with error, therefore we use two-stage least squares, (2SLS) in estimating the Phillips curve. We apply the same instruments as in Kokoszcyński et al. (2010), i.e. the constant, lagged inflation expectations and remaining explanatory variables (or their lags). Alternatively, the Phillips curve was estimated with the Generalized Method of Moments (GMM). The results were very similar to those obtained with 2SLS. We do not report them, being aware of the fact that the number of observations at the disposal limits the reliability of GMM outcomes.

Source: own calculations on the basis of GUS, NBP and Reuters data.

Table 14: Inflation expectations in the hybrid NKPC – estimation results of eq. (10), core inflation measure excluding foodstuffs and energy

Agents	Data source, measure, lags	$R_{adj}^2$	$\alpha_1$	$\alpha_2$	$\alpha_3$	$\alpha_4$	F-prob $\alpha_1 + \alpha_2 = 1$
Consumers	GUS, objectified, $m = 2, n = 1$	0.89	0.42 (0.05)	0.36 (0.04)	0.29 (0.09)	-0.03 (0.01)	0.00
	GUS, subjectified, $m = 2, n = 1$	0.87	0.21 (0.04)	0.42 (0.06)	0.60 (0.15)	-0.07 (0.04)	0.00
Enterprises	NBP, main, $m = 1, n = 0$	0.62	0.58 (0.29)	0.49 (0.15)	0.82 (0.22)	-0.15 (0.04)	0.70
	NBP, alternative, $m = 1, n = 0$	0.72	0.60 (0.17)	0.51 (0.08)	0.73 (0.13)	-0.11 (0.04)	0.41
Financial sector agents	Reuters, $m = 2, n = 1$	0.86	0.43 (0.09)	0.32 (0.07)	0.58 (0.08)	-0.05 (0.02)	0.00

Estimation technique: see: Table 13.

Source: own calculations on the basis of GUS, NBP and Reuters data.

## Conclusions

The results of testing various features of consumers', enterprises' and financial sector analysts' inflation expectations presented in this study complement findings from earlier studies on this topic.

Formation of inflation expectations in Poland is diversified among analysed groups of agents, especially in terms of the efficiency with which available information is processed. There is a clear distinction between consumer inflation expectations on the one hand and inflation expectations of financial sector analysts and enterprises on the other hand. It is obvious that consumers and professional forecasters from financial institutions form their expectations in different ways, however it is surprising how small (or even negligible) the differences existing between financial sector analysts' and enterprises' inflation expectations are. Such similarity probably results not only from capacities of enterprises in observing and forecasting changes in the macroeconomic environment on their own, but at least to some extent reflects the fact that enterprises monitor closely inflation expectations of professional forecasters and use them in setting their expectations.

Results on the features of Polish enterprises' inflation expectations presented in this paper are to some extent different from those reported in the existing literature, suggesting a relatively smaller degree of their forward-lookingness and problems with processing available information (Tomczyk 2005). Those differences probably are caused by two factors. Firstly, in this paper we use survey-based measures of enterprise inflation expectations in a precisely defined 12-month horizon, while in the previous studies direct measures of expectations formed for the unclear horizon of the next 3-4 months were used.<sup>24</sup> Secondly, there is an over-representation of big firms in the sample of enterprises whose expectations are monitored in the NBP survey.<sup>25</sup> Although it can be justified by the concentration of macroeconomic processes, such over-representation can bias upwards the assessment of the degree of expectations' accuracy and forward-lookingness, given that analytical capacities of big enterprises are probably more developed than those of small firms.

Inflation expectations in Poland do not fulfil the main requirements of the rational expectations hypothesis; especially they violate the unbiasedness property. It refers to expectations of all groups of economic agents under consideration, but especially to inflation expectations of consumers. However, even if their degree of rationality is relatively small, it is higher than in the past (e.g. Łyziak 2005).<sup>26</sup>

In line with previous studies, this paper shows that the inflation target of the National Bank of Poland has a strong impact on inflation expectations of financial sector analysts and a relatively small impact on consumer inflation expectations. However, those are enterprises whose inflation expectations display the highest degree of anchoring. Combining this observation with the relatively high degree of their forward-lookingness and a

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<sup>24</sup>See e.g. Tomczyk (2007).

<sup>25</sup>See: NBP (2011), p. 53.

<sup>26</sup>There are two variables, i.e. industrial output and oil prices, that in the past were not processed efficiently by consumers (Łyziak 2005), but nowadays, according to the estimates presented in this paper, do not lead to inflation expectational errors.



significant role in affecting actual price dynamics, we can perceive enterprises' inflation expectations as an efficient channel of monetary transmission in Poland.

Direct measures of inflation expectations are useful in modelling inflation in Poland. The results of the estimation of the hybrid New Keynesian Phillips curve show that expectations of each of the groups of economic agents considered are statistically significant in explaining price changes in the Polish economy.

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## Annex: Quantification of the alternative measure of enterprise inflation expectations in Poland

This annex presents the method of quantifying the alternative measure of enterprise inflation expectations in Poland proposed in Łyziak (2012). For the purposes of the present study we do not introduce any modifications to this method.

The main measure of Polish enterprises' inflation expectations is a mixture of the results from quantitative survey question (2001Q1-2008Q2) and the results from quantifying qualitative survey data with the probability method (since 2008Q3). Alternatively, we use another measure of enterprises' expectations. With respect to 2001Q1-2008Q2 it is calculated on the basis of individual quantitative opinions on future inflation. They are translated into implied individual responses to the qualitative survey question and then aggregated. Having the implied distribution of survey responses, we quantify the expected rate of price change with the probability method. In this way we obtain the probability measure of enterprises' inflation expectations for the whole period under consideration.

Quantification of enterprise inflation expectations in 2001Q1-2008Q2 is iterative and involves the following steps, as proposed in Łyziak (2012):

1. For each of the quarters we select starting values  $s_t^0$  and  $l_t^0$  that determine the length of so-called sensitivity intervals, i.e. the intervals of expected inflation that make the respondent declare that “prices will rise at the same rate” or that “prices will stay at their present level”. It is assumed that those intervals are symmetric and surround, respectively, current rate of inflation:  $(\pi_t^0 - s_t; \pi_t^0 + s_t)$  and zero:  $(-l_t; l_t)$ . Starting values  $s_t^0$  and  $l_t^0$  can be set e.g. on the basis of average values of those parameters as resulting from the quantification of enterprises' inflation expectations on the basis of qualitative survey question as used in the NBP's Quick Monitoring since the 3rd quarter 2008.
2. Each individual quantitative response is translated into implied individual response to the qualitative question, according to the following scheme:
  - if the quantitative estimate of expected price change falls within the interval:  $(\pi_t^0 + s_t; +\infty)$ , then the respondent is assumed to claim that: “prices will rise faster than at present”;
  - if the quantitative estimate of expected price change falls within the interval:  $(\pi_t^0 - s_t; \pi_t^0 + s_t)$ , then the respondent is assumed to claim that: “prices will rise at the same rate”;
  - if the quantitative estimate of expected price change falls within the interval:  $(l_t; \pi_t^0 - s_t)$ , then the respondent is assumed to claim that: “prices will rise more slowly”;
  - if the quantitative estimate of expected price change falls within the interval:  $(-l_t; l_t)$ , then the respondent is assumed to claim that: “prices will stay at their present level”;

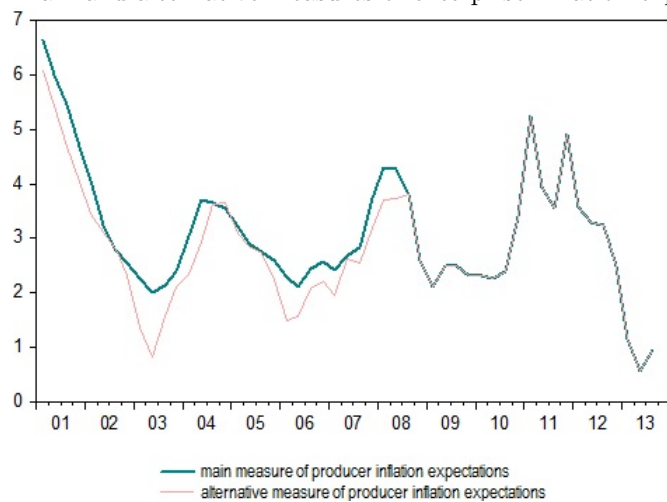
- if the quantitative estimate of expected price change falls within the interval:  $(-\infty; -l_t)$ , then the respondent is assumed to claim that: “prices will go down”.
3. Implied individual qualitative responses are aggregated and expressed in terms of the distribution of responses to the qualitative survey question. The fraction of respondents selecting “do not know” category of response to the quantitative question are adjusted while transforming it to the analogous implied fraction in qualitative question. It is due to the fact that it was sizeably higher when the survey question was quantitative (25% on average in 2001Q1-2008Q2) than when it has been qualitative (12% on average in 2008Q3-2011Q1). This difference is likely to be caused by another form of the survey question – it is observed that when asking agents less specialized in macroeconomic forecasting about their expectations, uncertainty is significantly higher if the survey question is quantitative than if it is qualitative (e.g. Jonung 1986). Therefore we proceed with the following adjustment of the fraction of respondents who asked in the quantitative manner about their expectations selected “do not know” response:
- We refer to consumer survey data<sup>27</sup> to compare the fraction of respondents selecting “do not know” response while responding to qualitative survey question in 2001Q1-2008Q2 (8.7%) and 2008Q3-2011Q1 (8.8%).
  - Having at the disposal an average fraction of enterprises selecting this option of response to the qualitative survey question in 2008Q3-2011Q1 (12.1%) and assuming that the proportions of average uncertainty in both periods should be the same for consumers and enterprises, we conclude that the implied fraction of enterprises selecting the response “do not know” in the qualitative question in the first of periods should have been approximately 11.9%.
  - The remaining part of the actual fraction of respondents selecting the response “do not know” while responding to the quantitative question (approximately 13%) is divided among the implied fractions of respondents in qualitative survey question proportionally to its levels based on the aggregation of responses.
4. Having the implied distribution of responses to the qualitative survey question, we quantify the expected rate of inflation with the probability approach assuming its normal distribution in the population and inflation perception equal to the current CPI inflation. As a result, we obtain the mean of the distribution, its standard deviation as well as sensitivity interval parameters  $s_t^{pr}$  and  $l_t^{pr}$ .
5. Parameters  $s_t^{pr}$  and  $l_t^{pr}$ , likely to be different from their initial values assumed in the step 1, are used as initial values.
6. Steps 2-5 of the above quantification method are repeated till the convergence between starting values of sensitivity interval parameters and their values quantified is achieved.

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<sup>27</sup>In the method proposed in Lyziak (2012) the GfK Polonia survey data were used.

Figure 3 presents the resulting alternative measure of enterprises' inflation expectations jointly with the main measure. Both measures behave in a similar way in terms of tendencies; however the alternative measure is usually lower than the main one. Differences between both series are particularly large in periods of relatively low inflation and inflation expectations.

Figure 3: Main and alternative measures of enterprise inflation expectations



Source: own calculations on the basis of GUS and NBP data.