Inflation Expectations Measurement and its Effect on Inflation Dynamics in Colombia

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Abstract

Accurate measurement of inflation expectations is crucial due to its significant impact on inflation dynamics and the potential for biased estimates when using different measurement methods. The main objective of this study is to determine whether the effect of inflation expectations on inflation dynamics in Colombia depends on the measurement method employed. We achieve this by estimating New-Keynesian Phillips Curves using various measurement methods for inflation expectations employing data from financial markets, economic surveys, and macroeconomic models. Our analysis focuses on any differences in the statistical significance and magnitude of the effects of inflation expectations on inflation dynamics using different measurement methods. Our results reveal that while all measures of inflation expectations have a statistically significant effect, the magnitude of the effect varies depending on the measurement method employed. Specifically, market-based expectations have a more substantial effect on inflation dynamics compared to survey-based and model-based expectations.

JEL classification: C26, D84, E12, E31.

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1. Introduction

Inflation expectations represent a critical factor influencing monetary policy and economic stability, as they affect the decisions of households, businesses, and investors regarding consumption, investment, and pricing. Empirical studies, such as those by Mankiw *et al*. (2003), Svensson (1997), Gürkaynak *et al*. (2005), and Coibion and Gorodnichenko (2015), have emphasized the importance of inflation expectations in determining actual inflation rates, guiding central banks' policy decisions, and impacting the real economy. Given the significance of inflation expectations in monetary policy and economic stability, accurate measurement of this variable is essential, since employing different measurement methods can lead to biases that affect estimates of inflation dynamics (Lindé, 2005; Rudd and Whelan, 2005).

The literature on inflation expectations consistently shows that this component matters when explaining inflation dynamics. Almost all empirical studies that have estimated inflation rates report a statistically significant effect for inflation expectations. However, and despite the conclusive evidence pointing towards the relevance of expectations, economists don’t really have a precise idea about the magnitude of this effect. Estimates for this variable vary considerably, with studies yielding effects that range from 0.1 to 1.3.

This variation poses significant challenges for central banks, who rely on an increasing number of measures of inflation expectations when conducting policy analysis (Sousa & Yetman, 2016). In considering the various measures, practitioners should ponder the potentially heterogeneous effects of expectations in inflation to avoid unintended policy effects. For example, excessive policy shocks resulting from assessments based on measures that overestimate the effect of expectations might create unnecessary contractions in economic activity and even generate financial risks. Conversely, modest policy responses when using measures that underestimate this effect might prove insufficient in containing episodes of elevated inflation.

In this study, we will show that some of the variation in the effect of expectations on inflation dynamics is explained by differences in the measurement of this variable. We do so by estimating New Keynesian Phillips Curves (NKPC) using measures of expectations from different sources, including financial markets, economic surveys, and

macroeconomic models. We find a heterogeneous effect of expectations on inflation dynamics in Colombia which depends on the measurement of this variable. Particularly, when using financial market data, our results indicate that a one percentage-point (pp) increase in expectations leads to a median expected increment of 0.96 pp in inflation, which diminishes to 0.78 and 0.50 percentage points when using survey-based and model-based expectations, respectively.

These variations plausibly reflect fundamental differences in the formation of expectations that come from different sources, which we relate to asymmetric losses, differences in forecasting costs and information rigidities. Mainly, we argue that financial market participants overshoot their expectations to hedge against future losses resulting from underpredicting inflation. If expectations are anchored, as has been the case in Colombia during the last decades, this overstatement should translate into higher future inflation. We also postulate that, when selecting forecasting methods, not all agents face the same cost, with sophisticated predictors demanding more resources. As such, we expect the use of different forecasting methods across sources to produce varying estimates for expectations in estimations of inflation dynamics. Finally, we argue that staggered information updates about future economic activity leads to disagreements in inflation expectations.

Besides contributing to the literature on inflation dynamics, our paper offers valuable insights for central banks and policymakers. By recognizing the distinctive effect of the various measures of inflation expectations, central banks can implement policy responses to economic shocks that are consistent with the actual impact of expectations on inflation dynamics, thereby enhancing the effectiveness of monetary policy. Furthermore, we discuss possible explanations for the mediating mechanisms behind the differences in the effect of expectations on inflation dynamics, where evidence is quite limited.

The remainder of this study is organized as follows: Section two explains the different measures of inflation expectations used in our study. Section three describes the data. Section four outlines the empirical strategy. Section five presents our results. Section six discusses the differences in the effect of inflation expectations on inflation dynamics in Colombia. Finally, Section seven concludes and analyzes the implications of our findings for monetary policy.

2. Measures of Inflation Expectations in Colombia

The measures of inflation expectations used in our study consist of one-year-ahead expectations that come from financial markets, economic surveys, and macroeconomic models. The market-based measure of expectations is the Breakeven Inflation (BEI) rate, which is calculated as the difference between the yields of nominal and inflation-indexed bonds with equivalent maturities. The BEI rate indicates the expected inflation rate at which an investor is indifferent between holding nominal and inflation-indexed bonds and reflects the compensation that investors require for bearing inflation risk when holding fixed-rate bonds. To overcome limitations associated with separating market expectations from other factors that affect yield curves, our estimations use a BEI rate that filters out inflation and liquidity risk premia[1].

The survey-based measures for expectations come from the Quarterly Survey of Economic Expectations (QSEE) of the Central Bank of Colombia (CBoC), where respondents provide forecasts for macroeconomic variables of interest. The use of surveys eliminates the need to rely on indirect measurements for expectations, such as market-based measures (Adam and Padula, 2011; Henzel and Wollmershäuser, 2008). Moreover, survey respondents usually represent various economic sectors, such as businesses, industry, and consumers. In particular, the QSEE polls agents from finance, retail, industry, transportation, communications, academia, and labor unions. However, relying on forecasts from a diverse group of economic agents leads to subjectivity that could create biases stemming from shocks that affect responses from a particular sector. This hinders the effectiveness of survey expectations in reflecting aggregate changes in inflation expectations (Clements, 2019; Pesaran and Weale, 2006)[2].

Model-based expectations are generated by the 4GM, a semi-structural economic model that reflects key features of the Colombian economy and supports monetary policy analysis at the CBoC. In this model, inflation expectations are endogenously determined by movements in relative prices and affect monetary policy through deviations from their

[1] Our estimations employ a BEI measure for Colombia proposed by Espinosa-Torres *et al*. (2017), which removes inflationary and liquidity risk premia.

[2] Our overall result does not change when we use expectations from specific agents polled in the QSEE, suggesting that there is no bias arising from specific sectors. In fact, Iregui et al. (2021) show that the effect of inflation expectations in Colombia resulting from NKPC estimations does not change when using expectations from different QSEE agents. To facilitate the comparison between measures of inflation expectations from various sources, we decided to show aggregate expectations for the QSEE.

long-term target (González et al., 2020). These expectations are based on systematic empirical relationships and economic theory, constituting a consistent analytical approach toward forecasting inflation. Nonetheless, they are determined by model specifications and assumptions, limiting their ability to reflect changes in factors that affect inflation expectations, such as climate related shocks and variations in commodity prices.

Each measure has its own strengths and limitations, enhancing suitability for specific purposes. Market measures are generally available at a higher frequency, increasing responsiveness to macroeconomic developments. Additionally, their precision is favored by the fact that compensation of inflation-protected securities depends on the quality of the forecast. On the other hand, survey measures are more reliable when markets for inflation-protected securities are underdeveloped or display considerable liquidity risk. Finally, model measures facilitate the analysis of fundamental drivers of inflation, as they are based on systematic empirical relationships and reduce the incidence of transitory shocks that affect actual inflation (Sousa & Yetman, 2016).

Furthermore, these measures employ distinct forecasting methods, which explains some of the variation in the effect of expectations on inflation dynamics. Market expectations are formulated by financial analysts, who have access to dedicated datasets and extensive experience in financial asset trading. Model expectations require economic modelling through time-series, structural models, and Bayesian models that involve specialized econometric methods. Conversely, survey expectations come from agents that lack access to the information and expertise of professional forecasters. Additionally, these measures may be influenced by changes in prices relevant to price-setters and consumers, such as food and energy prices and wages (Mankiw, Reis and Wolfers, 2003; Blanchflower and MacCoille, 2009; Coibion, Gorodnichenko and Kamdar, 2017).

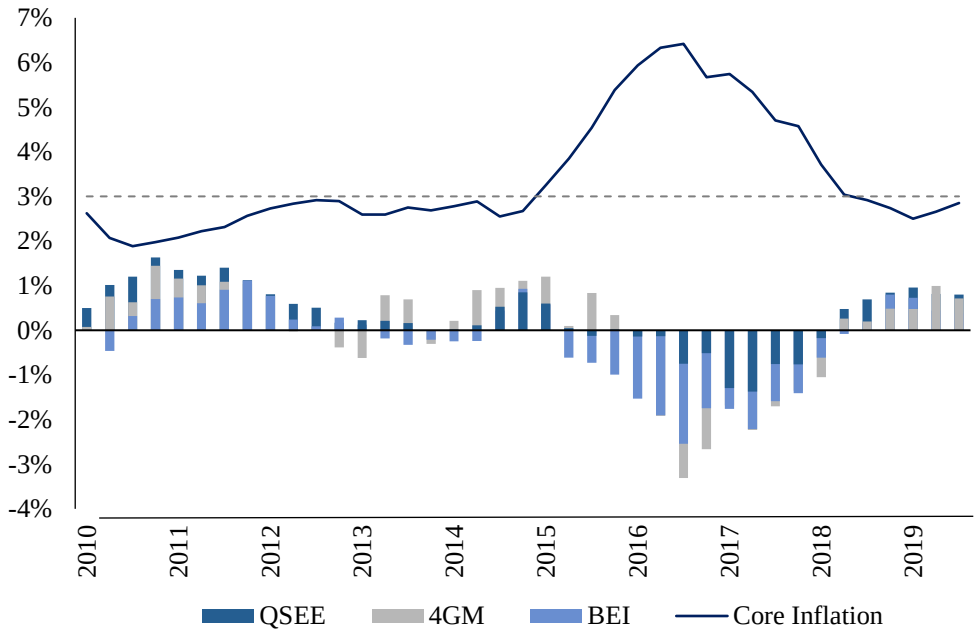
3. Data

The data for inflation expectations in Colombia corresponds to annualized variation in core CPI, which excludes food and energy prices from headline inflation. We also use an alternative measure of core inflation developed by the CBoC, which removes the 15 most volatile prices each period from headline inflation. This minimizes biases arising from possible correlations between expectations and transitory shocks that affect headline inflation (Vargas, 2016). By excluding these volatile components, actual inflation

provides a better signal of the underlying inflationary pressures driven by fundamental factors, bolstering the accuracy of the measures of expectations used in this study. In fact, when we conduct our estimations using headline inflation the forecasting precision of our measures diminishes considerably, undermining our empirical approach. Nonetheless, these measures of core inflation capture between 68% and 88% of the overall variation in headline inflation in Colombia (González et al. 2020), such that changes in expectations would reflect a significant proportion of the effect of this variable on inflation dynamics.

The monetary policy framework in Colombia during our study period, which spans from 2010 to 2019, consisted of an inflation-targeting regime with a flexible exchange rate. During this time, inflation expectations remained anchored fluctuating around the CBoC's long-term target of 3% (Vargas-Herrera, 2016). Figure 1 shows the deviations of the various measures of expectations with respect to actual inflation. Forecast errors averaged one percentage point with disagreements arising during episodes of elevated inflation that were caused by substantial drops in oil prices and climate-related shocks between 2015 and 2017, which deteriorated terms of trade and increased the relative price of food (Gonzalez et al., 2020).

Figure 1. Inflation Expectations Deviations from Core Inflation in Colombia



The measure of core inflation contained in this figure excludes food and energy prices.

The measures of inflation expectations used in our study capture a considerable proportion of the variation of actual inflation. The results of Fisher's test and Pesaran-

Timmerman's test for Colombia using these measures over the period 2009-2019 indicate an overall forecasting accuracy that ranges between 72% and 77% (Iregui et al., 2021)[3].

4. Empirical Strategy

New-Keynesian Phillips Curve

We estimate inflation dynamics through the hybrid NKPC proposed by Galí and Gertler (1999), which states that inflation in each period depends on past inflation[4], inflation expectations, and a measure of real economic activity approximated through real marginal costs or the output gap[5]. This relationship is expressed in Equation [1], where π_t is inflation in period *t*; x_t approximates real economic activity; $E_t\{\pi_{t+1}\}$ represents inflation expectations for the following period, and ε_t is an error-term.

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t\{\pi_{t+1}\} + \lambda x_t + \varepsilon_t \qquad [1]$$

Previous estimates indicate that the NKPC constitutes a reasonable representation of inflation dynamics. Estimates for various countries yield a statistically significant coefficient for expectations and past inflation, with average effects of 0.67 and 0.45 percentage points, respectively[6]. Real economic activity mostly lacks statistical significance and exerts a negligible effect on inflation. Among the studies that have estimated the NKPC for Colombia are Gómez *et al*. (2002), Bejarano (2005), Galvis (2010), and Cháves (2011), which report estimates for inflation expectations ranging from 0.46 to 0.95.

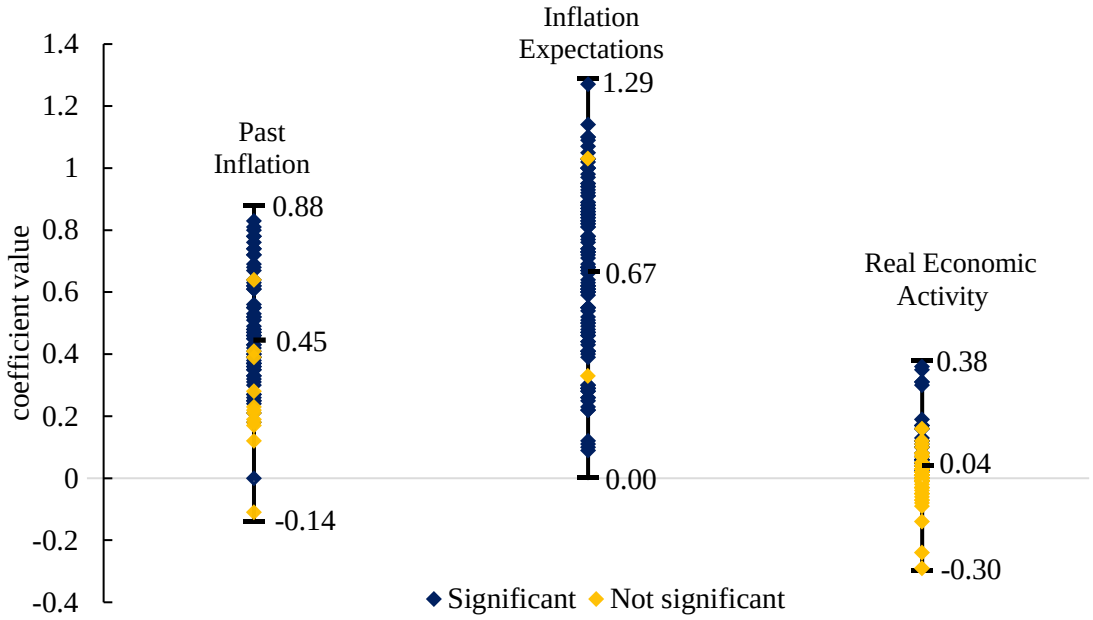
[3] Fisher's test and Pesaran-Timmerman's test are two commonly used statistical tests in the analysis of inflation forecasts. Fisher's test examines if inflation expectations and actual inflation are cointegrated. Pesaran-Timmerman's test examines if the sign of changes in inflation expectations corresponds to the sign of changes in actual inflation.

[4] Galí and Gertler (1999) incorporate past inflation into the NKPC to account for the high degree of inflation persistence observed in inflation dynamics (Galí *et al*., 2005; Stock and Watson, 2007; Pivetta and Reiss, 2007; Nason and Smith, 2008).

[5] According to Galí and Gertler (1999), using the output gap to approximate real economic activity results in measurement error because potential output is unobservable. Instead, they propose using real marginal costs arguing that this variable can be directly measured and reflects inflationary pressures in the economy by considering the markup set by firms operating in a monopolistically competitive market. This allows for more accurate measurement of the relationship between real economic activity and inflation.

[6] These values correspond to the average of estimates reported by empirical studies that estimate the NKPC.

Figure 2. Estimates for NKPC (1949-2016).



Note: this figure summarizes a literature review regarding estimations of the NKPC between 1949 and 2016. For each component of the NKPC (e.g., past inflation, inflation expectations, and real economic activity) we indicate the median value of the coefficient and its statistical significance at a 95% confidence level. We examined 19 studies which report a total of 121 estimates for inflation expectations, 83 for past inflation, and 120 for real economic activity. These vary according to the estimation method, country sample, measurement of inflation expectations and real economic activity, and empirical specification (see Annex 1).

Generalized Method of Moments (GMM) Estimation

Our estimations employ the GMM, which mitigates endogeneity that potentially arises from measurement error or reverse causality by including instruments that are highly correlated with inflation expectations but lack correlation with the error term. Measurement error could arise because inflation expectations are either difficult to measure or not directly observable. Reverse causality is explained by the fact that persistent shocks to inflation could alter expectations, complicating identification of a causal effect. Our choice of instruments consists of 2-6 lags of inflation, the output gap, and interest rates, including combinations of these instruments. Table 1 describes the variables and instruments used in our NKPC estimations.

Table 1. Variables Description.

Variable	Measure	Frequency	Calculation
Actual inflation*	Annualized core inflation	Monthly	i) Headline inflation excluding food and energy prices. ii) Headline inflation excluding the 15 most volatile prices each period.
Survey-based expectations	Inflation expectations in the QSEE	Quarterly	Forecast among respondents of a quarterly economic survey.
Market-based expectations	Breakeven Inflation Rate	Daily	BEI: difference between the prices of fixed nominal rate government bonds and inflation-indexed government bonds with equivalent maturities.
Model-based expectations	Inflation expectations from the 4GM	Quarterly	Inflation expectations endogenously determined in a macroeconomic model for the Colombian economy.
Real marginal costs	Labor share of income	Quarterly	Ratio of real wages to GDP, multiplied by the marginal product of labor[7].
Output gap*	Deviation of quarterly real GDP from its long-term trend	Quarterly	Cyclical component of real GDP using the Hodrick-Prescott filter.
Interest rate*	Central Bank Policy Rate	Daily	Interest rate on short-term loans between banks.

1) *Indicates variables that are used as instruments in our GMM estimations.
2) Daily and monthly data are converted into quarterly variables using the mean value for each quarter.

Specification Checks

We performed several checks to ensure that any differences we detect in the effect of expectations are not related to the validity of our instruments, differences in explanatory power, or variations in forecast precision across measures. Our first check consisted of Hansen's Over-Identification (OI) test, which tests for correlation between regressors and the error term (i.e., endogeneity). Second, we analyzed the goodness-of-fit of our estimations by comparing the median r-squared and median root-mean-squared error of our estimations. Finally, we examined forecasting accuracy through Fisher's test (FT) and Pesaran and Timmerman's test (PT). In total, we performed 360 checks using the abovementioned criteria: 120 for each measure of expectations using two measures of

[7] We use the same value for the marginal product of labor that was used in Bejarano (2005).

core inflation, two measures of real economic activity, and 2-6 lags for six different sets of instruments.

Table 2. Specification Checks Using Different Measures of Inflation Expectations.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
BEI	95.8%	0.936	0.334	0.000	0.000	115
QSEE	90.0%	0.952	0.265	0.000	0.000	108
4GM	98.3%	0.961	0.261	0.000	0.000	118
Mean/Total	**94.7%**	**0.952**	**0.286**	**0.000**	**0.000**	**341**

(1) Specifications that accept OI test null hypothesis

(2) Median r-squared

(3) Median root-mean-squared error

(4) P-value FT test

(5) P-value PT test

(6) Estimations

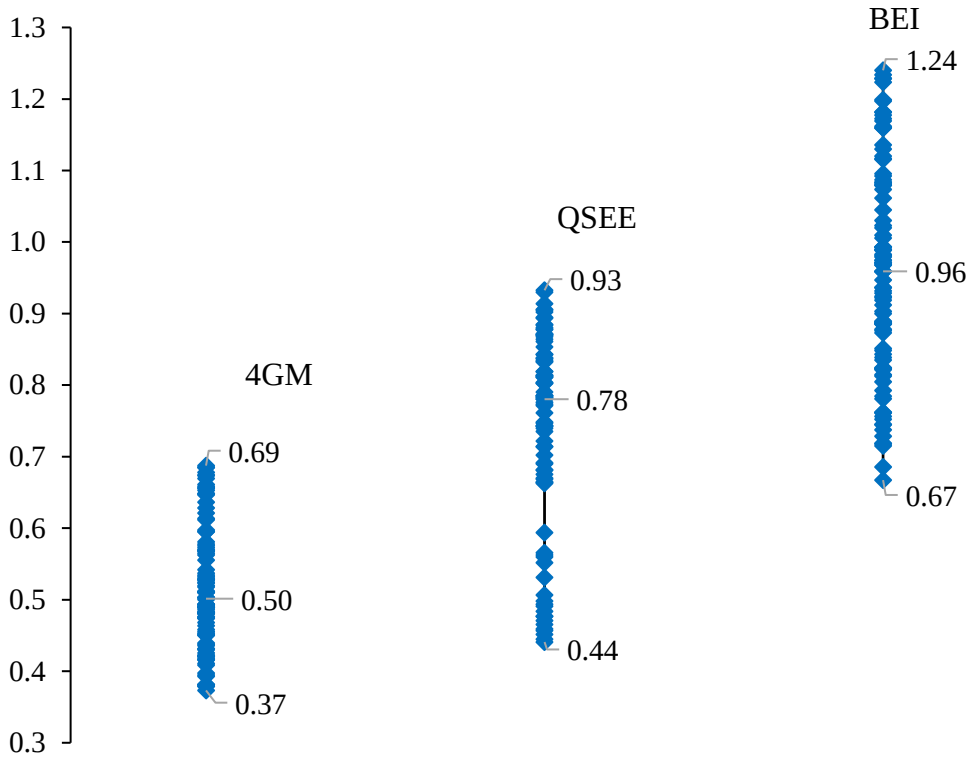
1) The null hypothesis for Hansen's OI test states that there is no correlation between regressors and the error term. Non rejection of the null hypothesis implies that the proposed model does not exhibit endogeneity.
2) The FT test examines whether expectations and actual inflation are co-integrated. The PT establishes if the sign of changes in expectations corresponds to the sign of changes in actual inflation. A rejection of the null hypothesis in either test implies that the measure of expectations being tested correctly predicts changes in inflation.

According to the results of these checks, all specifications used valid instruments, exhibited high explanatory power, and attained acceptable forecasting accuracy. As shown in column (1) of Table 2, we accepted the null hypothesis of joint validity of instruments in at least 90% of our proposed empirical specifications, with an overall acceptance rate of 94.7%. Moreover, columns (2) and (3) show that our estimations yield an expected median r-squared of 95% and similar root mean-squared errors, indicating high explanatory power and equivalent prediction errors across measures. Likewise, in columns (4) and (5) our models display equivalent forecasting accuracy, as we rejected the null hypotheses for the FT and PT tests for all measures. Hence, we conclude that any differences we observe in the magnitude of estimates plausibly capture fundamental differences in the formation of expectations that come from different sources. Upon removing specifications that lack valid instruments, we have a total of 341 estimations, as indicated in column (6).

5. Results

To facilitate the presentation of our results, we removed extreme values representing a combined 8% of our sample. Specifically, we trimmed two symmetric tails (4% on each side) of the distributions corresponding to the estimates of the different measures of inflation expectations. Additionally, we discarded estimates (7 in total) that lacked statistical significance. Hence, our sample dropped from 341 to 304, which represents 89% of the original estimates sample[8]. Figure 3 presents our findings, which include 304 NKPC estimates for inflation expectations.

Figure 3. NKPC Estimates of Inflation Expectations in Colombia



Note: each point represents an estimate for inflation expectations using different measures of core inflation, real economic activity, and instrumental variables. There are a total of 304 estimates: 108 for 4GM; 91 for QSEE; and 105 for BEI. For each measure of expectations, Figure 3 indicates the maximum, minimum and median value of estimates. All estimates for inflation expectations in this figure exhibit statistical significance at a 95% confidence level.

Our findings indicate that expectations exert a statistically significant effect on inflation in Colombia and that estimates for this variable range between 0.37 and 1.24, which is

[8] Our findings do not change due to this restriction, and we have included the original sample and results in Annex 2.

consistent with the empirical evidence shown in Figure 2.[9] Furthermore, the size of the effect depends on the measurement of this variable. Mainly, when we consider market-based measures, a one percentage point increase in expectations leads to an expected median increment in actual inflation of 0.96 percentage points, while survey and model-based expectations yield median effects of 0.78 and 0.50 percentage points, respectively.

These differences are statistically significant according to the results of a Kolmogorov-Smirnov (KS) test for equivalence of distributions, which compares the distributions of estimates resulting from NKPC estimations using the different measures of core inflation, real economic activity, and inflation expectations discussed in our study[10]. The results of the KS test are presented in Table 3, which shows the KS test statistics and their corresponding p-values in parenthesis. These indicate that the distributions resulting from the use of different measures of inflation expectations in NKPC estimations in Colombia are statistically different, allowing us to conclude that the effect of this variable depends on its measurement.

Table 3. Kolmogorov-Smirnov Test for Equivalence of Distributions.

	4GM	**BEI**
BEI	0.981 (0.000)	
QSEE	0.715 (0.000)	0.607 (0.000)

Note: the null hypothesis of the Kolmogorov-Smirnov (K-S) test states that the two samples tested belong to the same distribution. Rejection of the null hypothesis indicates that the two samples belong to different distributions. At a 95% confidence level, the null hypothesis is rejected when the p-value is lower than 0.05.

6. Discussion

The observed statistical differences in the effect of inflation expectations on inflation dynamics in Colombia among various sources could be explained by asymmetric losses

[9] According to the information shown in Figure 3, the coefficient for inflation expectations should lie between 0.1 and 1.3 and should be statistically significant.

[10] The K-S test calculates the maximum difference between the cumulative distribution functions (CDFs) of the two samples to determine whether two samples of data come from the same distribution. The larger the difference, the more likely it is that the two samples come from different distributions.

from forecasting errors, differences in forecasting costs, lags in information dissemination across economic agents, and modelling limitations.

Financial market analysts are compensated based on the quality of their forecasts since real returns on government bonds depend on uncertain values of future inflation (Schuh, 2001). Given that higher than anticipated inflation can result in negative real returns, these agents bear a higher cost of underpredicting inflation. To hedge against inflationary risk, investors overshoot their expectations, which creates an upward bias when using market-based measures (Capistran & Timmerman, 2009).

When selecting forecasting methods, not all agents face the same cost, with specialized predictors demanding more resources (Brock & Hommes, 1997). Economic modelling requires dedicated staff and training, while trading of financial assets involves access to specialized data. Consumers and firms typically lack the extensive knowledge and expertise that professional forecasters and economists have (Sousa & Yetman, 2016). These agents predominantly form their expectations based on price indexation –to past inflation– or forecasts from specialized agents, albeit with a certain lag (Caroll, 2003). These cost variations prompt agents to select distinct forecasting methods (Branch, 2004), producing varying effects for expectations.

Disagreement in expectations could also be explained by staggered information updates regarding future economic activity (Mankiw et al., 2003). According to Mankiw & Reis (2002), these information rigidities arise due to costs of collecting and processing information, such that certain agents employ outdated information when forming expectations. Not surprisingly, especially considering their access to specialized datasets, financial analysts constantly monitor and update their expectations based on macroeconomic developments (Sousa & Yetman, 2016). Conversely, less sophisticated agents gradually acquire information from specialized forecasters by occasionally reading news reports (Caroll, 2003).

Finally, model-based expectations are determined by specifications and assumptions derived from economic theory and systematic empirical relationships. In Colombia, the 4GM assumes a monetary policy regime where the central bank reacts to deviations of inflation expectations from their long-term target. However, economic shocks that cause these deviations are limited in their ability to reflect changes in economic factors that

affect inflation expectations, such as changes in commodity prices and climate-related shocks (see Figure 1). This limitation reduces the correlation between actual inflation and expectations, resulting in comparatively smaller estimates in NKPC.

7. Conclusion

Our study provides empirical evidence showing that the effect of inflation expectations on inflation dynamics in Colombia depends on the measurement of this variable. We found varying effects of expectations in NKPC estimations, with the size of the coefficient ranging between 0.37 and 1.24, in line with the existing empirical evidence. Market-based measures exhibit comparatively greater effects on inflation dynamics: a one percentage point increase in expectations leads to an expected median increment in actual inflation of 0.96 percentage points, while survey and model-based expectations yield median effects of 0.78 and 0.50 percentage points, respectively. Our findings are consistent with the existing empirical evidence on the effect of expectations and our results are robust to the use of alternative measures of core inflation and real economic activity. Possible explanations for the statistical differences we observe in the effect of expectations on inflation relate to asymmetric losses, variations in forecasting costs, information rigidities, and economic modelling limitations.

Inflation expectations play a critical role in determining inflation dynamics. Therefore, it is crucial for central banks to consider differences in the effect of this variable associated with the use of different measures. By recognizing their distinct effects, practitioners can implement policy changes that are consistent with the actual impact of expectations on inflation rates, thereby enhancing the effectiveness of monetary policy.

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Annex 1. New Keynesian Phillips Curve Estimations – Literature Review.

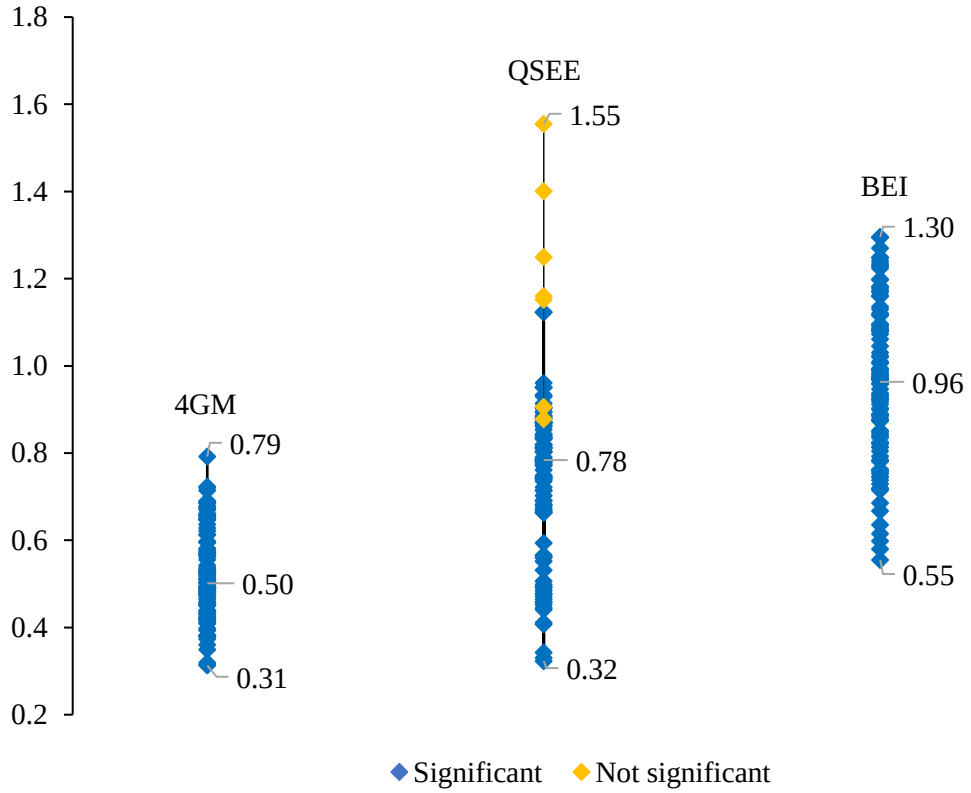
Country	Period	Inflation Expectations	Real Economic Activity	Estimation Method	NKPC	Study
Germany	1993-2004	Survey	Output gap	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1970-1999	Survey	Output gap	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1970-1999	Survey	Real marginal costs	GMM	Hybrid	Jondeau and Le Bihan (2005)
Eurozone	1993-2004	Survey	Real marginal costs	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1970-1999	Survey	Real marginal costs	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1970-1999	Survey	Output gap	GMM	Hybrid	Jondeau and Le Bihan (2005)
Argentina	1993-2003	Model	Output gap	GMM	Hybrid	D'Amato and Garegnani (2009)
	1993-2003	Model	Output gap	GMM	Hybrid	D'Amato and Garegnani (2009)
	1993-2003	Model	Output gap	GMM	Hybrid	D'Amato and Garegnani (2009)
Bolivia	2006-2014	Survey	Output gap	GMM	Hybrid	Murillo (2014)
Brazil	2002-2012	Model	Real marginal costs	GMM	Standard	Arruda *et al*. (2018)
	2002-2012	Model	Real marginal costs	GMM	Hybrid	Arruda *et al*. (2018)
	2002-2012	Survey	Real marginal costs	GMM	Standard	Arruda *et al*. (2018)
	2002-2012	Survey	Real marginal costs	GMM	Hybrid	Arruda *et al*. (2018)
	2002-2012	Model	Output gap	GMM	Standard	Arruda *et al*. (2018)
	2002-2012	Model	Output gap	GMM	Hybrid	Arruda *et al*. (2018)
	2002-2012	Survey	Output gap	GMM	Standard	Arruda *et al*. (2018)
	2002-2012	Survey	Output gap	GMM	Hybrid	Arruda *et al*. (2018)
Canada	1963-2000	Survey	Real marginal costs	GMM	Hybrid	Nason and Smith (2008)
	1963-2000	Survey	Real marginal costs	OLS	Hybrid	Nason and Smith (2008)
Chile	2002-2006	Survey	Output gap	GMM	Hybrid	Medel (2015)
	2002-2006	Survey	Output gap	GMM	Hybrid	Medel (2015)
Colombia	1984-2002	Model	Real marginal costs	GMM	Standard	Bejarano (2005)
	1984-2002	Model	Real marginal costs	GMM	Hybrid	Bejarano (2005)
	2003-2009	Survey	Output gap	GMM	Hybrid	Cháves (2011)
	2003-2009	Model	Output gap	GMM	Hybrid	Cháves (2011)

Country	Period	Inflation Expectations	Real Economic Activity	Estimation Method	NKPC	Study
	1990-2006	Model	Real marginal costs	GMM	Standard	Galvis (2010)
	1982-2001	Model	Output gap	GMM	Hybrid	Gómez *et al.* (2002)
United States	1968-2003	Survey	Output gap	OLS	Hybrid	Adam and Padula (2011)
	1968-2003	Survey	Marginal costs	OLS	Hybrid	Adam and Padula (2011)
	1968-2003	Survey	Output gap	OLS	Standard	Adam and Padula (2011)
	1968-2003	Survey	Marginal costs	OLS	Standard	Adam and Padula (2011)
	1968-2000	Survey	Real marginal costs	GMM	Standard	Brissimis and Magginas (2008)
	1968-2000	Survey	Real marginal costs	GMM	Hybrid	Brissimis and Magginas (2008)
	1968-2000	Survey	Real marginal costs	GMM	Standard	Brissimis and Magginas (2008)
	1968-2000	Survey	Real marginal costs	GMM	Hybrid	Brissimis and Magginas (2008)
	1968-2006	Survey	Real marginal costs	GMM	Standard	Brissimis and Magginas (2008)
	1968-2006	Survey	Real marginal costs	GMM	Hybrid	Brissimis and Magginas (2008)
	1960-1997	Survey	Real marginal costs	GMM	Hybrid	Galí and Gertler (1999)
	1960-1997	Survey	Real marginal costs	GMM	Standard	Galí and Gertler (1999)
	1960-1997	Survey	Output gap	GMM	Hybrid	Galí, Gertler and López-Salido (2005)
	1960-1997	Survey	Real marginal costs	GMM	Hybrid	Galí, Gertler and López-Salido (2005)
	1960-1997	Model	Real marginal costs	GMM	Hybrid	Galí, Gertler and López-Salido (2005)
	1960-1997	Model	Output gap	GMM	Hybrid	Galí, Gertler and López-Salido (2005)
	1960-1997	Model	Real marginal costs	GMM	Hybrid	Galí, Gertler and López-Salido (2005)
	1960-1997	Model	Output gap	GMM	Hybrid	Galí, Gertler and López-Salido (2005)
	1993-2004	Survey	Output gap	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1970-1999	Survey	Output gap	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1970-1999	Survey	Real marginal costs	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1967-2009	Model	Real marginal costs	GMM	Standard	Mazumder (2011)
	1967-2009	Survey	Real marginal costs	GMM	Standard	Mazumder (2011)
	1967-2009	Model	Real marginal costs	GMM	Hybrid	Mazumder (2011)
	1967-2009	Survey	Real marginal costs	GMM	Hybrid	Mazumder (2011)
	1949-2001	Survey	Real marginal costs	GMM	Hybrid	Nason and Smith (2008)
	1949-2001	Survey	Real marginal costs	OLS	Hybrid	Nason and Smith (2008)
	1968-2005	Survey	Output gap	OLS	Hybrid	Zhang *et al.* (2009)
	1968-2005	Model	Output gap	GMM	Hybrid	Zhang *et al.* (2009)
	1998-2005	Survey	Output gap	GMM	Hybrid	Zhang *et al.* (2009)
	1968-1999	Survey	Output gap	GMM	Hybrid	Zhang *et al.* (2009)
	1960-2005	Survey	Output gap	GMM	Hybrid	Zhang *et al.* (2009)
France	1993-2004	Survey	Output gap	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Standard	Henzel and Wollmershaeuser (2006)

Country	Period	Inflation Expectations	Real Economic Activity	Estimation Method	NKPC	Study
	1993-2004	Survey	Output gap	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1970-1999	Model	Output gap	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1970-1999	Model	Real marginal costs	GMM	Hybrid	Jondeau and Le Bihan (2005)
Italy	1993-2004	Survey	Output gap	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1970-1999	Model	Output gap	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1970-1999	Model	Real marginal costs	GMM	Hybrid	Jondeau and Le Bihan (2005)
Peru	2004-2016	Model	Output gap	OLS	Hybrid	Mendoza and Perea (2017)
United Kingdom	1993-2004	Survey	Output gap	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	OLS	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Standard	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Real marginal costs	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1993-2004	Survey	Output gap	GMM	Hybrid	Henzel and Wollmershaeuser (2006)
	1987-2007	Survey	Output gap	OLS	Hybrid	Jean-Baptiste (2012)
	1987-2007	Survey	Real marginal costs	OLS	Hybrid	Jean-Baptiste (2012)
	1987-2007	Survey	Real marginal costs	GMM	Hybrid	Jean-Baptiste (2012)
	1987-2007	Survey	Real marginal costs	GMM	Hybrid	Jean-Baptiste (2012)
	1970-1999	Survey	Output gap	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1970-1999	Survey	Real marginal costs	GMM	Hybrid	Jondeau and Le Bihan (2005)
	1961-2000	Survey	Real marginal costs	GMM	Hybrid	Nason and Smith (2008)
	1961-2000	Survey	Real marginal costs	OLS	Hybrid	Nason and Smith (2008)

Annex 2. NKPC Estimates of Inflation Expectations in Colombia

(Full sample of Estimates)



Note: each point represents an estimate for inflation expectations using different measures of core inflation, real economic activity, and instrumental variables. There are a total of 341 estimates: 118 for 4GM; 108 for QSEE; and 115 for BEI. For each measure of expectations, this figure indicates the maximum, minimum and median value of estimates. All estimates for inflation expectations (except 7 estimates for QSEE) exhibit statistical significance at a 95% confidence level.