Inflation Expectations Measurement and its Effect on Inflation Dynamics in Colombia

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.

Keywords: inflation expectations measurement, inflation dynamics, New-Keynesian Phillips Curve, Generalized Method of Moments.

1. Introduction

Inflation expectations play a crucial role in monetary policy and economic stability, as they influence 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).

Inflation expectations can be measured through financial market data, economic surveys, or macroeconomic models, with each method potentially producing different effects on inflation dynamics. The existing empirical evidence shows that the size of the effect of inflation expectations on inflation dynamics ranges from 0.1 to 1.2. In Colombia, where our data originates, estimates range between 0.46 and 0.95, despite using similar data and estimation methods. Although the exact mechanisms behind the differences in the effect of inflation expectations on inflation dynamics are yet to be fully understood, it is expected that some of these variations arise from differences in the measures of inflation expectations.

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 (NKPC) employing different measurement methods for inflation expectations using quarterly data from financial markets, economic surveys, and macroeconomic models. Our study period is 2010-2019 and our analysis concentrates on 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.

Besides adding to the existing literature on the role of inflation expectations in understanding inflation dynamics, our paper offers valuable insights for central banks and policymakers. By recognizing the distinct effects of 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.

The remainder of this study is organized as follows: Section two explains and compares the different measurements of inflation expectations used in our analysis. Section three describes the data used in our estimations. Section four outlines the empirical strategy used to estimate the effect of inflation expectations on inflation dynamics. Section five presents the results, including robustness checks using alternative measures of core inflation and real economic activity. Finally, Section six provides concluding remarks and discusses the implications of our findings for monetary policy.

2. Measuring Inflation Expectations

The market-based measure of inflation expectations is the break-even inflation (BEI) rate, which is calculated as the difference between the yields of nominal government bonds and inflation-indexed bonds with equivalent maturities. The BEI rate reflects the average inflation rate at which an investor is indifferent between holding nominal bonds and inflation-indexed bonds over a specific period. To overcome limitations associated with separating inflation expectations from other factors affecting the yields of government bonds and inflation-indexed bonds, such as inflationary risk and liquidity premia, our estimations employ a BEI measure for Colombia estimated by Espinosa-Torres *et al*. (2017), which removes these additional components.

Model-based expectations are obtained from macroeconomic modeling through time-series, structural models, and Bayesian models, which rely on systematic empirical relationships and economic theory. Although they represent a consistent analytical approach toward forecasting inflation, they are determined by model specifications and assumptions, limiting their ability to reflect changes in factors that affect inflation expectations, such as climate and commodity price shocks, is limited.

Survey-based expectations are obtained from polls in which respondents provide forecasts for macroeconomic variables of interest, eliminates the need to rely on indirect

measurements for expectations, such as market-based or model-based measures (Adam and Padula, 2011; Henzel and Wollmershäuser, 2008). Surveys include respondents from various economic sectors, such as businesses, industry, and consumers. However, they rely on opinions from a diverse group of economic agents leading to subjectivity and potential biases that could hinder their effectiveness in reflecting aggregate changes in inflation expectations (Clements, 2019; Pesaran and Weale, 2006).

The differences in the effects of these measures on inflation dynamics can be attributed to the varying sources of information and the unique characteristics associated with each measure, which influence the relationship between inflation expectations and actual inflation. Market-based measures may be more forward-looking and responsive to changes in economic fundamentals and their expected path, as they aggregate the views of market participants who have a financial stake in making accurate forecasts. To hedge against potential losses resulting from unexpected shocks, investors might overshoot their expectations. Conversely, since survey-based expectations reflect views of price-setters, their behavior may be determined by changes in factors relevant to this type of economic agents, such as nominal wages and input costs (Mankiw, Reis and Wolfers, 2003; Blanchflower and MacCoille, 2009; Coibion, Gorodnichenko and Kamdar, 2017). Model-based expectations are constrained by the underlying model's specifications and assumptions, making them less responsive to changes in economic conditions.

3. Data

The data for inflation expectations in Colombia comes from the Central Bank of Colombia (CBoC) and corresponds to inflation expectations over a one-year period. Market-based expectations were obtained from records pertaining to auctions of sovereign debt. Survey-based expectations come from the Quarterly Survey of Economic Expectations (QSEE), conducted by the CBoC among agents from various economic sectors, including finance, retail, industry, transportation, communications, academia, and labor unions. Model-based expectations come from the 4GM, a semi-structural New-Keynesian rational expectations economic model that reflects key features of the Colombian economy and supports monetary policy decisions at the CBoC[1].

[1] In this model, inflation expectations are endogenously determined by movements in relative prices and affect monetary policy through deviations from their long-term target (González et al., 2020).

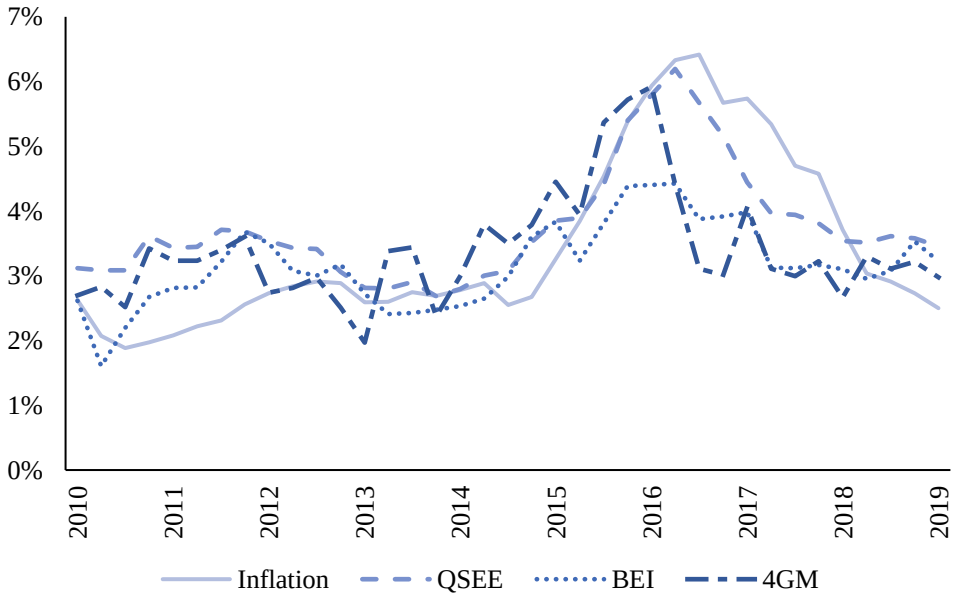
Our measure of inflation consists of core inflation, which excludes volatile components, such as food and energy prices. This minimizes biases arising from the correlation between inflation expectations and exogenous shocks that affected headline inflation during our study period, such as climate-related shocks and commodity price shocks (Vargas, 2016). By excluding these volatile components, core inflation may provide a better signal of the persistent inflationary pressures that are driven by more fundamental factors, such as changes in the labor market or monetary policy, the main components of the NKPC.

The monetary policy framework in Colombia during our study period consisted of an inflation-targeting regime with a flexible exchange rate. During this period, inflation expectations remained anchored, with headline inflation fluctuating around its long-term target of 3% (Vargas *et al*., 2009; Echavarría *et al*., 2011; González *et al*. 2011; López *et al*., 2016). Between 2015 and 2016 the Colombian economy experienced exogenous shocks that led to episodes of elevated inflation. These were caused by climate-related events that affected the relative price of food, coupled with a substantial drop in oil prices that deteriorated the country's terms of trade. Nonetheless, inflation expectations remained anchored around the central bank's long-term target (Vargas-Herrera, 2016; González *et al*., 2020).

According to Iregui *et al*. (2020), the measures of inflation expectations used in this study exhibit similar predictive capacity. The results of Fisher's test and Pesaran-Timmerman's test for Colombia over the period 2009-2019 using quarterly data show that these measures exhibit an accuracy that ranges between 72% and 77% when predicting the direction of changes in actual inflation[2]. Hence, the measurements of inflation expectations used in our estimations of the NKPC should capture a considerable proportion of the variation of actual inflation.

[2] Fisher's test and Pesaran-Timmerman's test are two commonly used statistical tests in the analysis of inflation forecasts. Fisher's test examines whether inflation expectations and actual inflation are cointegrated and tests the null hypothesis that the two series are not cointegrated. On the other hand, Pesaran-Timmerman's test examines the accuracy of inflation expectations by testing whether the direction of change in inflation expectations corresponds to the actual direction of change in inflation. Its null hypothesis is that the inflation expectation and the actual inflation series are independent. A rejection of the null hypothesis in either test implies that the measure of inflation expectations being tested has significant predictive power for inflation.

Figure 1. Inflation Expectations and Core Inflation in Colombia (2010-2019).



4. Empirical Strategy

4.1. New-Keynesian Phillips Curve

We estimate inflation dynamics through the hybrid New-Keynesian Phillips Curve (NKPC) proposed by Galí and Gertler (1999). The hybrid NKPC states that inflation in each period depends on past inflation[3], inflation expectations, and an indicative measure of real economic activity, usually approximated through the output gap or real marginal costs. This relationship is expressed in Equation [1], where π_t is inflation in period *t*; χ_t approximates real economic activity; $E_t\{\pi_{t+1}\}$ represents inflation expectations for the following period.

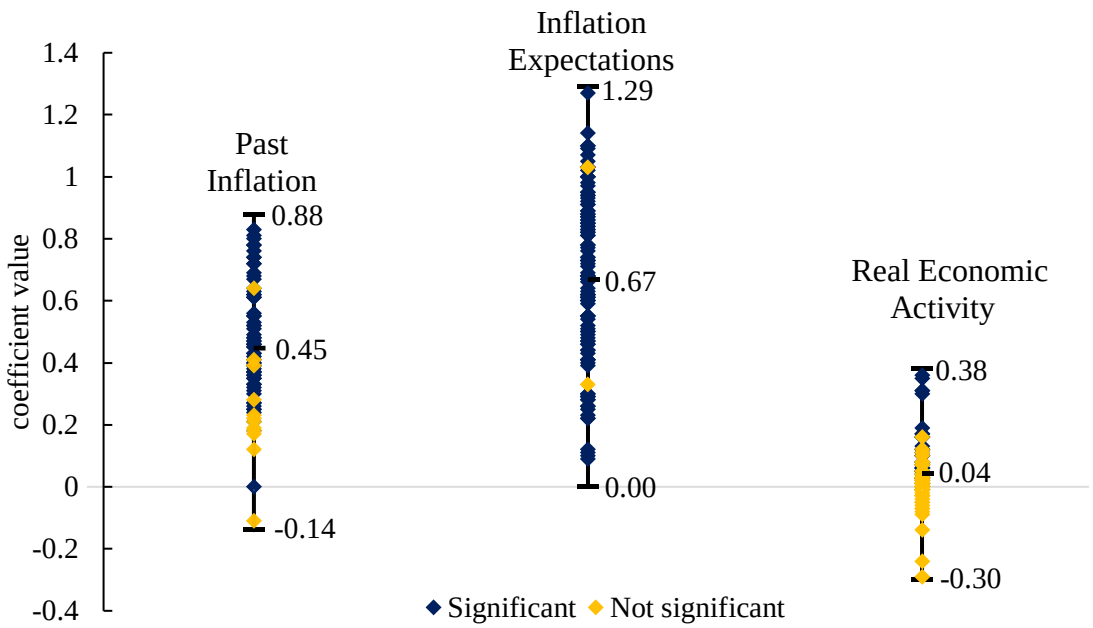
$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t\{\pi_{t+1}\} + \lambda x_t + \varepsilon_t \qquad [1]$$

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[4]. Real economic activity mostly lacks statistical

[3] 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).
[4] These values correspond to the average of estimates reported by empirical studies that estimate the NKPC.

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.

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).

4.2. GMM Estimation

Our estimations employ the Generalized Method of Moments (GMM), which mitigates endogeneity that potentially arises from measurement error or reverse causality. Measurement error could arise because inflation expectations and output gap are either difficult to measure or not observable. Reverse causality is explained by the fact that significant changes in inflation impact expectations regarding the future behavior of this variable. Therefore, we use between 3-6 lags of actual inflation as instruments for inflation expectations[5]. We approximate real economic activity through real marginal cost

[5] We use between 3-6 lags because GMM estimation requires the number of moment conditions (i.e., number of instruments) to be at least as large as the number of parameters to be estimated.

deviations with respect to their long-run trend[6]. Table 1 describes the variables used in our NKPC estimations.

Table 1. Variables Description.

Variable	Measure	Calculation	Definition
Inflation	Core inflation	Quarterly average of core inflation.	Core inflation: annual variation in monthly core CPI.
Inflation Expectations	Survey-based expectations	Average forecast for inflation expectations in the QSEE.	Inflation expectations among respondents of a quarterly economic survey.
	Market-based expectations	Quarterly average of monthly BEI.	BEI: difference between the prices of fixed nominal rate government bonds and inflation-indexed government bonds with equivalent maturities.
	Model-based expectations	Quarterly inflation expectations from the 4GM.	Inflation expectations endogenously determined in a macroeconomic model for the Colombian economy.
Real Economic Activity	Real marginal costs	Quarterly real marginal costs	Real marginal costs: ratio of nominal wages to nominal GDP, multiplied by the marginal product of labor.

Past inflation and real marginal costs have been widely used in previous studies as instruments for inflation expectations in NKPC estimations using GMM, as they are highly correlated with expectations but uncorrelated with the error term, allowing for consistent estimations of model parameters. Furthermore, these instruments can help address the issue of measurement error when approximating real economic activity, since using real marginal costs instead of the output gap can lead to more accurate measurements of the relationship between economic activity and inflation, as argued by Galí and Gertler (1999).

We conducted several tests to ensure that differences in statistical significance or the size of the effect across measures of expectations are not due to variations in the validity or explanatory power of different models or to differences in the accuracy and precision of

[6] According to Galí and Gertler (1999), using the output gap to approximate real economic activity results in measurement errors because potential output is an unobservable variable. Therefore, they propose using real marginal costs instead, arguing that this measure of real economic activity considers the markup set by firms operating in a monopolistically competitive market and thus, the degree of pressure on prices in the economy in each period. This allows for more accurate measurement of the relationship between real economic activity and inflation.

forecasts. The validity of our proposed instruments was checked using Hansen's Over-Identification (O-I) test, which tests the null hypothesis that there is no correlation between regressors and the error term. We also evaluated the goodness-of-fit of our models using r-squared and root-mean-squared error. Additionally, we compared the accuracy and precision of different measures of inflation expectations using Fisher's and Pesaran and Timmerman's tests, which assess the ability of expectations to predict changes in the direction of inflation.

According to the results of the tests, all specifications used appropriate instruments since we accepted the null hypothesis of joint validity of instruments in every case. Moreover, our NKPC estimations yielded an R-squared of at least 89% and similar root mean-squared errors, indicating good model fit across all specifications. Additionally, our models demonstrated equivalent forecasting accuracy, as we rejected the null hypotheses for both Fisher's and Pesaran-Timmerman's tests for all expectations measures.

Table 2. Model Specification Tests Using Different Measures of Inflation Expectations.

	(1)			**(2)**			**(3)**		**(4)**
	Max	Min	Mean	Max	Min	Mean	Fisher	P-T	O-I Test
4GM	0.967	0.956	0.962	0.274	0.237	0.257	0.000	0.000	100%
BEI	0.913	0.890	0.903	0.433	0.391	0.409	0.000	0.000	100%
QSEE	0.956	0.948	0.951	0.298	0.279	0.290	0.000	0.000	100%

(1) R-squared.
(2) Root mean-squared error.
(3) P-value of Fisher and Pesaran-Timmerman's tests of forecast accuracy.
(4) Percentage of model estimations that accept the null hypothesis in Hansen's O-I test.

5. Results

Table 3 presents the results of our analysis, which includes 12 NKPC estimations using three different measures of inflation expectations and four sets of instruments. Consistent with the empirical evidence shown in Figure 2, our findings indicate that inflation expectations have a statistically significant effect on inflation dynamics, and that the size

of the coefficient in Colombia ranges between 0.4 and 1.2.[7] However, the magnitude of the effect varies depending on the measure of expectations. For instance, when we use market-based measures, a one percentage point increase in expectations leads to a proportional increase in actual inflation, while model-based expectations and survey-based expectations yield expected effects of approximately 0.5 and 0.7 percentage points, respectively.

Table 3. Estimates of Inflation Expectations in Colombia Using Different Measures of Inflation Expectations.

Instrument	4GM	QSEE	BEI
3 Lags	0.525	0.664	1.130
	(0.000)	(0.000)	(0.000)
4 Lags	0.555	0.740	1.199
	(0.000)	(0.000)	(0.000)
5 Lags	0.562	0.735	1.229
	(0.000)	(0.000)	(0.000)
6 Lags	0.408	0.743	1.083
	(0.000)	(0.000)	(0.000)

Note: p-values in parenthesis. Instruments correspond to lags of core inflation.

We then performed a Kolmogorov-Smirnov (K-S) test for equivalence of distributions to compare the distributions of the estimates from different estimations of the NKPC using different measures of core inflation, real economic activity, and inflation expectations[8]. The results of the K-S test are presented in Table 4, which shows values for the K-S test statistics and the p-values in parenthesis. We found that, regardless of the measure of expectations used in our estimations, the effect of expectations is statistically significant, although varying in size. Overall, our results suggest that the measurement of inflation expectations affects inflation dynamics in Colombia.

[7] According to Figure 2, the coefficient for inflation expectations in NKPC estimations should range between 0.1 and 1.2 (0.46 and 0.95 in Colombia) and the effect of expectations on inflation dynamics should be statistically significant.

[8] 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.

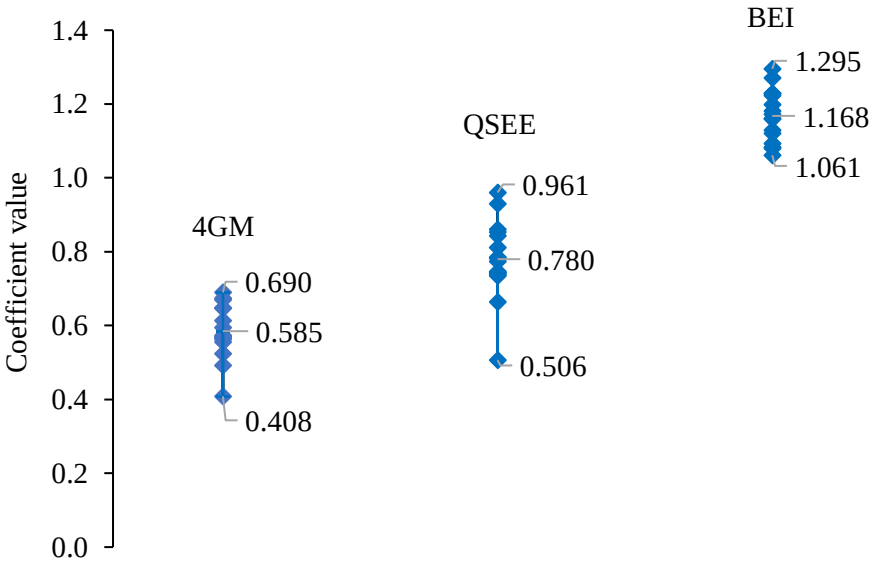
Table 4. K-S Test for Equivalence of Distributions.

	4GM	BEI
BEI	0.937 (0.000)	
QSEE	0.625 (0.004)	0.938 (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.

To assess the robustness of our results, we checked the consistency of our estimates using alternative measures of core inflation and real economic activity. We used an additional measure of core inflation that excludes the 15 most volatile prices in each period, as well as the output gap as a proxy for real economic activity. The output gap is calculated as the deviation of GDP from its long-term trend. By including these measures, we obtained a total of 48 estimates from combining two measures of core inflation, two measures of real economic activity, three measures of inflation expectations, and four sets of instruments for inflation expectations. Figure 3 presents the results of our robustness checks.

Figure 3. Robustness Checks.



Note: each point in Figure 3 represents an estimate for inflation expectations using a specific measure of core inflation, inflations expectations, and real economic activity. There are a total of 48 estimates. For each measure of inflation expectations, Figure 3 indicates the maximum, minimum and average value of estimates. All estimates for inflation expectations are statistically significant at a 95% confidence level.

6. Conclusion

Our study provides empirical evidence indicating that the effect of inflation expectations on inflation dynamics in Colombia depends on the measurement method for this variable. We found that inflation expectations have a statistically significant effect on inflation dynamics, with the size of the coefficient ranging between 0.4 and 1.2, depending on the measure of expectations used. Market-based measures of expectations led to a proportional increase in actual inflation, whereas model-based expectations and survey-based expectations yielded smaller effects of 0.5 and 0.7 percentage points, respectively. Our findings are consistent with existing empirical evidence and are robust to estimations of the NKPC using various measures of core inflation, real economic activity, and inflation expectations.

In Colombia, central bank credibility is high, and expectations have remained anchored since the implementation of the inflation-targeting regime in 1999 (González *et al*., 2020; Vargas *et al*., 2009). This implies that differences in the formation of expectations among economic agents constitute one of the underlying mechanisms explaining the distinctive effect of different measures of inflation expectations on inflation dynamics.

The BEI rate reflects the average inflation rate at which an investor is indifferent between holding nominal bonds and inflation-indexed bonds. To hedge against any losses resulting from unexpected shocks that affect bond yields, investors might overshoot their expectations, explaining the greater effect observed when using market-based measures. Additionally, financial markets constantly revise their expectations based on updated information regarding economic fundamentals, such that changes in market-based expectations reflect broader economic views that impact actual inflation.

Economic surveys reflect views of price-setters, meaning their expectations may be determined by changes in factors that exhibit nominal rigidity, such as wages. This limits the revision of expectations, hindering the correlation between changes in expectations and other macroeconomic factors that affect inflation dynamics. Additionally, previous studies show that in Colombia these agents follow time-dependent price-setting rules (Zarate *et al.*, 2011; Misas *et al*., 2011), plausibly overshooting expectations due to uncertainty regarding the chances of future price adjustments.

Finally, the 4GM assumes a monetary policy regime where the central bank reacts to deviations of inflation expectations from their long-term target, such that changes in expectations reflect model specifications, disregarding changes in macroeconomic factors that affect inflation dynamics. This limitation reduces the correlation between actual inflation and expectations, resulting in comparatively smaller estimates in NKPC.

Inflation expectations play a critical role in determining inflation dynamics. Therefore, it is essential for central banks to consider the potential biases arising from the use of different measures of inflation expectations when designing and implementing monetary policy. By recognizing the distinct effects of various measures of inflation expectations, central banks can implement policy changes that are consistent with the actual impact of expectations on inflation dynamics, thereby enhancing the effectiveness of monetary policy.

References

Adam, K., and Padula, M. (2011). Inflation Dynamics and Subjective Expectations in the United States. *Economic Inquiry, 49*(1), 13-25.

Arruda, E. F., Olivindo, M. T. A., and Castelar, I. (2018). Business cycles, expectations and inflation in Brazil: a New-Keynesian Phillips curve analysis. *CEPAL Review*.

Bejarano, J. A. (2005). Estimación estructural y análisis de la curva de Phillips neokeynesiana para Colombia. *Revista ESPE*(48), 64-117.

Blanchflower, D. G. and MacCoille, C. (2009). The formation of inflation expectations: an empirical analysis for the UK (No. w15388). *National Bureau of Economic Research*.

Brissimis, S. N., and Magginas, N. (2006). Inflation forecasts and the New Keynesian Phillips curve. *International Journal of Central Banking*, 1-22.

Cháves-Castro, A. H. (2011). Análisis dinámico de la inflación en Colombia a partir de la curva de Phillips neokeyneriana (NKPC), Ensayod de Economía, (21)39, 19-48.

Clements, M. (2019). Macroeconomic survey expectation, Palgrave Texts in Econometrics, Palgrave Macmillan.

Coibion, O., and Gorodnichenko, Y. (2015). Is the Phillips curve alive and well after all? Inflation expectations and the missing disinflation, *American Economic Journal: Macroeconomics*, 7(1), 197-232.

Coibion, O., Gorodnichenko, Y. and Kamdar, R. (2018). The formation of expectations, inflation, and the phillips curve, *Journal of Economic Literature*, 56(4), 1447-1491.

D'Amato, L., and Garegnani, M. (2009). La dinámica de corto plazo de la inflación: estimando una curva de Phillips híbrida neokeynesiana para Argentina (1993-2007), Ensayos Económicos del BCRA, 33-56.

Echavarría, J. J., López, E., and Misas, M. (2011). La persistencia estadística de la inflación en Colombia. En E. López, and M. T. Ramírez (Edits.), *Formación de precios y salarios en Colombia, tomo I* (2-44). Bogotá: Banco de la República.

Echavarría, J. J., Rodríguez, N., and Rojas, L. E. (2011). La meta del Banco Central y la persistencia de la inflación en Colombia. En E. López, and M. T. Ramírez (Edits.), *Formación de precios y salarios en Colombia, tomo I*, (46-69). Bogotá: Banco de la República.

Espinosa-Torres, J. A., Melo-Velandia, L. F., and Moreno-Gutiérrez, J. F. (2017). Expectativas de inflación, prima de riesgo inflacionario y prima de liquidez: una descomposición del break-even inflation para los bonos del Gobierno colombiano. *Revista Desarrollo y Sociedad*, (78), 315-365.

Galí, J., and Gertler, M. (1999). Inflation dynamics: A structural econometric analysis. *Journal of Monetary Economics*, 44(2), 195-222. doi:10.1016/S0304-3932(99)00023-9

Galí, J., Gertler, M., and López-Salido, J. D. (2001). European inflation dynamics. *European Economic Review*, 45(7), 1237-1270. doi:10.1016/S0014-2921(00)00105-7

Galí, J., Gertler, M., and López-Salido, J. D. (2005). Robustness of the estimates of the hybrid New Keynesian Phillips curve. *Journal of Monetary Economics*, 52(6), 1107-1118.

Galvis-Circo, J. C. (2010). Estimación de la Curva de Phillips neokeynesiana para Colombia: 1990-2006. *Lecturas de Economía* (73), 11-47. doi:10.17533/udea.le.n73a7863

García, J., and Werner, S. (2021). Inflation News and Euro-Area Inflation Expectations. *International Journal of Central Banking*, 17(3), 1-60. ,https://www.ijcb.org/journal/ijcb21q3a1.htm

Gómez, J., Uribe, J. D; Vargas, H. (2002). The implementation of inflation targeting in Colombia. Borradores de Economía 202, 1-60. Banco de la República.

González, A., Guarín, A., Rodríguez, D., and Vargas, H. (2020). *4GM: A New Model for the Monetary Policy Analysis in Colombia.* Borradores de Economía No 1106, Banc de la República.

González-Molano, E., Jalil Barney, M, A., and Romero-Chamorro, J. V. (2011). Inflación y expectativas de inflación en Colombia. *Capítulo 13. Inflación y expectativas de inflación en Colombia*.

González-Molano, E., Hernández-Ortega, R., Caicedo-García, E., Martínez-Cortés, N., Romero, J. V., and Grajales-Olarte, A. (2020). *Nueva Clasificación del BANREP de la Canasta del IPC y revisión de las medidas de Inflación Básica en Colombia.* Borradores de Economía No 1122, Banco de la República.

Gürkaynak, R. S., Sack, B., and Wright, J.H. (2010). The TIPS yield curve and inflation compensation. *American Economic Journal: Macroeconomics*, 2(1), 70-92.

Henzel, S., and Wollmershäuser, T. (2008). The New Keynesian Phillips Curve and the Role of Expectations: Evidence from the CESifo World Economic Survey. *Economic Modelling, 25*(5), 811-832. doi:10.1016/j.econmod.2007.11.010

Henzel, S., and Wollmershäuser, T. (2006). The New Keynesian Phillips Curve and the Role of Expectations: Evidence from the Ifo World Economic Survey.

Iregui, A., Anzola, C., Ballén, L., Bejarano, V., González, E., Grajales, A., . . . Torres, P. (2021). ¿Qué nos dicen las encuestas sobre la formación de expectativas de inflación? *Ensayos sobre Política Económica (ESPE)*(100).

Jean-Baptiste, F. (2012). Forescasting whith the new Keynesian Phillips curve: Evidence from survey data. *Economics Letters*. 117(3), 811-813.

Jondeau, E., and Le Bihan, H. (2005). Testing for the new Keyesian Phillips curve, Additional international evidence. *Economic Modelling*. 22(3), 521-550.

Lindé, J. (2005). Estimating New-Keynesian Phillips Curves: a full information maximum likelihood approach, *Journal of Monetary Economics*, No, 52.

López-Enciso, E. A., Vargas-Herrera, H., and Rodríguez-Niño, N. (2016). *La estrategia de inflación objetivo en Colombia. Una visión histórica.* Borradores de Economía, No 952, Banco de la República.

Mankiw, G., Reis, R., and Wolfers, J. (2003). Disagreement about Inflation Expectations. *NBER Macroeconomics Annual,* 18, 209-248. doi:10.1086/ma.18.3585256

Mazumder, S. (2011). The empirical validity of the New Keynesian Phillips curve using survey forecasts of inflation. *Economic Modelling*, 28(6), 2439-2450.

Medel, C. (2015). Dinámica inflacionaria y la curva de Phillips híbrida neokeynesiana: el caso de Chile. *Monetaria,* 37(1), 209-248.

Melo-Velandia, L., and Moreno-Gutiérrez, J. (2010). *Actualización de la descomposición del BEI cuando se dispone de nueva información.* Banco de la República, Borradores de Economía No. 620.

Mendoza, I., and Perea, H. (2017). La relación entre la actividad y la inflación: estimación de una Curva de Phillips para Perú. *BBVA Research*.

Murillo-Reyes, A. (2014). Estimación de una curva de Phillips Neokeynesiana para Bolivia. Banco Central de Bolivia.

Nason, J. M., and Smith, G. (2008). The New Keynesian Phillips Curve: Lessons From Single-Equation Econometric Estimation. *Economic Quarterly, 94*(4), 361–395.

Pesaran, H. M., and Weale, M. (2006). Survey expectations. en G. Elliot, C. W. J. Granger y A, Timmemann (eds.), *Handbook of Economic Forecasting,* Elsevier, 1(14), 715-776. doi.org/10.1016/S1574-0706(05)01014-1

Pesaran, H. M., and Timmerman, A. (1992).A simple nonparametric test of predictive performance., *Journal of Business and economic statistics,* 10(4), 461-465.

Pivetta, F., and Reis, R. (2007). The Persistence of Inflation in the United States. *Journal of Economic Dynamics and Control, 31*(4), 1326-1358. doi:https://doi.org/10.1016/j.jedc.2006.05.001

Rudd, J., and Whelan, K. (2005). New tests of the New Keynesian Phillips Curve. *Journal of Monetary Economics,* 52(6), 1167-1181. 1, doi. org/10.1016/j.jmoneco.2005.08.006

Stock, J. H., and Watson, M. (2007). Why Has U.S. Inflation Become Harder to Forecast? *Journal of Money, Credit and Banking, 39*(1), 13-33. doi:https://doi.org/10.1111/j.1538-4616.2007.00014.x

Svensson, L. E. (1997).Inflation forecast targeting: Implementating and monitoring inflation targets. *European economic reviww,* 41(6), 1111-1116.

Vargas, H. (2016). *Inflation Expectations and a Model-Based Core Inflation Measure in Colombia.* Borradores de Economía No 928, Banco de la República.

Vargas, H., González, A., González, E., Romero, J. V., and Rojas, L. E. (2009). *Assessing.* Borradores de Economía No 558, Banco de la República.

Zarate, H., and Rengifo, A. (2013). Forecasting annual inflation with power transformations: the case of inflation targeting countries. Banco de la República.

Zhang, C., Osborn, D., and Kim, D. H. (2009). Observed inflation forecasts and the new keynesian Phillips curve. *Oxford Bulletin of Economics and Statistics,* 71(3), 375-398.

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)