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Commodity Price Shocks and Inflation within an Optimal Monetary Policy Framework: The Case of Colombia

Abstract

We estimate food, oil and energy price effects on inflation in a small-open-economy model for Colombia. Such an economy exports and imports commodities and has an inflation-targeter central bank who follows an optimal interest rate rule. We found evidence of small effects of commodity prices shocks on headline inflation once the reaction of monetary authority has been taken into account. Thus, our interpretation is that monetary authority has faced rightly the shocks to commodity

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prices. Inflation expectations are the main determinant of inflation during the inflation targeting regime. Commodity prices movements are to a great extent included in the information set to form expectations.

Keywords: commodity prices, inflation-targeting regime, optimal monetary policy, expectations.

JEL classification: E43, E58.

1. INTRODUCTION

The behavior of commodity prices is matter of permanent concern among its producers, investors, policymakers and economists. The reason is that commodity prices changes potentially may bring about new economic conditions and give signals on the future path of some relevant domestic macroeconomic variables. That is the case of inflation in countries where commodity prices shocks represent important sources of either demand or supply pressures. In consequence, the question whether monetary authorities should react to commodity prices fluctuations effects on domestic inflation is not trivial.

Output disturbances are different in nature and require different policy responses. The basic theory on monetary economics suggests that monetary authority should offset demand shocks but accommodate supply shocks (Clarida, Galí, and Gertler, 1999). Thus, identifying the nature of shocks is just one of the tasks to which monetary authorities are faced to (see Uribe, 2010). In this sense, it is necessary to gauge the magnitude of the effects: If there a significant long-lasting impact exists, then an adequate response will have to be implemented. For example, fluctuations of the commodity exports prices that lead to reactions of aggregate national income may represent an important source of inflation due to demand pressures in countries where these products are the core of the economic activity (IMF, 2008). However, if the country is net importer of commodities the policy reaction could be different depending on the pass-through from import prices to inflation.[1]

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[1] Some standard small open economy models link the inflation impact

Regardless of the apparent importance of commodity prices shocks on inflation, there is no much research devoted to the study and estimation of this phenomenon by invoking an economic model in which the inflation process can be derived as we do below. Most research is carried out in the spirit of either general equilibrium (Medina and Soto, 2007) or empirical models (Pedersen and Ricaurte, 2014). In a recent work, Jalil and Tamayo (2011) estimated first and second round effects of food international prices on inflation of Brazil, Chile, Colombia, Mexico and Peru. The authors found that, for Colombia, the effects of commodity price shocks disappear four months after the shock, estimating an elasticity of 0.27 of domestic prices to the international prices. When inflation is decomposed into core inflation without food and food price changes, the elasticities are, on average, 0.194 and 0.477, respectively. With respect to the second round effects, they provided evidence that the effects take place within a period close to four months, though the numerical magnitude is lower than 10% of the first round effects.

On the effects of commodity prices shocks on inflation and inflation expectations in Colombia, recently Arango, Chavarro and González (2013) found evidence of first-round and second-round effects between 1990 and 2010. Their empirical results showed that there is a positive and significant pass-through from food and oil international prices to the domestic prices of some selected items of the CPI and PPI baskets. Nevertheless, the magnitudes of the effects are small: They found an elasticity of domestic prices to international prices between 0.1 and 0.3 on average.[2] The estimated effects on core inflation and inflation expectations are higher, especially in the case of food prices shocks. In particular, a 1% rise in the internation-

of imports prices to the weight given to imports in the CPI (see for example, Galí et al., 2005), while others, such as McCallum and Nelson (2001), show that the transmission to inflation is limited to the extent to which relative price shocks affect aggregate supply.

[2] For items as cocoa, coffee, sugar, palm-oil, sun-flower oil and soy-oil the elasticity is higher than 0.5.

al price of food brings forth a rise of 0.56% on core inflation and explains about 32% of the changes on inflation expectations in one-month horizon, with an important decline on the latter when the time-horizon is extended. According to these authors, the reduction of the pass-through coefficient of food prices to core inflation since the inflation-target regime was established shows that there have been significant gains by controlling inflation.

However, the approaches of Jalil and Tamayo (2011) and Arango, Chavarro and González (2013) are empirical in essence. None of them present a theoretical setting in which the behavior of monetary authority within a proper framework to face shocks is explicit. This is relevant because Colombia's central bank follows an inflation-targeting strategy and is committed to control inflation to provide conditions for a sustainable economic growth path. In our view, the final pass-through from commodity prices shocks to domestic inflation should be analyzed taking into account the reaction function implicit in the monetary policy rule.

Accordingly, this article is aimed to determine how much of international commodity price shocks are passed through inflation under an optimal monetary policy framework. This subject is important for two reasons. On the one hand, Colombia is a commodity exporter hence changes in commodity world markets may have a direct impact on the economy through channels encompassing gross domestic product growth, exchange rate movements, financial (un)balances, inflation behavior and a higher exposure to the dynamics of aggregate demand in emerging and developed economies. On the other hand, it is worth to evaluate how an optimal monetary policy framework leads to a higher domestic price stability given the commodity prices movements.

The theoretical body we use is based on Walsh (2002) and De Gregorio (2007), which consists of a text-book model used to explain the inflation targeting strategy which is explained below.[3] In that sense, this paper might be though as an empirical attempt to verify the goodness of this simple model to explain the inflation determinants in a small open economy. The theoretical device is enriched with four shocks: Cost-push, demand, and two structural. The demand shock is attempted to capture the idea that movements in commodity prices (oil, coal, etc.) have effects mainly via aggregate demand rather than supply in the economy.[4] As we will see below, the success of the model is not complete tough auspicious. Moreover, the results suggests that commodity price shocks and other demand and supply shocks are of minor importance while expectations are the main determinant of inflation during the inflation targeting regime. Thus, we claim that the monetary authority has faced rightly the shocks to commodity prices during this regime.

The article develops in six sections of which this "Introduction" is the first. The second shows some facts of the recent behavior of commodity prices and inflation. The third section presents and explains the model and provides some intuition. The fourth section is devoted to explain the way in which structural shocks, commodity prices shocks and inflation expectations are obtained. Section fifth shows and discusses the results. Finally, the sixth section draws some conclusions.

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[3] This framework was also used by Vargas and Cardozo (2013).

[4] This conjecture is supported by two facts. First, Colombia is a net oil-exporter country (oil exports represented 34.3% of total exports on average between 2005 and 2010). In addition, the government is the major stockholder of the main oil firm in Colombia (revenues received by the government from oil are about 12% of total government income between 2007 and 2013). Second, the symptoms of Dutch decease undergone by the Colombian economy, associated to the well behavior of the terms of trade. In fact, the industrial sector maintained a 3.1% annual growth rate between 2000 and 2013, interrupted by the crisis occurred in 2008 and 2009 when the growth was 0.6% and −4.1%, respectively. In the aftermath, the annual growth rate of the sector was 1.8%, well below the whole economy (4.4%).

2. SOME FACTS ON RECENT BEHAVIOR OF COMMODITY PRICES

Figure 1 shows nominal food and crude oil price indexes.[5] After a period of relative stability, during the past decade the index of food world prices grew up by more than 110% between January 2000 and December 2013 and by more than 339% in the case of crude oil during the same period. In real terms, between January 2000 and December 2013, the percentage variations of food and crude oil prices were of 52% and 218%, respectively, while from January 1990 to December 1999 the registered percentage variations were of −41% and −9%, respectively. All these price movements, as has been argued in previous research (see Frankel, 2006; Bernanke, 2006), are consequence of both supply and demand shocks. On the one hand, an increasing demand for commodities by large emerging economies as China and India has soared commodity prices. The transition to other types of energy, in particular an increasing demand for biofuels, has raised the price of land and, in turn, increased the cost of food production. Financial developments in commodities markets, climate phenomena and supply shocks in the crude oil market are also among the reasons that explain the upsurge in commodity world prices.

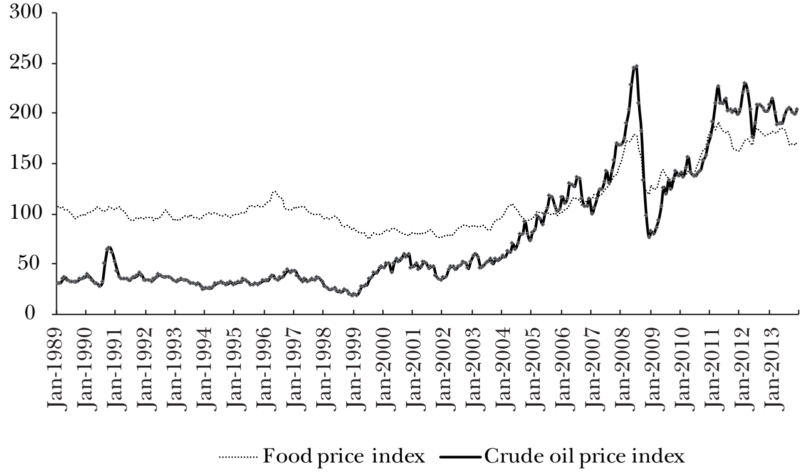
Potentially, commodity price booms bring about first and second round effects on inflation. The former consist of primary or direct effects while the latter are linked to a rise in underlying inflation. This is the case when the increases in food and fuel prices drive up expectations and underlying inflation producing further price increases and demand for higher wages. This is especially important for those economies where commodities account for a large share of final expenditure and where monetary policy has only limited credibility. To the extent that commodity prices shocks are large and persistent, inflation risks increase and second

[5] Our reference prices are food and crude oil international price indexes from the IMF.

Figure 1

FOOD AND CRUDE OIL PRICE INDEXES

(base: Jan-2005=100)



Sources: IMF, National Administrative Department of Statistics (DANE), and authors' calculations.

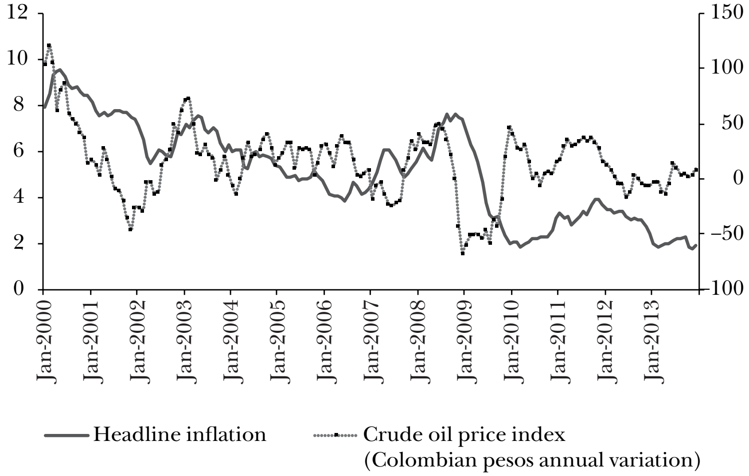
round effects arise, requiring an accurate and timely policy response. In other words, if shocks to commodity prices are transitory, they are expected to damp in the short run with persistent effects on neither expectations nor underlying inflation. In contrast, with large and persistent shocks, as were the cases of recent episodes, monetary authorities face a challenge since the shocks are transmitted to inflation expectations and prices of other goods and services in the economy (Bernanke, 2006).

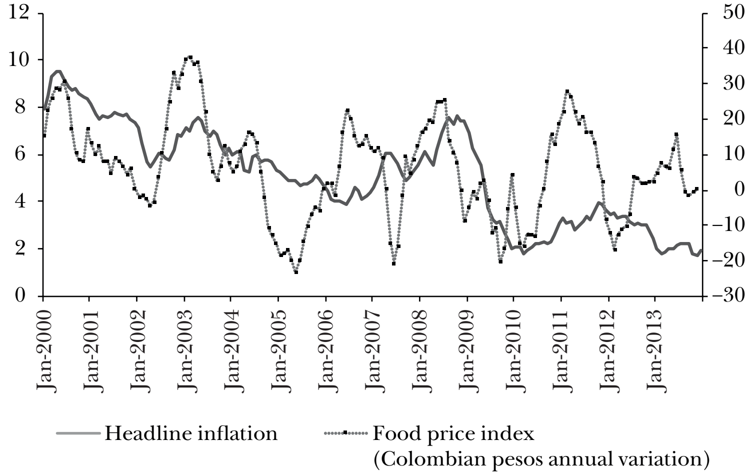
Figure 2 presents some of the variables we use to analyze the effect of commodity price shocks on inflation in Colombia; later we shall introduce the expectations processes. The upper panel presents the headline inflation and the annual variation of crude oil (LHS) and food international prices (RHS), both expressed in Colombian pesos. Two things are worth highlighting. First, there is some coincidence between

Figure 2

COMMODITY PRICES ANNUAL VARIATION, HEADLINE INFLATION AND POLICY RATE

(percent)



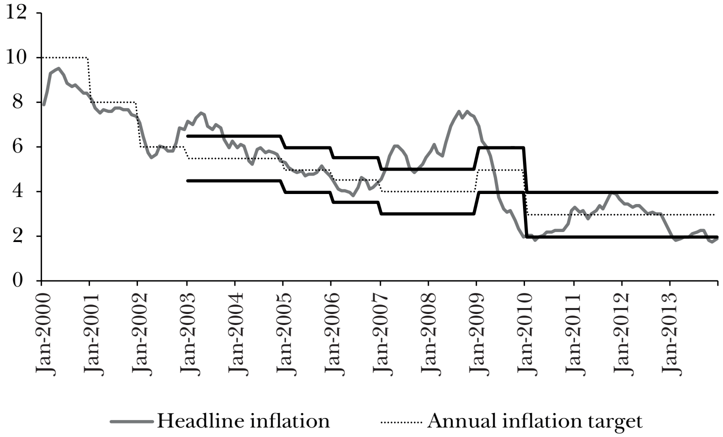


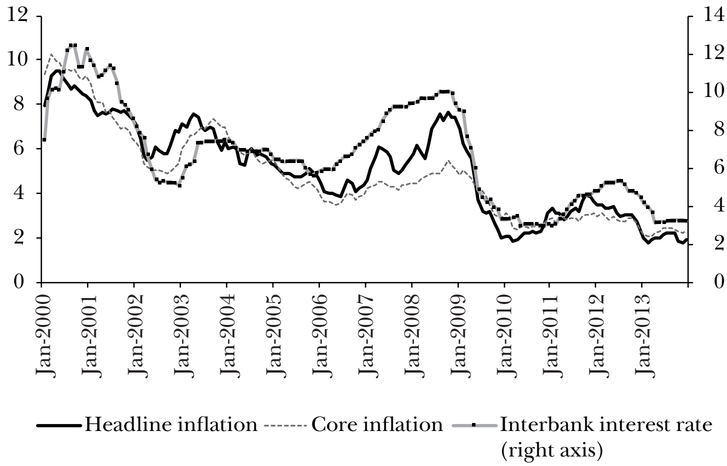
Note: the right axis measures the annual percentage change of international prices.
Source: IMF; National Administrative Department of Statistics (DANE); and author's calculations.

Figure 2

COMMODITY PRICES ANNUAL VARIATION, HEADLINE INFLATION AND POLICY RATE

(percent)





Note: the right axis measures the interbank interest rate.
Source: IMF; National Administrative Department of Statistics (DANE); and author's calculations.

international commodity price movements and domestic headline inflation during the same period.[6] Second, the more recent developments of inflation in Colombia would suggest an effective reaction of monetary authority, as new increases in crude oil and food world prices did not have an impact on inflation which has been maintained within the rank-target (see the LHS lower panel). The lower panel (RHS) of Figure 2 shows the behavior of policy rate (measured by interbank interest rate) and headline inflation and core inflation as measured as inflation without food and regulated prices.

3. THE MODEL

As we mentioned before, the aim of this paper is to analyze the effects of commodity prices shocks on domestic inflation in Colombia based on a model in which monetary authority reacts to deviations of output from its flexible price equilibrium level, deviations of the inflation rate from its target and deviations of real exchange rate from its long run equilibrium value. We formulate a data generating process for inflation,

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6 For example, in 2007, inflation in Colombia reached a level of 5.69%, surpassing the upper limit of the inflation target by 119 basis points. This, as pointed out by the monetary authority of Colombia (see, inflation report December 2007), was mainly due to a food inflation higher than expected with world commodity prices explaining a large part of this increase. At the end of 2008, inflation in Colombia jumped to 7.67%, missing this time the upper limit of the target by 317 basis points. Once again, the monetary authority of Colombia argued that high international oil prices and other commodity prices, not only created inflation pressures on domestic food and fuel prices, but also had a considerable impact on inflation expectations. The length of increasing international commodity prices and its impact on expectations for further prices increases and total inflation was underestimated by some central banks, a situation that also apparently occurred in Colombia. As we will see below, there is no evidence to reject such statement if we include the permanent component of commodity prices into the picture.

π_t, in the context of a small open economy with an inflation-targeting strategy, and estimate the effect on this of commodity prices (demand) shocks,[7] inflation expectations, cost-push shocks,[8] and two structural shocks.

The framework is based on two relations: An expectations augmented Phillips curve and a description of monetary policy behavior, reflecting the policymaker's preferences in trading off output gap, inflation and exchange rate deviations (see Walsh, 2002). The latter implies a central bank that sets its policy instrument to stabilize inflation, output gap and exchange rate. A monetary policy rule (MPR thereafter) emerges when monetary authority balances the marginal costs and benefits of its policy actions. In other words, the MPR shows a relation between the output gap, misalignments of exchange rate, and deviations of inflation from the target consistent with a monetary authority designed to minimize the costs of output and inflation variability.[9]

The MPR shows the reaction of the monetary authority. Once this authority observes the current inflation, decides optimally on the size of the output gap and the exchange rate deviation. In this set up, the long-run equilibrium occurs when the output gap equals zero, current inflation equals the central bank's target and the exchange rate is on the long-run level. As pointed out by Gertler, Galí and Clarida (1999), the policy design problem consists of characterizing how the interest rate should adjust to the current state of the economy.

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7 We refer here to shocks to the international prices of oil and energy.

8 As we explain below, a fraction of these corresponds to shocks to the international price of food.

9 Nevertheless, factors other than systematic monetary policy influence aggregate demand and output in ways that monetary authority cannot perfectly foresight. In addition, policymakers may have goals beyond inflation and output gap stabilization that would shift the relation between the output gap and inflation described by the monetary policy rule. A random disturbance variable denoting the net impact on output of those additional factors can then be added to the model.

We follow De Gregorio (2007) and Walsh (2002) to lay out a model consisting of three basic equations: An expectations-augmented Phillips curve, which schedules the aggregate supply of the economy, an IS-type aggregate demand and a MPR derived below from the objective function of a monetary authority assumed to follow an optimum rule.

The Phillips curve and the IS curve are given by:

1 $$\pi = \pi^e + \theta\left(y - \bar{y}\right) + \delta\left(q - \bar{q}\right) + \omega\varepsilon^{food} + \varepsilon ,$$

2 $$y - \bar{y} = A - \varphi\left(i - \pi^e\right) + \alpha q + \rho\mu^{crude\ oil} + \mu ,$$

where, π stands for the annual rate of inflation, π^e are the inflation expectations, y is the output, $\bar{y}$ is the flexible price equilibrium output level, q stands for the real exchange rate, $\bar{q}$ is the long run value of the real exchange rate, A is a composite factor accounting for autonomous spending, i is the nominal interest rate, $\bar{\pi}$ is the annual inflation target, ε^{food} and $\mu^{crude\ oil}$ are the components of commodity prices orthogonal to expectations mechanisms, ε and μ stand for cost-push and demand shocks, respectively, and θ, δ, φ, ω, α, ρ are unknown parameters.

According to Equations 1 and 2, a fraction of cost-push and demand shocks is strictly related to pressures coming from shocks to international food and crude oil prices respectively. Thus, both ε and μ are residuals of a regression of each on both ε^{food} and $\mu^{crude\ oil}$. The way in which ε, μ, ε^{food} and $\mu^{crude\ oil}$ are identified and obtained is explained below.

Following De Gregorio (2007), the optimization problem faced by monetary authority can be written as: $\min \lambda(y-\bar{y})^2 + (\pi - \bar{\pi})^2 + \beta(q-\bar{q})^2$ subject to 1 and 2. The loss function accounts for deviations of output from its flexible price equilibrium level, inflation rate from its target and deviations of real exchange rate from its long run equilibrium value. The model also includes an uncovered interest parity condition, $r = r^* + \bar{q} - q$, and the Fisher equation, $i = r + \pi^e$.

From the first order conditions of the optimization problem, the MPR is given by

3 $$\pi-\bar{\pi}=-\left(\frac{\alpha\lambda}{\alpha\theta+\delta}\right)(y-\bar{y})-\left(\frac{\beta}{\alpha\theta+\delta}\right)(q-\bar{q}).$$

This curve reflects the trade-off faced by monetary authority in terms of keeping inflation, output and real exchange rate as close as possible to their target or equilibrium levels. After replacing MPR in the Phillips curve and the IS curve, we find the optimal interest rate rule (IRR),

4 $$i=\bar{i}+\left(1+\frac{\theta\alpha+\delta}{\upsilon}\right)\left[\pi^{e}-\bar{\pi}\right]+\frac{\theta(\alpha\theta+\delta)+\alpha\lambda}{\upsilon}(\rho\mu^{crude\ oil}+\mu)+ +\frac{(\alpha\theta+\delta)}{\upsilon}(\omega\varepsilon^{food}+\varepsilon),$$

where $\bar{i}=r^{*}+\bar{\pi}$ and $\upsilon=\alpha^{2}\lambda+\varphi\alpha\lambda+\beta+(\theta\alpha+\delta)(\delta+\alpha\theta+\varphi\theta)$.

The IRR shows the reaction of the monetary authority when inflation expectations are different from the target, or commodity price, demand or other cost-push shocks reveal. It is evident that the higher the value of β, the less the reaction of monetary authority to shocks or expectations.[10] Recall that parameter υ contains β, and the former appears in the denominator of each coefficient.

After some algebra manipulation, the inflation process can be written as

5 $$\pi=\left(\frac{\alpha^{2}\lambda+\varphi\alpha\lambda+\beta}{\upsilon}\right)\pi^{e}+\left[1-\left(\frac{\alpha^{2}\lambda+\varphi\alpha\lambda+\beta}{\upsilon}\right)\right]\bar{\pi}+ +\left(\frac{\beta\theta-\delta\alpha\lambda}{\upsilon}\right)(\rho\mu^{crude\ oil}+\mu)+\left(\frac{\alpha^{2}\lambda+\varphi\alpha\lambda+\beta}{\upsilon}\right)(\omega\varepsilon^{food}+\varepsilon),$$

[10] Parameter β represents the weight of the deviations of real exchange rate from its long run value.

where the sources of inflation process in this model become clear. In first place, we observe that the higher the expectations the higher the annual inflation. At the same time, positive realizations of, almost, all shocks will render a higher inflation rate. However, in the case of shocks to oil prices or structural demand, the inflation reaction will be different depending on which force is greater either $\beta\theta$ or $\delta\alpha\lambda$. The former parameters represent, on the one hand, the weight of deviations of exchange rate from its long run value in the loss function and the parameter linked to the marginal cost in the Phillips curve. On the other hand, the parameters, $\delta\alpha\lambda$, represent the contribution to inflation of deviations of exchange rate from its long run value in the Phillips curve, the coefficient of real exchange rate in the IS equation, and the weights of the gap in the loss function, respectively. Thus, if the value of the product $\beta\theta$ is greater (less) than the product $\delta\alpha\lambda$, any positive shock to oil prices or a demand shock will increase (reduce) inflation. In particular, if the monetary authority expresses a concern on the deviations of the real exchange rate from its long run value, the increase of the nominal interest rate will be less than otherwise. In the extreme case that the monetary authority does not express any concern at all about the real exchange level in the loss function $(\beta = 0)$, any shock to oil prices or demand shock will drive to a reduction in inflation given the reaction condensed in the IRR.

The inflation process can also be written as:

$$\pi - \bar{\pi} = \left(\frac{\alpha^2\lambda + \varphi\alpha\lambda + \beta}{\upsilon} \right)(\pi^e - \bar{\pi}) + \left(\frac{\beta\theta - \delta\alpha\lambda}{\upsilon} \right)(\rho\mu^{crude\ oil} + \mu) + \left(\frac{\alpha^2\lambda + \varphi\alpha\lambda + \beta}{\upsilon} \right)(\omega\varepsilon^{food} + \varepsilon), \tag{6}$$

which is the equation we actually estimate. In essence, it shows that, within this economic framework, deviations of inflation from the target are caused by deviations of inflation expectations from the target, and shocks to commodity prices, demand and other cost-push shocks. In the next section we show how some variables included in the model are built.

4. DATA: COMMODITY PRICE SHOCKS, INFLATION EXPECTATIONS, MONTHLY INFLATION TARGET AND SUPPLY AND DEMAND SHOCKS

The estimation of Equation 6 requires some data that are not readily available. That is the case of inflation expectations mechanisms, trajectories of commodity price shocks orthogonal to inflation expectations, monthly series of inflation target[11] and identified structural shocks. We now consider each in turn.

4.1 Expectations Mechanisms

The first mechanism we use to measure inflation expectations is the break-even inflation (BEI from now on) which uses information of secondary market of debt in Colombia. In this case, by invoking Fisher equation, inflation expectations are computed at different horizons as the difference between the nominal yield of fixed income bonds and the real yield on inflation linked bonds, both issued by the government. Accordingly, BEI rates from 1-year and 2-years yield curves stand for our market-based measures of inflation expectations. The second indicator of inflation expectations is the forward BEI which in essence derives expectations from one and two years BEI forward curves and reflects the expected inflation in a year time for the following year.

Finally, inflation expectations are also obtained by assuming that agents form their expectations about future inflation, one and two-years ahead ($s = 12, 24$ months), according to a specific process. To this aim, we use an imperfect rational expectations mechanism, wich is a moving average process given by:

7 $$\pi^{e}_{t-S,t} = \kappa\pi^{headline}_{t-S} + (1-\kappa)\pi^{headline}_{t},$$

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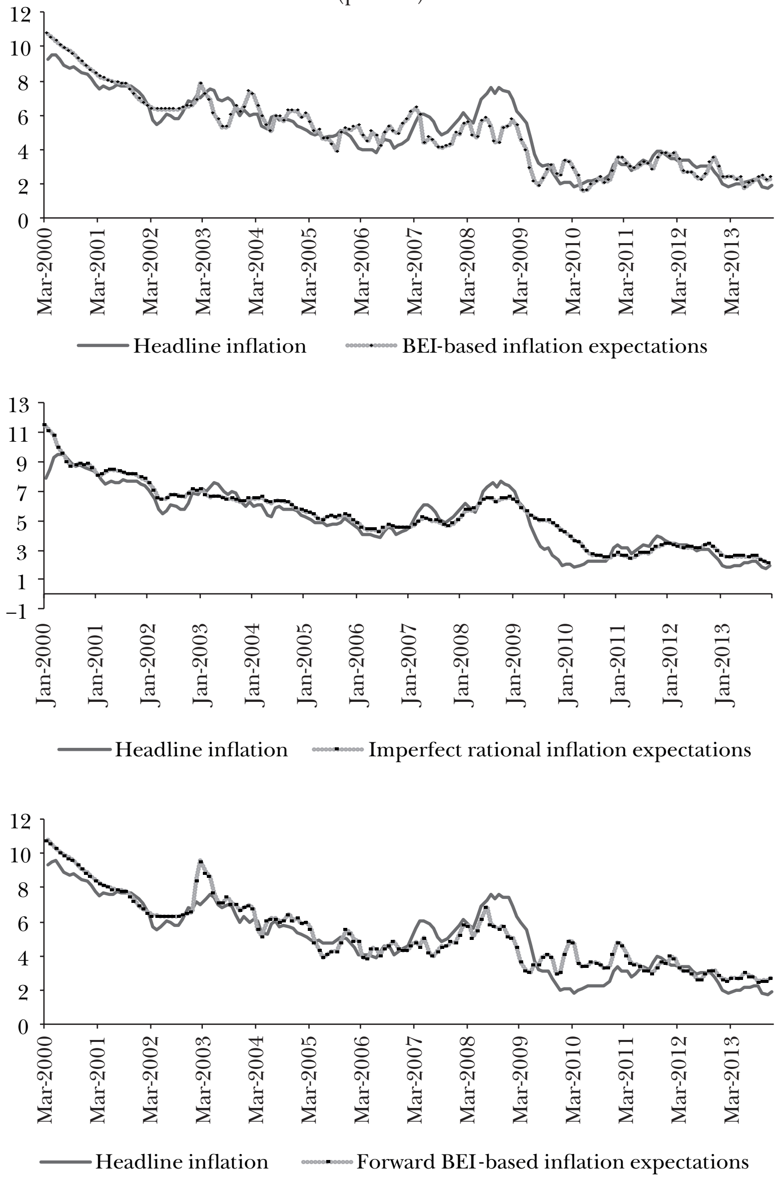
[11] This is so, because we use monthly data on the estimation. Then, we need an estimation of the monthly target of inflation in order to calculate the deviation of monthly inflation rate from its implicit target.

Figure 3

PANEL A. INFLATION EXPECTATIONS ONE YEAR AHEAD

(percent)

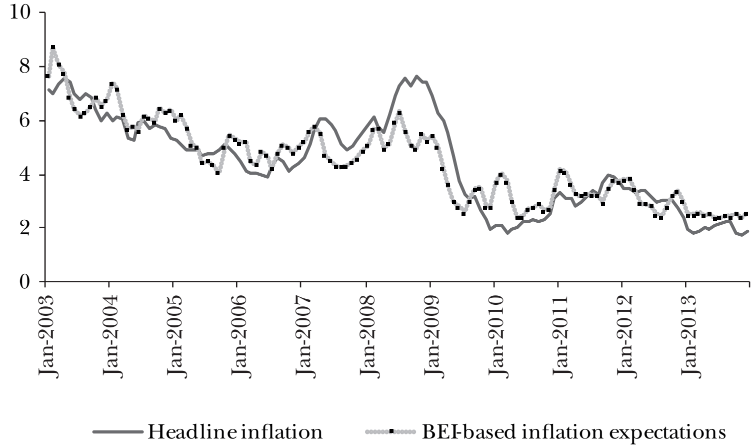


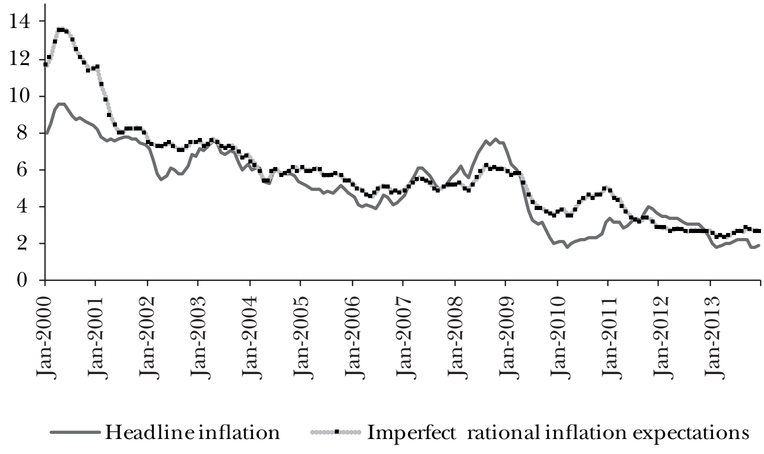
Sources: DANE, Banco de la República (Colombia), and authors' calculations.

Figure 3

PANEL B. INFLATION EXPECTATIONS TWO YEARS AHEAD

(percent)





Sources: DANE; Banco de la República (Colombia); and authors' calculations.

where both headline inflation and inflation expectations correspond to annual inflation rates. This mechanism is based on the hypothesis that agents assign a weight κ [12] to inflation observed s periods ago and a $(1-\kappa)$ weight to current inflation, when predicting how inflation is expected to behave in the future. This mechanism supports the inertia property of the inflation expectations process. Figure 3 presents the relation between headline inflation and inflation expectations. Figures are depicted accounting for the fact that agents form their inflation expectations in advance, so that current inflation outcomes are related to their corresponding inflation expectations formed 12 and 24 months ago.

When expectations are imperfeclyt rational, the inflation process can be written as:

8
$$\pi-\bar{\pi}=\frac{\kappa\left(\alpha^{2}\lambda+\varphi\alpha\lambda+\beta\right)}{\upsilon-(1-\kappa)\left(\alpha^{2}\lambda+\varphi\alpha\lambda+\beta\right)}(\pi_{-s}-\bar{\pi})+$$
$$+\frac{\beta\theta-\delta\alpha\lambda}{\upsilon-(1-\kappa)\left(\alpha^{2}\lambda+\varphi\alpha\lambda+\beta\right)}\left(\rho\mu^{crude\ oil}+\mu\right)+$$
$$+\frac{\left(\alpha^{2}\lambda+\varphi\alpha\lambda+\beta\right)}{\upsilon-(1-\kappa)\left(\alpha^{2}\lambda+\varphi\alpha\lambda+\beta\right)}(\omega\varepsilon^{food}+\varepsilon).$$

4.2 Commodity Prices Shocks

In assessing the pass-through of commodity price shocks to inflation is crucial to define what a price shock is. To this end, we use the Hodrick-Prescott filter to decompose the annual variation of commodity prices between permanent and transitory components, being the latter the unexpected one.

Accordingly, we have chosen three commodity price indexes from the IMF Primary Commodity Prices: crude oil, energy and food. On the demand side, we consider shocks to oil and energy

[12] The value of κ we use is 0. 44.

price fluctuations and denote them by $\mu^{crude\ oil}$ (which include a simple average of three spot prices: Dated Brent, West Texas Intermediate and the Dubai Fateh) and μ^{energy} (which include petroleum, natural gas and coal price indexes), respectively, while shocks to food price fluctuations are denoted by ε^{food}. All these shocks should satisfy the key restriction of being orthogonal to the inflation expectations mechanisms defined above, an assumption that we test. We also test the assumption that inflation expectations should be correlated to the permanent (long-run) component of crude oil, energy and food prices but no to the transitory (cyclical) component.

To verify the latter assumption, we calculate the Pearson correlation coefficients between each of the expectations mechanisms and the permanent and transitory components of commodity prices fluctuations. Table 1 shows the estimated correlation coefficients between each expectations mechanism and both the permanent and transitory components of annual variation of commodity prices, denominated in dollars. For all the mechanisms, inflation expectations are correlated with the long run component of commodity prices annual variation.

The imperfect rational expectations mechanism shows the lower correlation coefficient while expectations as predicted by BEI mechanism show the highest correlation. The cyclical components of annual variation in commodity prices show no correlation with inflation expectations, with the only exception of forward BEI mechanism. However, we will consider that, in general, transitory components of international commodity prices are not correlated with inflation expectations in Colombia.[13]

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[13] We also run regressions of inflation expectations on permanent and temporary components of commodity prices indexes. The results are similar to those of Table 1; that is, in general, permanent components of commodity prices explain inflation expectations while temporary components do not. The results are not shown but are available upon request.

Table 1

CORRELATION OF INFLATION EXPECTATIONS WITH PERMANENT AND TRANSITORY COMPONENTS OF ANNUAL VARIATION OF COMMODITY PRICES DENOMINATED IN DOLLARS

	One year ahead			*Two years ahead*	
Price	*BEI*	*Forward BEI*	*Imperfect rational*	*BEI*	*Imperfect rational*
Crude oil					
Permanent	0.36[a]	0.28[a]	0.20[a]	0.47[a]	0.29[a]
p-value	0.00	0.00	0.01	0.00	0.00
Transitory	0.04	0.13	0.03	0.09	0.10
p-value	0.57	0.10	0.67	0.30	0.19
Energy					
Permanent	0.42[a]	0.33[a]	0.27[a]	0.53[a]	0.34[a]
p-value	0.00	0.00	0.00	0.00	0.00
Transitory	0.06	0.15	0.04	0.13	0.11
p-value	0.41	0.05	0.59	0.14	0.14
Food					
Permanent	−0.38[a]	−0.42[a]	−0.47[a]	0.44[a]	−0.54[a]
p-value	0.00	0.00	0.00	0.00	0.00
Transitory	0.12	0.17[b]	0.00	0.12	0.09
p-value	0.12	0.03	0.96	0.17	0.26

Note: Numbers correspond to the Pearson correlation coefficient, with the associated *p*-value below. [a] represents significance at 1%, and [b] at 5 per cent.

4.3 Monthly Target for the Annual Rate of Inflation

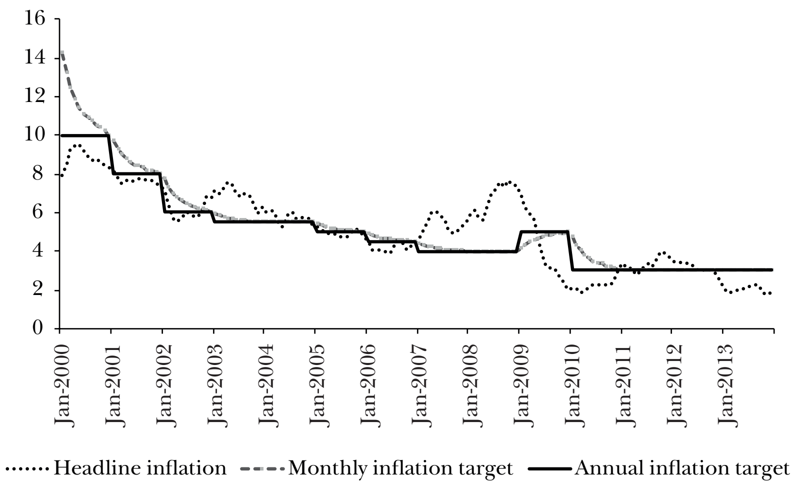
Our estimations of the inflation process require having a monthly-basis adjusted value of the target for the annual rate of inflation, a variable that is not available. To do so, we first establish a criterion to determine whether the target was reached or not in a sample of 22 years from 1991 to 2013. Thus, we calculate the ratio of the observed inflation rate to its target value and evaluate whether this ratio exceeds or falls behind a maximum level; we denote this value by g.[14] Essentially, we are estimating a monthly target based on the path of years for which target has been reached (see Arango, García and Posada, 2013).

Once we established the number of years for which target was attained, we calculate the average contribution of each month of the year to the annual rate of inflation. This is, in a year in which the target was hit, on average how much of the annual inflation rate was reached on January, how much on February, and so on, until the last month of the year. We obtain an average monthly contribution to hit the target from the sample of years matching the criterion. Then, we use these contributions and the corresponding target for every year of the sample to calculate, in a monthly basis, the inflation target. Figure 4 shows our monthly-basis adjusted target along with inflation rates observed from 2000m01 to 2013m12.

Figure 4

MONTHLY TARGET OF THE ANNUAL RATE OF INFLATION

(percent)



Sources: DANE, and authors' calculations based on Arango et al. (2013a).

[14] We fixed g equal to 0.05 and found a total of seven years in which this criterion is met.

4.4 Structural Shocks

Apart from the commodity prices shocks, the model also includes two additional shocks which are plugged into the Phillips curve and IS curve. The first is a cost-push (supply) shock and the second a demand shock. The approach we follow to obtain the set of structural supply and demand shocks is based on the estimation of a structural VAR model for the price level and output, which is derived from a basic aggregate demand-aggregate supply model, AD-AS. The set of structural shocks is obtained by using the Cover, Enders and Hueng (2006) approach (CEH thereafter), in which the usual long run restrictions are imposed to identify the shocks. In particular, CEH suggest that the aggregate demand shock has no long-run effect on real output. This approach, besides the long-run neutrality condition, allows some correlation between the demand and supply shocks. More generally, CEH do not impose any constraints to the variance-covariance matrix of structural shocks. Instead, they impose the normalization restrictions usually suggested in an AD-AS model: One-unit supply shock shifts AS by one unit and the effect of one-unit demand shock is also one-unit over AD (see Appendix 1 for details).

According to the authors, there are several arguments to justify the contemporaneous correlation between supply and demand shocks. On the one hand, monetary or fiscal policy may react according to current and past state of economic activity. On the other hand, from the new Keynesian point of view, some firms increase output, rather than prices, in response to a positive demand shock. Finally, to obtain supply and demand shocks orthogonal to commodity prices shocks, regressions of the former on the latter are estimated and the residuals from that regression are the shocks that enter into the inflation model. However, given that results remain the same with and without orthogonal shocks, we decided to maintain the original structural shocks.

5. ESTIMATION AND RESULTS

Estimations were performed using the time series of headline and core inflation, commodity prices denominated in dollars and in local currency (Colombian pesos)[15] and both monthly and annual inflation target. The results are also presented for the different expectations mechanisms and combination of commodity shocks. In the case of BEI and forward BEI expectations, the samples go from March 2000 to December 2013 with expectations one year ahead and from January 2003 to December 2013 with imperfect rational expectations. Estimations were performed for the whole inflation targeting regime period: January 2000 to December 2013 and two subsamples: from January 2000 up to December 2006, which corresponds to the period before the commodity boom, and from January 2007 to December 2013.

According to the results in Table 2, with commodity prices denominated in dollars, there is evidence of effects in the deviation of the observed headline inflation with respect to the monthly inflation target of oil and energy price shocks though the coefficients are rather small. In the two sub-periods these shocks are also significant when forward BEI expectations are considered. The coefficients have negative sign which could be suggesting that, in expression 6 $\beta\theta < \delta\alpha\lambda$ as an indication that real exchange rate deviations are not that important for the monetary authority if this result were due to a small value of β (recall this is the weight of real exchange rate in the loss function presented above). Effects on inflation derived from the structural shocks are not significant, except in the case of BEI and imperfect rational expectations. Even though this result holds for the whole period, it does not for the two subsamples since demand shocks seem to play a role for the inflation process between 2000 and 2006 but only in the case of BEI expectations. Interestingly, only expectations seem to be relevant for the whole period and the subsamples: All coefficients of the expectations processes are significant and have a positive sign.

[15] This is aimed to capture some masked effect that could be in place via the exchange rate.

Table 2

ESTIMATES USING HEADLINE INFLATION, MONTHLY TARGET AND ONE YEAR AHEAD EXPECTATIONS
(commodity prices denominated in dollars)

Expectation mechanism	*Constant*	*Expectation deviation*	*Demand-shock*	*Cost-push shock*	*Crude oil*	*Energy*	*Food*	*Number of observations*	*F*	*Adjusted R^2*
Inflation targeting regime (January 2000 to December 2013)										
BEI	0.002	1.088[a]	0.001[b]	−0.001	−0.007		−0.007	166	18.70	0.630
	0.002	1.100[a]	0.001[b]	−0.001		−0.005	−0.010	166	18.06	0.624
Forward BEI	−0.001	1.075[a]	0.001	−0.001	−0.014[b]		−0.002	166	9.505	0.606
	−0.001	1.097[a]	0.001	−0.001		−0.014[b]	−0.005	166	8.836	0.597
Imperfect rational	−0.002	1.314[a]	0.000[b]	−0.000	−0.006		0.019	168	35.01	0.790
	−0.002	1.332[a]	0.000[c]	−0.000		−0.004	0.015	168	37.12	0.785
January 2000 to December 2006										
BEI	−0.001	0.926[a]	0.001[a]	−0.001	−0.006[a]		−0.010	82	18.31	0.558
	−0.001	0.930[a]	0.001[a]	−0.001		−0.006[b]	−0.010	82	18.86	0.554
Forward BEI	−0.002[a]	0.778[a]	0.000	−0.000	−0.008[a]		−0.007	82	37.63	0.789
	−0.002[a]	0.784[a]	0.000	−0.000		−0.009[a]	−0.006	82	44.71	0.790

Imperfect rational	−0.002	1.110[a]	0.000	−0.000	−0.006		0.006	84	15.70	0.779
	−0.002	1.122[a]	0.000	−0.000		−0.005	0.005	84	14.81	0.774
January 2007 to December 2013										
BEI	0.005[b]	1.183[a]	0.001	0.002	−0.008		−0.005	84	21.68	0.692
	0.005[b]	1.204[b]	0.001	0.002		−0.004	−0.013	84	19.36	0.687
Forward BEI	−0.001	1.552[a]	0.001	−0.001	−0.019[a]		−0.005	84	35.30	0.633
	−0.001	1.630[a]	0.001	−0.001		−0.021[b]	−0.008	84	35.28	0.629
Imperfect rational	−0.002	1.507[a]	0.001	0.000	−0.010		0.028	84	64.92	0.812
	−0.002	1.533[a]	0.001	0.000		−0.007	0.021	84	60.00	0.804

[a] represents significance at 1%, [b] at 5% and [c] at 10% based on Newey-West standard errors.
Source: authors' calculations.

Table 3 shows the estimates of specification 6 with commodity prices denominated in local currency. Under this specification the coefficients of commodity price shocks (oil and energy) are marginally higher than in dollars and shocks to international food prices are now significant under the imperfect rational mechanism, for the whole period.

The positive effect observed of international food prices shocks, denominated in local currency, for the whole sample period when expectations are imperfect rational, is in line with the statements of the monetary authority of Colombia in 2007 and 2008 (see Footnote 6). It seems that pressures to international food prices were effectively transmitted to inflation. On this, two points are in order. First, when the sample period is split these effects are no longer observable casting some doubt on the interpretation of the monetary authority about the inflation outcomes in those years.[16] Second, those results would also cast some doubt on the assertion that in Colombia, during 2007 and 2008, shocks to prices of food and oil were weakened because of the appreciation of local currency (see Uribe, 2010). This is because when we use commodity prices shocks denominated in (the appreciated) local currency, food becomes significant and the coefficients of oil crude and energy become higher in absolute value. According to Table 3, this is the case with crude oil and energy under forward BEI expectations. Thus far, commodity prices shocks, mainly those to oil and energy, do affect the inflation process in Colombia but –given the size of the coefficients– they do it in a moderate way.

The evidence corresponding to the cases of crude oil and energy prices is not only consistent with the recent findings in the literature of a decrease in the contribution of oil prices to headline inflation (see for example De Gregorio et al., 2007), but is also related to the fact that long-term fluctuations in energy and crude oil prices are to a great extent already incorporated on inflation expectations.[17]

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[16] A possible interpretation is that movements in commodity prices were transmitted to inflation via expectations.

[17] As shown in Table 1, second round effects coming from annual

Moreover, to the extent that inflation expectations may contain a broad range of information about inflation coming from different sources,[18] it makes sense to find out that this is the main and more robust variable accounting for the deviations of the rate of inflation from target, as supported by estimation results. Accordingly, the message so far is that central bank's accomplishment of its price stability mandate by means of anchoring inflation expectations to the target is not only crucial, but is probably the essential feature and task under an optimal monetary policy regime.

The theoretical specification of expressions 6 and 8 suggests three results. First, the coefficient associated to expectation deviations should be bounded by 0 and 1. Second, this coefficient should be equal to the coefficient of structural supply shock (cost-push shock). Finally, the coefficient of expectation deviations under imperfect rational mechanism in specification 8 should be higher than the corresponding to specification 6. Unfortunately, only the third prediction holds; this either weakens the validity of the model or casts some doubt on the construction of some variables we have used.[19]

The model was also estimated by using the underlying inflation instead of headline inflation.[20] The former was obtained by using annual variations of CPI without food and regulated prices.[21] As before, the results presented in Tables 4 and 5

variation in international food prices might be at play via inflation expectations.

[18] Some results, not included in the text, show that the permanent component of commodity prices variations is statistically significant explaining inflation expectations.

[19] Another version of the model was estimated by using inflation obtained from annualized monthly variation of CPI, the corresponding set of structural shocks and two versions of the inflation target: Monthly and annual. However the results are almost the same.

[20] This suggestion is due to an anonymous referee that we appreciate. Core inflation is measure as total inflation excluding food and administrated goods.

[21] Also annualized monthly variations of CPI without foods and

Table 3

ESTIMATES USING HEADLINE INFLATION, MONTHLY TARGET AND ONE-YEAR AHEAD EXPECTATIONS
(commodity prices denominated in local currency)

Expectation mechanism	*Constant*	*Expectation deviation*	*Demand-shock*	*Cost-push shock*	*Crude oil*	*Energy*	*Food*	*Number of observations*	*F*	*Adjusted* R^2
	Inflation targeting regime (January 2000 to December 2013)									
BEI	0.002	1.061[a]	0.001[b]	−0.002	−0.009		0.008	166	21.05	0.619
	0.002	1.073[a]	0.001[a]	−0.002		−0.008	0.006	166	18.54	0.609
Forward BEI	−0.001	1.057[a]	0.001	−0.001	−0.016[b]		0.010	166	11.24	0.593
	−0.001	1.079[a]	0.001	−0.001		−0.017[b]	0.009	166	10.41	0.579
Imperfect rational	−0.002	1.305[a]	0.000	−0.000	−0.005		0.022[b]	168	52.93	0.800
	−0.002[c]	1.321[a]	0.000	−0.000		−0.003	0.020[b]	168	52.93	0.796
	January 2000 to December 2006									
BEI	−0.001	0.913[a]	0.001[a]	−0.000	−0.006[c]		0.006	82	14.94	0.543
	−0.001	0.916[a]	0.001[a]	−0.001		−0.006	0.006	82	15.65	0.538

Forward BEI	−0.002[a]	0.799[a]	0.000	0.000	−0.007[b]		0.001	82	41.57	0.785
	−0.002[a]	0.804[a]	−0.000	−0.000		−0.008[b]	−0.000	82	50.33	0.785
Imperfect rational	−0.002[c]	1.107[a]	0.000	−0.000	−0.006		0.017	84	13.94	0.791
	−0.002[c]	1.118[a]	0.000	−0.000		−0.006	0.016	84	13.40	0.786
					January 2007 to December 2013					
BEI	0.004[b]	1.146[a]	0.001	−0.002	−0.012		0.011	84	23.65	0.684
	0.004[b]	1.168[a]	0.001	−0.002		−0.010	0.008	84	21.67	0.671
Forward BEI	−0.001	1.455[a]	0.001	−0.002	−0.027[a]		0.019	84	12.39	0.608
	−0.001	1.540[a]	0.001	−0.002		−0.030[a]	0.019	84	10.06	0591
Imperfect rational	−0.002	1.489[a]	0.001	0.001	−0.005		0.026	84	67.20	0.818
	−0.002	1.504[a]	0.000	0.001		−0.003	0.024	84	59.39	0.815

[a] represents significance at 1%, [b] at 5% and [c] at 10% based on Newey-West standard errors.
Source: authors' calculations.

include the monthly inflation target to compute the deviations of underlying inflation and inflation expectations; below we will use the annual target along the year.

In the version of the model in which commodity prices are denominated in dollars (see Table 4), demand and supply shocks have a more prominent role than in the case of headline inflation, mainly during the second subperiod; in contrast, commodity prices shocks do not have any significant effect on underlying inflation. Table 5 shows the results in which commodity prices are denominated in local currency. In this case, shocks to crude oil and energy prices are significant only in the second part of the sample under forward BEI expectations.

Models of Tables 4 and 5 have two important characteristics. First, the coefficients of expectations deviation are between 0 and 1 for the whole sample period and for period 2007-2013. Second, the coefficient of imperfect rational expectations is higher than the corresponding to BEI and forward BEI mechanisms. Thus, these data does not reject the model in these respects; however, the restriction that the coefficients of supply shocks and deviation expectations are equal is rejected.

These results may suggest that, under this optimal monetary policy framework –everything else equal–, inflation deviations are explained to a great extent by deviations of inflation expectations from target.[22] Therefore, as long as monetary authority reacts timely and accurately, such deviations should tend to decline, driving both underlying inflation and inflation expectations to the target. Moreover, an optimal monetary policy regime effectively conducts to a lesser exposure of inflation to commodity prices cyclical fluctuations.

Another version of the model corresponding to expressions 6 and 8 was obtained by using annual inflation target instead

regulated prices were used, but the results are, in general, the same.

[22] Recall we were expecting that cost-push shocks were also significant and that its coefficient be equal to the coefficient of deviations expectations. However, this restriction is not validated.

of the monthly one that we had been using so far.[23] The results in Table 6 suggest that the inflation process in Colombia is mainly driven by expectations. Structural and commodity prices shocks are only marginally important.

One remaining question is why the coefficients associated to inflation expectations in the cases of headline inflation are greater than in the cases of core inflation. Our intuition is that some of the permanent components of shocks are allowed to pass-through to transitory components of headline inflation but are not allowed to pass-through underlying inflation.

Estimation results for commodity prices denominated in local currency and with inflation expectations two years ahead are presented in Appendix 2. Results show an important decrease on the coefficients associated with the deviation of expectations from target for BEI expectations, indicating that, as time-horizon increases, inflation expectations converge to target.

[23] This specification was also recommended by an anonymous referee.

Table 4

ESTIMATES USING CORE INFLATION, MONTHLY TARGET AND ONE YEAR AHEAD EXPECTATIONS

(commodity prices denominated in dollars)

Expectation mechanism	*Constant*	*Expectation deviation*	*Demand-shock*	*Cost-push shock*	*Crude oil*	*Energy*	*Food*	*Number of observations*	*F*	*Adjusted R^2*
	Inflation targeting regime (January 2000 to December 2013)									
BEI	−0.011[a]	0.503[a]	0.001[a]	−0.001	−0.002		−0.009	166	4.75	0.295
BEI	−0.011[a]	0.505[a]	0.001[a]	−0.001		−0.001	−0.010	166	4.80	0.294
Forward BEI	−0.012[a]	0.626[a]	0.001	−0.000	−0.005		−0.010	166	5.09	0.451
Forward BEI	−0.012[a]	0.637[a]	0.001	−0.000		−0.006	−0.009	166	4.87	0.455
Imperfect rational	−0.013[a]	0.771[a]	0.000	0.000	−0.003		0.006	168	11.30	0.553
Imperfect rational	−0.013[a]	0.775[a]	0.000	0.000		−0.003	0.006	168	11.45	0.553
	January 2000 to December 2006									
BEI	−0.015[a]	1.006[a]	0.001[c]	0.000	−0.002		−0.017	82	25.45	0.652
BEI	−0.015[a]	1.007[a]	0.001[c]	0.000		−0.001	−0.018	82	25.01	0.651
Forward BEI	−0.002[a]	0.748[a]	0.000	−0.000	−0.004		−0.014	82	18.93	0.685
Forward BEI	−0.002[a]	0.751[a]	0.000	−0.000		−0.004	−0.014	82	19.08	0.684

Imperfect rational	−0.016[a]	1.078[a]	−0.001	0.001	0.001		0.000	84	19.05	0.747
	−0.016[a]	1.094[a]	−0.001	0.001		0.004	−0.002	84	17.80	0.750
					January 2007 to December 2013					
BEI	−0.007[a]	0.272[a]	0.001[a]	−0.002[a]	−0.003		0.000	84	4.53	0.418
	−0.007[a]	0.280[a]	0.001[a]	−0.002[a]		−0.003	−0.001	84	5.05	0.415
Forward BEI	−0.008[a]	0.272[a]	0.002[a]	−0.002[a]	−0.006		0.000	84	6.69	0.271
	−0.008[a]	0.286[a]	0.002[a]	−0.002[a]		−0.007	−0.001	84	6.98	0.266
Imperfect rational	−0.008[b]	0.339[a]	0.001[b]	−0.001	−0.004		0.008	84	4.24	0.458
	−0.008[b]	0.349[a]	0.001[b]	−0.001		−0.004	0.007	84	4.26	0.454

Note: [a] represents significance at 1%, [b] at 5% and [c] at 10% based on Newey-West standard errors.
Source: authors' calculations.

Table 5

ESTIMATES USING CORE INFLATION, MONTHLY TARGET AND ONE YEAR AHEAD EXPECTATIONS
(commodity prices denominated in local currency)

Expectation mechanism	*Constant*	*Expectation deviation*	*Demand-shock*	*Cost-push shock*	*Crude oil*	*Energy*	*Food*	*Number of observations*	*F*	*Adjusted R^2*
	Inflation targeting regime (January 2000 to December 2013)									
BEI	−0.011[a]	0.486[a]	0.001[b]	−0.001	−0.004		0.000	166	4.57	0.280
	−0.011[a]	0.491[a]	0.001[b]	−0.001		−0.003	0.000	166	4.60	0.278
Forward BEI	−0.012[a]	0.622[a]	0.001[b]	−0.001	−0.008		−0.003	166	7.33	0.434
	−0.012[a]	0.637[a]	0.001[b]	−0.001		−0.009	−0.002	166	6.57	0.436
Imperfect rational	−0.013[a]	0.768[a]	−0.000	0.000	−0.003		0.008	168	10.16	0.555
	−0.013[a]	0.773[a]	−0.000	0.000		−0.003	0.008	168	10.28	0.555
	January 2000 to December 2006									
BEI	−0.015[a]	1.008[a]	0.001	0.000	−0.002		−0.001	82	21.74	0.635
	−0.015[a]	1.009[a]	0.001	0.000		−0.000	−0.003	82	22.83	0.634
Forward BEI	−0.016[a]	−0.778[a]	0.000	0.001	−0.003		−0.007	82	17.76	0.682
	−0.016[a]	−0.780[a]	−0.000	0.001		−0.003	−0.007	82	18.11	0.681

Imperfect rational	−0.016[a]	1.078[a]	−0.001[c]	0.001	0.001		0.010	84	15.42	0.759
	−0.016[a]	1.092[a]	−0.001[c]	0.001		0.003	0.007	84	14.82	0.761
					January 2007 to December 2013					
BEI	−0.007[a]	0.269[a]	0.001[a]	−0.002[a]	−0.005		0.002	84	4.77	0.416
	−0.007[a]	0.277[a]	0.002[a]	−0.002[a]		−0.005	0.001	84	5.33	0.410
Forward BEI	−0.008[a]	0.253[a]	0.002[a]	−0.002[a]	−0.007[b]		0.005	84	8.33	0.269
	−0.008[a]	0.277[a]	0.002[a]	−0.002[a]		−0.008[c]	0.005	84	7.96	0.259
Imperfect rational	−0.008[a]	0.338[a]	0.001[b]	−0.001	−0.003		0.006	84	4.36	0.453
	−0.008[a]	0.345[a]	0.001[b]	−0.001		−0.003	0.006	84	4.42	0.451

Note: [a] represents significance at 1%, [b] at 5% and [c] at 10% based on Newey-West standard errors.
Source: authors' calculations.

Table 6

ESTIMATES USING CORE INFLATION, ANNUAL TARGET AND ONE YEAR AHEAD EXPECTATIONS
(commodity prices denominated in dollars)

Expectation mechanism	*Constant*	*Expectation deviation*	*Demand-shock*	*Cost-push shock*	*Crude oil*	*Energy*	*Food*	*Number of observations*	*F*	*Adjusted R^2*
Inflation targeting regime (January 2000 to December 2013)										
BEI	−0.009[a]	0.302[a]	0.001[c]	−0.000	0.001		−0.007	166	6.14	0.157
	−0.009[a]	0.299[a]	0.001[c]	−0.000		0.002	−0.008	166	6.38	0.159
Forward BEI	−0.011[a]	0.435[a]	0.001	−0.000	−0.001		−0.008	166	7.36	0.323
	−0.011[a]	0.438[a]	0.001	−0.000		−0.002	−0.008	166	6.98	0.323
Imperfect rational	−0.011[a]	0.476[a]	0.000	0.000	−0.000		0.003	168	8.21	0.287
	−0.011[a]	0.475[a]	0.000	0.000		0.000	0.002	168	7.46	0.287
January 2000 to December 2006										
BEI	−0.014[a]	0.761[a]	0.001	0.000	−0.001		−0.014	82	15.74	0.428
	−0.014[a]	0.767[a]	0.000	0.000		−0.000	−0.015	82	15.23	0.427
Forward BEI	−0.014[a]	0.594[a]	−0.000	0.001[b]	−0.002		−0.011	82	12.01	0.594
	−0.014[a]	0.595[a]	−0.000	0.001[b]		−0.002	−0.011	82	12.05	0.593

Imperfect rational	−0.015[a]	0.754[a]	−0.000	0.001[c]	0.000		−0.002	84	8.81	0.437
	−0.015[a]	0.756[a]	−0.000	0.001[b]		0.002	−0.003	84	8.42	0.439
					January 2007 to December 2013					
BEI	−0.006[a]	0.246[a]	0.001[a]	−0.001[b]	0.003		−0.006	84	5.34	0.379
	−0.006[a]	0.240[a]	0.001[a]	−0.001[b]		0.003	−0.007	84	5.80	0.382
Forward BEI	−0.007[a]	0.240[b]	0.001[a]	−0.001[b]	−0.000		−0.003	84	5.50	0.244
	−0.007[a]	0.238[b]	0.001[a]	−0.001[b]		0.000	−0.004	84	5.57	0.244
Imperfect rational	−0.007[a]	0.291[b]	0.001[b]	−0.001	0.001		0.002	84	3.62	0.366
	−0.007[a]	0.287[b]	0.001[b]	−0.001		0.002	0.001	84	3.57	0.368

Note: [a] represents significance at 1%, [b] at 5% and [c] at 10% based on Newey-West standard errors. Source: authors' calculations.

Table 7

ESTIMATES USING CORE INFLATION, ANNUAL TARGET AND ONE YEAR AHEAD EXPECTATIONS
(commodity prices denominated in local currency)

Expectation mechanism	*Constant*	*Expectation deviation*	*Demand-shock*	*Cost-push shock*	*Crude oil*	*Energy*	*Food*	*Number of observations*	*F*	*Adjusted R^2*
	Inflation targeting regime (January 2000 to December 2013)									
BEI	−0.009[a]	0.287[a]	0.001[c]	−0.001	0.001		−0.001	166	5.68	0.151
	−0.009[a]	0.284[a]	0.001[c]	−0.001		0.001	−0.002	166	5.88	0.152
Forward BEI	−0.011[a]	0.424[a]	0.001[b]	−0.000	−0.003		−0.003	166	8.68	0.309
	−0.011[a]	0.428[a]	0.001[b]	−0.000		−0.003	−0.003	166	8.21	0.308
Imperfect rational	−0.011[a]	0.474[a]	0.000	0.000	−0.000		0.005	168	8.83	0.293
	−0.011[a]	0.473[a]	0.000	0.000		0.000	0.004	168	7.84	0.293
	January 2000 to December 2006									
BEI	−0.014[a]	0.736[a]	0.000	0.000	−0.001		0.002	82	10.39	0.408
	−0.014[a]	0.733[a]	0.000	0.000		0.001	0.001	82	10.92	0.407
Forward BEI	−0.014[a]	0.604[a]	−0.000	0.001[b]	−0.001		−0.003	82	10.41	0.583
	−0.014[a]	0.604[a]	−0.000	0.001[b]		−0.001	−0.003	82	10.53	0.582

Imperfect rational	−0.015[a]	0.745[a]	−0.001[c]	0.001[b]	−0.000		0.012[c]	84	8.14	0.469
	−0.015[a]	0.747[a]	−0.001[b]	−0.000		0.001	0.010	84	8.30	0.470
					January 2007 to December 2013					
BEI	−0.006[a]	0.252[a]	0.001[a]	−0.001[b]	0.002		−0.009	84	4.94	0.402
	−0.006[a]	0.248[a]	0.001[a]	−0.001[b]		0.002	−0.010	84	5.29	0.404
Forward BEI	−0.007[a]	0.248[b]	0.002[a]	−0.001[c]	−0.001		−0.006	84	6.15	0.264
	−0.007[a]	0.248[b]	0.002[a]	−0.002[b]		−0.001	−0.006	84	6.10	0.263
Imperfect rational	−0.007[a]	0.293[b]	0.001[b]	−0.001	0.003		−0.004	84	3.99	0.360
	−0.007[a]	0.286[b]	0.001[b]	−0.001		0.003	−0.005	84	3.86	0.363

Note: [a] represents significance at 1%, [b] at 5% and [c] at 10% based on Newey-West standard errors. Source: authors' calculations.

6. MAIN FINDINGS AND CONCLUSIONS

This paper analyzes the effects of the recent movements of commodity prices, in the domestic inflation of Colombia derived from an optimal monetary policy framework. The empirical specification is derived from a simple, yet intuitive, text-book model of a small open economy that follows an optimal monetary policy rule, close to those used by inflation targeting countries. The model is highly demanding in terms of variables; thus, we use different definitions of inflation, expectations, inflation target, and shocks. The estimations were performed for the whole period of the inflation targeting regime: January 2000 to December 2013 and two subsamples: from January 2000 up to December 2006 which corresponds to the period before the commodity boom and from January 2007 to December 2013, subsample period after the boom.

The whole picture shows an inflation process governed by expectations in Colombia. Our findings also suggest that crude oil, energy, and food price shocks have a small influence on inflation irrespective that commodity prices shocks are rated in dollars or Colombian pesos. This would support the recent findings in the literature of a substantial decrease in the pass-through of oil prices to headline inflation. Our interpretation is that much of permanent movements in commodity prices are passed through inflation via expectations if agents judge that such movements are persistent. Finally, the contribution of demand and cost-push shocks in inflation is also small.

The model and estimations suggest that under an optimal monetary policy framework –everything else equal– deviations of inflation from target will respond to deviations of inflation expectations from target. Therefore, as long as monetary authority reacts timely and accurately, such deviations will tend to decline, leading both inflation and inflation expectations to the target. In our view, monetary authority has faced rightly the shocks to commodity world prices. When the target was missed, in 2007 and 2008, the reasons should be others.

APPENDICES

Appendix 1

Identification and Estimation of Supply and Demand Shocks

The explanation of Cover, Enders and Hueng (2006), CEH, method can be undertaken by means of the standard Blanchard-Quah (1989), BQ, identification scheme; that is what we do first. Then we introduce the modification of CEH. Given the aggregate demand- aggregate supply model, AD-AS

1 $$y_t^s = y_{t/t-1} + \alpha\left(p_t - p_{t/t-1}\right) + \varepsilon_t \ ,$$

2 $$\left(y_t + p_t\right)^d = \left(y_{t/t-1} + p_{t/t-1}\right)^d + \eta_t \ ,$$

3 $$y_t^s = y_t^d \ .$$

Which can be expressed in matrix form

4 $$\begin{bmatrix} 1 & -\alpha \\ 1 & 1 \end{bmatrix}\begin{bmatrix} y_t \\ p_t \end{bmatrix} = \begin{bmatrix} 1 & -\alpha \\ 1 & 1 \end{bmatrix}\begin{bmatrix} y_{t/t-1} \\ p_{t/t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t \\ \eta_t \end{bmatrix},$$

5 $$\begin{bmatrix} y_t \\ p_t \end{bmatrix} = \begin{bmatrix} y_{t/t-1} \\ p_{t/t-1} \end{bmatrix} + \begin{bmatrix} 1 & -\alpha \\ 1 & 1 \end{bmatrix}^{-1}\begin{bmatrix} \varepsilon_t \\ \eta_t \end{bmatrix}.$$

with variance-covariance of the vector of structural shocks

$$\begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon,\eta} \\ \sigma_{\varepsilon,\eta} & \sigma_\eta^2 \end{bmatrix}.$$

Assuming that the expectation of each variable is a linear combination of its own lags, then Equation 5 reduces to a VAR model:

6 $$\begin{bmatrix} y_t \\ p_t \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix}\begin{bmatrix} y_t \\ p_t \end{bmatrix} + \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}\begin{bmatrix} \varepsilon_t \\ \eta_t \end{bmatrix}.$$

The long run- response of the shocks is given by:

7 $$\Psi_\infty = \left[I - A(1)\right]^{-1}\Theta \ ,$$

where $\Theta = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}, \quad A(1) = \begin{bmatrix} A_{11}(1) & A_{12}(1) \\ A_{21}(1) & A_{22}(1) \end{bmatrix}.$

According to BQ, imposing the assumption that the AD shock, η_t , has no long-run effect on output, and assuming that $\sigma_\varepsilon^2 = 1,\ \sigma_\eta^2 = 1,\ \sigma_{\varepsilon,\eta} = 0$ imply that $c_{12}\left[1 - A_{22}(1)\right] + c_{22}A_{12}(1) = 0$.

With this restriction, the signs of c_{ij} are not identified, and there are four possible solutions for those values, choosing the one that implies a positive long-run effect of demand shock on price and a positive long-run effect of supply shock on output.

On the other hand, CHE using the values of c_{ij} derived from Equation 5, and without imposing any restriction over the variance-covariance matrix of structural shocks, only one solution is gotten by assuming the neutrality condition in 7:

$$\begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} = \begin{bmatrix} \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix},$$

$$\alpha = A_{12}(1) / \left[1 - A_{22}(1)\right],$$

and the variance-covariance matrix of structural shocks can be estimated from the variance-covariance matrix of the VAR innovations, after knowing the value of α .

$$\begin{bmatrix} \mathrm{var}(e_{1t}) & \mathrm{covar}(e_{1t}, e_{2t}) \\ \mathrm{covar}(e_{1t}, e_{2t}) & \mathrm{var}(e_{2t}) \end{bmatrix} = \begin{bmatrix} \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} \sigma_\varepsilon^2 & \sigma_{\varepsilon,\eta} \\ \sigma_{\varepsilon,\eta} & \sigma_\eta^2 \end{bmatrix} \begin{bmatrix} \frac{1}{1+\alpha} & \frac{-1}{1+\alpha} \\ \frac{\alpha}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix}$$

In order to identify orthogonal structural shocks, the two ordering in the Cholesky decomposition are used. The first order assumes there is causality from supply shock, ε_t , to the demand shock, η_t , which may be imposed by assuming that $\eta_t = \rho\varepsilon_t + \nu_t$, where ν_t is a pure AD shock and ρ is the unexpected AD change due to an AS shock. On the other hand, the second order assumes there is causality from the demand shock to the supply shock. In this case, define $\varepsilon_t = \gamma\eta_t + \upsilon_t$, where υ_t is a pure AS shock and γ is the unexpected AS change induced by an AD shock.

Model in Equation 6 remains the same with any of the orderings, by assuming

$$\begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} = \begin{bmatrix} \frac{1+\alpha\rho}{1+\alpha}\sigma_{\varepsilon} & \frac{\alpha}{1+\alpha}\sigma_{v} \\ \frac{-(1-\rho)}{1+\alpha}\sigma_{\varepsilon} & \frac{1}{1+\alpha}\sigma_{v} \end{bmatrix}$$

or

$$\begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} = \begin{bmatrix} \frac{1}{1+\alpha}\sigma_{\delta} & \frac{\alpha+\gamma}{1+\alpha}\sigma_{\upsilon} \\ \frac{-1}{1+\alpha}\sigma_{\delta} & \frac{1-\gamma}{1+\alpha}\sigma_{\upsilon} \end{bmatrix}$$

then,

$$\begin{bmatrix} \text{var}(e_{1t}) & \text{covar}(e_{1t}, e_{2t}) \\ \text{covar}(e_{1t}, e_{2t}) & \text{var}(e_{2t}) \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} c_{11} & c_{21} \\ c_{12} & c_{22} \end{bmatrix}$$

Appendix 2

Results with Expectations Two Years Ahead

Table A1

ESTIMATES USING CORE INFLATION, ANNUAL TARGET AND TWO YEARS AHEAD EXPECTATIONS
(commodity prices denominated in local currency)

Expectation mechanism	*Constant*	*Expectation deviation*	*Demand-shock*	*Cost-push shock*	*Crude oil*	*Energy*	*Food*	*Number of observations*	*F*	*Adjusted* R^2
	Inflation-targeting-regime (January 2000 to December 2013)									
BEI	−0.008[a]	0.311[a]	0.001[a]	−0.001[b]	−0.004		0.000	132	21.35	0.340
	−0.008[a]	0.317[a]	0.001[a]	−0.001[b]		−0.004	0.001	132	19.04	0.337
Imperfect rational	−0.009[a]	−0.065	0.000	−0.000	0.001		0.007	168	1.816	0.000
	−0.008[a]	−0.073	0.000	−0.000		0.002	0.005	168	1.825	0.004
	January 2000 to December 2006									
BEI	−0.011[a]	0.495[a]	0.001	−0.000	−0.009[a]		0.007	48	36.43	0.535
	−0.011[a]	0.500[a]	0.001	−0.000		−0.009	0.008	48	34.99	0.524
Imperfect rational	−0.012[a]	−0.008	−0.000	0.001[a]	−0.000		0.014	84	2.251	0.020
	−0.012[a]	−0.015	−0.000	0.001[a]		0.000	0.013	84	2.341	0.020

	January 2007 to December 2013									
BEI	−0.007[a]	0.288[a]	0.001[a]	−0.001[a]	−0.000		−0.008	84	6.101	0.385
	−0.007[a]	0.287[a]	0.001[a]	−0.001[a]		0.000	−0.009	84	6.392	0.385
Imperfect rational	−0.007[a]	0.104	0.002[a]	−0.002[a]	0.003		−0.007	84	2.825	0.101
	−0.007[a]	0.094	0.002[a]	−0.002[a]		0.005	−0.008	84	2.879	0.116

Note: [a] represents significance at 1%, [b] at 5% and [c] at 10% based on Newey-West standard errors.
Source: authors' calculations.

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