Institute for International Economic Policy Working Paper Series
Elliott School of International Affairs
The George Washington University

Public Information and Household Expectations in Developing Countries: Evidence From a Natural Experiment

IIEP-WP-2009-8

Paul Carrillo
George Washington University

M. Shahe Emran
George Washington University

April 2009

Institute for International Economic Policy
1957 E St. NW, Suite 502
Voice: (202) 994-5320
Fax: (202) 994-5477
Email: **iiep@gwu.edu**
Web: **www.gwu.edu/~iiep**

PUBLIC INFORMATION AND HOUSEHOLD EXPECTATIONS IN DEVELOPING COUNTRIES: EVIDENCE FROM A NATURAL EXPERIMENT[1]

Paul Carrillo
Department of Economics
George Washington University

M. Shahe Emran
Department of Economics
George Washington University
and IPD, Columbia University

This version: April 2009

ABSTRACT

Governments provide public information about economic conditions to reduce information imperfections and facilitate efficient allocation of resources. Do households in developing countries rely on public signals to inform themselves about market conditions? To identify the importance of public information in households' price expectations, we take advantage of a unique natural experiment in Ecuador where the published inflation rate had been different from the true rate over a period of 14 months due to a software error. We find that the public signal about prices plays an important role in households' price expectations; the effect is stronger for better educated families, older people and men.

Keywords: Public Information, Price Expectations, Developing Countries, Natural Experiment, Heterogeneity

JEL Codes: O12, D10, D84

[1]We would like to thank Jeffrey Wooldridge, Steve Pischke, Rob McMillan, Dave Ribar, Caridad Araujo, Bryan Boulier, Alberto Chong, Shawn Cole, Fred Joutz, Wally Mullin, Norbert Schady, Stephen Smith, Tony Yezer, Forhad Shilpi and participants at the GWU Trade and Development Workshop for useful discussions and/or comments on an earlier draft. We are grateful to Juan Ponce from the Facultad Latinoamericana de Ciencias Sociales FLACSO-Ecuador for sharing the survey data with us and to Miguel Acosta and Wilson Perez from the Central Bank of Ecuador for their collaboration. The usual disclaimers apply.

Introduction

Governments provide public information about market conditions in part to reduce information imperfections and facilitate efficient allocation decisions in the economy. For example, consumer and producer price indices, indicators of aggregate economic activity such as GDP and the unemployment rate are regularly published by government agencies in almost all countries in the world. Rational agents are expected to use both public signals and idiosyncratic information generated by their own experiences to form expectations about the future and make their consumption and investment decisions. Do agents rely more on their own private information or on public signals to inform themselves about market conditions?

This paper takes advantage of a unique natural experiment in Ecuador to identify the effects of the information provided by the government about prices (the published inflation statistics) on households' expectations about the evolution of future prices. The evidence suggests that the public signal about prices plays an important *causal* role in the formation of households' price expectations and the effect is heterogeneous. The public price signal (published inflation rate) has a stronger effect on the price expectations of older people, better educated families and men.[2] To the best of our knowledge, this is the first paper in the literature to provide credible evidence on the *causal effect* of public information on household expectations formation.

In an idealized Arrow-Debreau competitive economy, the equilibrium prices faced by the agents in their market interactions are sufficient statistics: they aggregate all the dispersed

[2]The survey data available do not allow us to analyze the effects of public information on 'inflation expectations'. The survey contains information regarding the direction of expected price change (Do you think that prices will increase in next twelve months?). Our analysis thus focuses on 'price expectations' of households.

information across the economy in an efficient way. Thus, in such an environment, there is no role for any public signal, especially relating to prices. In a more realistic setting, the equilibrium prices faced by a household in any local market may not be sufficient statistics because of lack of market integration (especially relevant in developing countries with underdeveloped infrastructure) and also due to imperfect and asymmetric information. Thus the price data published by a central statistical agency (the CPI and inflation rate, for example) can play a useful role in aggregating dispersed information in an economy and help households and firms better understand the prevailing market conditions. In an economy with an incomplete set of markets, other non-price signals like the unemployment rate and output gap can also affect expectations of economic agents as to the likely evolution of prices in the economy; in the context of developing countries where the set of markets is rather limited, such quantity signals might be especially important.

Recent theoretical analysis shows that the importance of public information (signals) depends on the structure of interactions among agents (see, for example, Angeletos and Pavan 2007 and 2008, Amador and Weill, 2008, and Morris and Shin, 2002). Since public signals such as published statistics on economic activity or prices aggregate the dispersed information across the economy and thus reveal information about the actions of others, it is optimal for an individual agent (household) to put more weight on the public information when actions of different agents are strategic complements. Naturally, the importance of the public signal is a positive function of the strength of complementarity. A growing theoretical literature on the social value of public information shows that what is critical for welfare analysis is the weight that agents put on public information relative to their idiosyncratic private information. The related literature on social learning and herd behavior shows that

when individual agents rely more on public signals and thus underutilize their idiosyncratic information, this might create inefficient herd behavior and also retard the process of social learning (Banerjee, 1992, and Amador and Weill, 2007). There is, however, a long tradition in development economics that emphasizes the potentially beneficial role of public signals in escaping from low level equilibrium traps. When public signals are important in the formation of expectations of economic agents, the government may be able to coordinate expectations of private agents to attain Pareto-superior outcomes as emphasized in the recent literature on poverty traps and economic development (see, for example, Murphy et al., 1989, Rodriguez-Clare, 1996, Ray, 1998, Hoff and Stiglitz, 2001, and Bowles et. al., 2006).[3]

The literature on inflation expectations in developed countries is vast with many interesting and insightful contributions. The focus of a large part of the literature has been on relaxing the assumptions of the rational expectations model to better explain the dynamics of inflation observed in the data (see, for example, Sargent, 1993, MacCallum, 1992, Pesaran, 1987). The related literature on the New Keynesian Phillips Curve has been an active area of research with influential contributions (Gali and Gertler, 1999, Gali, Gertler, and Lopez-Salido, 2005, Woodford, 2003, Roberts, 1997, Fuhrer and Moore, 1995). The more recent literature on the sticky information (or rational inattentive agent) models of inflation expectations emphasizes the possibility that rational agents update their inflation expectations only periodically given the cost of acquiring price information (see, for exam-

[3]One can make an argument that the role of public information in developing countries is limited by lack of education and paucity of information transmission channels. However, because developing countries are also relatively "information poor," it is more likely that public information is not crowded out in the competition for scarce "attention" of the economic agents (Falkinger, 2008).

ple, Mankiw et al. 2003, 2006; Sims, 2003, Woodford, 2003, Branch, 2007; Carroll, 2003, Klenow and Willis, 2007). In contrast to developed countries, the literature on the inflation expectations (more generally price expectations) of households in developing countries is limited at best. Most of the existing literature on inflation in developing countries use aggregate macro models and aggregate data (see Jha, 2003, and Agenor and Montiel, 1999). The focus of this paper is rather different compared to the extant literature on inflation in both developed and developing countries.[4] It addresses the following question: how much does publicly provided price information affect the price expectations of the households? We provide some first credible evidence on the *causal effect* of public information on household price expectations in the context of a developing country, Ecuador.[5]

We utilize a unique natural experiment in Ecuador to identify and estimate the relevance of public information (the published inflation rate) to households' expectations about future prices. In March 2006, the National Bureau of Statistics of Ecuador (INEC) publicly announced a mistake on its consumer price index and inflation rate statistics. The mistake

[4]The literature on inflation has used the public information on inflation and unemployment to test two things. First, as a test of rationality, the focus has been on the question if the forecast error in inflation is systematically related to the available public information. Second, it has been used to test if a simple adaptive expectations model can fit the data well enough. The null hypothesis of adaptive expectations imply that there should not be any additional information in the published inflation and unemployment rates. For an interesting recent analysis, see Mankiw et. al. (2003). They find that the *forecast error* is systematically related to public information such as published inflation and unemployment statistics. They also find that the data reject a simple adaptive expectations model. Our focus is on the role of public information in the formation of the inflation expectations and thus we do not address the issue of rationality.

[5] To the best of our knowledge, there is no work that analyzes the effects of public signals on the price expectations in developing countries. Even in developed countries, the literature on modeling the actual inflation expectations of households using survey data is rather limited, as emphasized recently by Carroll (2003). Most of the work on inflation dynamics uses either time series macro data or focuses on explaining the central tendency in the household survey data utlizing the time variations for identification. For example, the dependent variable in the extensive analysis in Mankiw et. al. (2003) is the median inflation expectations. Recent exceptions include Bryan and Venkatu (2001), Branch (2004, 2007) along with Carroll (2003).

was attributed to a programming error that started in January 2005 after a new software was introduced. In April 2006, a revised series for the past 14 months was released. The resulting adjustments were large. For instance, the official annual inflation rate in February 2006 dropped from 5.3 percent to 3.8 once the correction was made. This was an unexpected event considering that the INEC had been successfully measuring prices for almost 40 years.

We use household survey data to analyze the effects of the exogenous change in the published inflation statistics arising from the programming error on household's survey expectations regarding future prices. The data set is a monthly survey used by the Central Bank of Ecuador to compute employment statistics and consumer confidence indexes in the three largest urban areas of the country. The survey contains information on the households' expectations about future prices as well as their individual characteristics (education, age, gender and income). We model price expectations as a function of the public signal, private information, and household's demographic characteristics. Probably the most important difficulty in isolating the effects of public information is to find adequate controls for the private information available to the households through the daily market interactions, for example, at the groceries, gas stations, and department stores. In the absence of adequate controls for the local information, public signals such as published inflation statistics (even if they are incorrect) will also reflect the private information as the CPI would be correlated with the local prices. We address this problem in three steps. First, we measure the public signal as the part of incorrect inflation which is due to the programming error (i.e., the gap between the incorrect and true inflation rates). Second, we use the true inflation rate as an additional control in the regressions. The actual CPI and inflation rate during the 14 month period when INEC had been publishing the incorrect CPI was unobservable to the

households. We use this unobserved city level inflation rate as a control for the idiosyncratic information set of the households in the different cities in the data set. The unobserved true inflation rate would affect household price expectations only insofar as it is correlated with the local price information. So it is likely to be an excellent control for the local prices correlated with the public signal. Finally, in all of the specifications, we employ city and month fixed effects.

The central result from the empirical analysis is that the public signal about prices plays an important role in the formation of household's price expectations. When the deviation of the incorrect inflation rate from the correct but unknown inflation rate is larger, the probability that a household expects the prices in the next twelve months to go up is also higher, after controlling for the correctly measured inflation rate, month and city fixed effects and individual characteristics like gender, age, education, and income. The effects of the public signal on household price expectations is heterogeneous.[6] That is, the effects are stronger for households headed by better educated and older people. There is also evidence of a gender effect, the price expectations of men are more influenced by the public signal compared to women. The estimated effects of public price signal are not small in terms of the magnitudes; for example, a 3 percentage points increase in the public price signal increases the number of households that think that the future prices would go up by about 10 percent according to the estimates that ignore the heterogeneity in the effects of the public information. The results from the more general specification that allows for

[6]The heterogeneity arises from differences in information sets. At any given period, a household would acquire information on only a small subset of the relevant variables as information acquisition is costly and depends on the availability of information channels. Even if information is available at no cost, different individuals are likely to have different information sets because of bounded rationality considerations (Sims, 2006). The importance of public signals may thus depend on individual characteristics such as education, age, gender and income.

heterogeneity imply that a 3 percentage points increase in the public signal would increase the probability that an individual expects prices to go up by about 0.14 if the individual has 18 years of education, while the corresponding number for an uneducated individual is only 0.047. The price expectations of young and uneducated women are not affected by the public information.

The rest of the paper is organized as follows: Section 1 provides brief background on Ecuador and the workings of INEC, the country's central statistical agency, before explaining details of the programming error in measuring the CPI from January 2005 to March 2006. The next section presents a conceptual framework and discusses our econometric strategy. Sections (3) and (4) describe the data and present the empirical results, respectively. Finally, the last section concludes with a summary of the findings.

(1) Measuring Prices in Ecuador

(1.1) Country Background

Ecuador is a developing country in South America. In 2006, its per capita GDP was close to $3,200, lower than most of the other countries in this continent except Bolivia and Paraguay. Ecuador's economy relies heavily on the oil industry. Oil exports accounted for about 55 percent of its total exports and more than 25 percent of the Central Government revenue came from oil-related royalties in 2006.

Ecuador suffered a severe financial crisis at the end of 1999 that precipitated a collapse of the banking system and a contraction of more than 6 percent in GDP. By December 1999, the national currency (sucre) had depreciated 195 percent over the past year and inflation rate accelerated from an annual rate of 27 percent in January 1998 to 78 percent

in January 2000. In January, 2000, a presidential decree approved a series of structural reforms to address the ongoing crisis including the adoption of the US dollar as the legal currency of the country (i.e., 'dollarization' in popular parlance). A slow economic recovery followed. Higher oil prices and increased remittances helped the country achieve an average annual growth rate close to 5 percent from 2001 to 2006. In addition, inflation drastically decreased from a peak of 108 percent in September 2000 to 16 percent in January 2002 and less than 2 percent by the end of 2004. Figure 1 shows the steady decline in inflation rates until the end of 2004; from this point on, inflation rates seemed to stabilize at around 4 percent.

(1.2) The Ecuadorian National Institute of Statistics: Methods and Credibility

Soon after its creation in 1976, the Ecuadorian National Institute of Statistics (INEC) started to compute Consumer Price Index (CPI) data on monthly basis. In the first workday of each month, the institute generally releases CPI data of the previous month. The INEC provides the official inflation estimate that is used for all legal matters in the country. Consistent with international practice, the CPI is computed as a weighted average of the prices of a representative basket of goods and services. The basket, weights, and base year are determined using information from the most recent income-and-expenditure survey.[7]

The INEC's director is appointed by the President. The lack of independence from the executive power may compromise the credibility of its statistics. However, manipulation of price statistics by INEC for political purpose has not been a serious concern in Ecuador.

[7]Income-and-Expenditure surveys are carried out by the INEC. The latest surveys were performed in 1975 (July 1975 – June 1976), 1994 (September 1994 – August 1995), and 2003 (February 2003 – January 2004).

The INEC follows a strict methodology to construct the CPI which limits the institute's ability to modify its estimates to suit political goals.[8] Its CPI and inflation estimates are deemed credible enough to be used by several international organizations such as the International Monetary Fund (IMF) and World Bank in their official statistics.

(1.3) The Natural Experiment: INEC's "Mistake"

Until December 2004, INEC constructed the CPI using a basket of approximately 195 goods and services that was determined using an income-and-expenditure survey from September 1994 to August 1995. From February 2003 to January 2004, a new survey was implemented and a basket of 299 goods and services was selected.[9] The INEC used this new basket to change the base year of the CPI and, starting in January 2005, its computation was based on this new basket (INEC, 2005). In March 19, 2006, the INEC publicly announced a mistake that affected the CPI indices published over the previous 14 months.[10] The revised CPI statistics for the 14 month period were published in April 5, 2006, and the resulting adjustments were large. For instance, as shown in Figures 2 and 3, the national annual inflation rate in February 2006 dropped from 5.3 percent to 3.8 percent once the correction was made.

We are not aware of any formal government publication that documents the details of this event except for a footnote in a statistical report published by the Central Bank of Ecuador (see Banco Central del Ecuador 2006, Table 4.1.1a, Footnote 1). To understand

[8] Other type of government statistics (such as GDP growth) may be more vulnerable to "adjustments" due to political pressure by the government and thus likely to be less credible.

[9] The new basket includes several items that households consumed in 2004 but were not available in 1994; these include cellular phones, DVD players, and personal computers, for example (INEC 2005).

[10] On March 19 2006, the INEC made a press release acknowledging a mistake in its CPI statistics (See, for example, *El Comercio*, pg 12, March 19, 2006, *Expreso*, pg. 8 March, 20, 2006, and *El Universo*, pg. A.10, March 21, 2006). Revised series were announced on April 5, 2006 (*El Universo*, pg A.2, April 6, 2006).

the nature of the INEC's mistake, we interviewed several staff members of the INEC, the Central Bank of Ecuador, and other government agencies and examined internal reports and presentations. The mistake was attributed to an error in the programming code (a bug) in the software that the INEC used to compute the CPI. Essentially, the error overestimated the price of housing and underestimated the prices of food-and-beverages. Other products were unaffected.[11] The adjustments in housing prices are particularly large. To estimate the housing CPI the INEC measures the rents of a sample of rental units in urban areas. Rental units in the sample are visited twice a year (once every six months). That is, about one sixth of the units in the sample are visited each month, the gross rent paid by the tenants is recorded, and a six-month rental change is estimated. After the base year was changed, INEC's software incorrectly imputed this *six-month* change as a *one-month* change. Such error can introduce large upward biases in the CPI statistics. For instance, if rental prices grow by 6 percent a year, the INEC's (incorrect) estimates would predict an annual 40 percent increase.

To measure prices of food-and-beverages, the INEC collects information on prices of a large number of fruits, vegetables, cereals, and beverages. Most of these data are gathered twice a month (once every two-weeks). After the data are collected, a two-week price change is computed. INEC's software incorrectly imputed this *two-week* price change as a *one-month* change introducing a negative bias in the CPI statistics.

Until July 2005 the downward bias in the prices of food-and-beverages were larger than the positive bias in the rental price. Thus, from January to July 2005, the "true" CPI was

[11]The INEC's press release on March 19 2006 briefly described the error in the housing component of the CPI. When the revised series where released, the mismeasurement of both food and housing components where acknowledged (see for example, *El Universo*, pg. A.2, April 6, 2006, *Expreso*, pg. 7, April 6, 2006, and *Dinero, Diario de Negocios*, pg. 1, April 6, 2006).

higher than the one that was originally reported. From July 2005 until February 2006, on the other hand, the positive biases were larger. The mistake in the INEC's CPI software was an unexpected event. More importantly, the adjustments made to the CPI (due to the nature of the error) and the time when the mistake was discovered are plausible exogenous events to any individual or household in the economy. We use these exogenous changes in the published CPI series to analyze the relationship between the household's expectations about future prices and the information provided by the government (the public signal). The next section discusses the econometric strategy in more detail and also lays out a simple conceptual framework to guide the empirical analysis.

(2) Conceptual Framework and Econometric Strategy

(2.1) Conceptual Framework

The expectation of an individual or a household i regarding an economic variable in period $t+1$ (denoted as X_{t+1}) is formed using the information available at the current period t. The expectation formation can be described as follows:

$$E_{i(t)}\left(X_{t+1}\right) = F\left(\Omega_{i(t)}, \Omega_{p(t)}, Z_i, \epsilon_i\right), \tag{1}$$

where the expectation regarding period $t+1$ is formed at period t utilizing two sources of relevant information: public $\left(\Omega_{p(t)}\right)$ and private $\left(\Omega_{i(t)}\right)$ information sets, and Z_i and ϵ_i are observable and unobservable individual or household characteristics respectively that may affect expectations formation.[12] The vector Z includes characteristics of households

[12] In an early analysis of inflation in Sweden, Jonung (1981) shows that public's expected inflation depends on their perception about the past inflation. The perception is formed using "two sets of data: (a) the public's recollection of price indices, collected and published primarily by government agencies, and (b)

such as education and age, while ϵ is a scalar that captures the idiosyncratic unobserved differences across households. The public information set consists of primarily the statistics published by government statistical agencies. In addition, professional inflation forecasts and independent media reports might be relevant, but they are rare in a developing country .[13] As discussed before, the typical elements in the private information set are prices faced in the daily market interactions, and also price information learnt from family, friends and neighbors. Assuming that the expectation function can be approximated by a linear conditional expectation function, we have the following specification (to simplify notation, assume that the information sets are singletons):

$$\begin{aligned} E_{i(t)}\left(X_{t+1}\right) &= E_{i(t)}\left(X_{t+1} \mid \Omega_{i(t)}, \Omega_{p(t)}, Z_i, \epsilon_i\right) \\ &= \gamma_0 + \gamma_1 \Omega_{p(t)} + \gamma_2 \Omega_{i(t)} + Z_i^{'} \Pi + \epsilon_i. \end{aligned} \tag{2}$$

Here γ_1 measures the relevance of the public signal and its relevance depends primarily on the precision (information content) of the public information relative to the private information (Amador and Weill, 2008).

The model in equation (2) is, however, restrictive in that it imposes a homogeneity restriction on the conditional response of agents to public information. We introduce heterogeneity in the effects of public information by including its interaction with the household head's characteristics like age, education and gender and also household income.

the individual's own experience of surveying prices and purchasing goods and services" (P. 962).

[13] Carroll (2003) develops and estimates an inflation expectations formation model using data from USA where the general public adopt the professionals' forecasts with a certain probability rather than trying to form their own rational forecast.

The general model of expectation can thus be written as follows:

$$\begin{aligned} E_{i(t)}\left(X_{t+1}\right) &= \gamma_0 + \gamma_1 \Omega_{p(t)} + \left(\Omega_{p(t)} * H_i\right)' \Gamma \\ &\quad + \gamma_2 \Omega_{i(t)} + Z_i' \Pi + \epsilon_i, \end{aligned} \tag{3}$$

where $H_i \subseteq Z_i$ is a vector of relevant characteristics of agent i such as age, gender, and education that might influence the impact of the public signal. A better educated individual is expected to be more responsive to the public signals because of better access to information channels and improved cognitive ability, among other things. Age might play a role as older people may be more budget-conscious and worry about prices more given a flat or declining earnings profile. They might also respond more to the public signal as the demands on their attention might be less when they are not active in the labor market. The gender difference in the effect of public signal may be due to differences in exposure to the media and differential in the precision of private information sets. Women usually do the daily shopping at the groceries and department stores, and thus are likely to have more market interactions than men. This means that the women will tend to have more precise information about the price trends in their own neighborhood and may rely more on the private information set when forming price expectations. The household income might determine the information channels available (such as television and radio) and thus affect the likelihood that the public signal reaches a given household.[14]

[14]The data set does not contain information on ownership of television and radio. However, we believe that household income and education are reliable controls for such heterogeneity in information channels. Also, note that it is unlikely that the ownership of television and radio would change significantly in a period of 14 months.

(2.2) Econometric Strategy

The source of the error in the INEC's estimates of CPI and inflation rate over the 14 month period is a random mistake in the computer software used to calculate the CPI. We use this "natural experiment" as the source of exogenous variations to identify the effects of public information about prices on the price expectations of households. One may, however, plausibly argue that the incorrect inflation rate or CPI is a deterministic function of the components of the true CPI, and thus it is correlated with the actual prices faced by the households in their daily market interactions. This means that in itself the incorrect inflation rate cannot identify the causal effects of the public signal as it may capture at least part of the private information set. To address this concern, we use a three pronged strategy. First, we measure the public signal as the part of incorrect inflation which is due to the programming error (i.e., the gap between the incorrect and true inflation rates).[15] Second, we add the true inflation rate (published in April 2006) in the city of residence of a household as an additional control in our empirical models. As discussed before, the "true" inflation rate was unobservable to households during the 14 month period when INEC had been publishing incorrect estimates and, it is plausible that this true inflation is correlated with the prices faced by the households in their daily market interactions. Thus, the true but unobserved inflation rate can be used as a control for the idiosyncratic price information of the households in the different cities in the data set. We emphasize here again that the true inflation rate is likely to be a good control for identification of the effect of public signal as it captures any private information that might be correlated

[15]We believe that the inflation rate rather than the CPI is the relevant public signal for forming expectations regarding future prices. The public release of price statistics and media reports concentrate mostly on the inflation rate and thus the households price perceptions are likely to respond to the published inflation rates.

with the public signal, i.e., the difference between the incorrect and correct inflation rates. If the true inflation rate is not correlated with the private information, it should have no impact on household's expectations, as it was not observed at that time. Third, all of the empirical models in this paper include city and month fixed effects. The city fixed effects control for the differential but time invariant component of the idiosyncratic information set available to the households in a given city, while the month fixed effects sweep off the effects of any macroeconomic news common to the cities which might influence the expectations of the households. One can also appeal to the voluminous literature on Phillips curve to argue that a household's price expectations and the labor market conditions are closely related. For identification of the effects of public price signal on household price expectations, we thus need to control for public signals on the labor market conditions, in particular the unemployment rate. To alleviate such concerns, we include city level monthly unemployment rate as an additional control in the regressions. The upshot of the above discussion is that conditional on the true inflation rate, city and month fixed effects and city level unemployment rate, the difference between the incorrect and the true inflation rates can be treated as a valid natural experiment for identification of the effects of public information on the price expectations of the households. If the public price signal does not matter, then the mistake itself should not affect household's expectations after controlling for the factors mentioned above.

To test this hypothesis, we use a simple empirical model based on equation (3) above. As is common with the survey data on price expectations, our data set from three cities in Ecuador provides us information about the direction of price expectations. More precisely, the survey allows us to use a binary variable which takes on the value of 1 when a household

thinks that the prices will go up in the next twelve months. Given the binary nature of the price expectation variable, we use a probit model:[16]

$$E\left(P_{ic(t+1)} \mid .\right) = \Phi \left(\begin{array}{c} \beta_0 + \beta_1 \tilde{P}_{ic(t)} + \left(\tilde{P}_{ic(t)} * H_i\right)' \Upsilon \\ +\beta_2 \hat{P}_{ic(t)} + \beta_3 U_{ic(t)} + Z_i' \Pi \end{array} \right) \tag{4}$$

where $P_{ic(t+1)}$ is a binary price expectation variable that takes on a value of 1 if the household i in city c surveyed in month t expects that the prices will go up in next twelve months, $\tilde{P}_{ic(t)}$ is the gap between the incorrect and correct inflation rate available to the household at period t, $\hat{P}_{ic(t)}$ is the true inflation rate, Z_i is a vector of household characteristics, and $H_i \subseteq Z_i$ is the subset of household characteristics that might influence the strength of the public signal's impact. Our focus is on the identification and estimation of the parameters β_1 and Υ. The model in equation (4) above is parsimonious in the sense that the public and private information sets include only the latest information available at period t on the relevant variables. In a general model, additional information from the past periods may be relevant in forming the household price expectations. For example, in addition to the most recent published inflation rate, the magnitude of the change in inflation rate between the last two periods may be important for the determination of expectations.[17] In the empirical analysis, we explore this possibility and check the robustness of the conclusions reached on the basis of the parsimonious specification in equation (4) above.

[16] In the empirical implementation, we also report results from linear probability model and logit model in an appendix.

[17] It is reasonable to assume that people pay more attention to the inflation rate when there is a relatively large change from one period to the next. Given the sample size, it is not possible to estimate a more general dynamic model.

(3) The Data and Variables

To estimate equation (4) we use data from a monthly survey that has been used by the Central Bank of Ecuador to produce consumer confidence indices and unemployment statistics.[18] The survey was financed by the Central Bank of Ecuador and carried out by the Facultad de Ciencias Sociales FLACSO-Ecuador, a leading university in the country. It is representative of the population of Quito, Guayaquil, and Cuenca, Ecuador's three largest urban centers.

The sample consists of a rotating panel of more than 3,000 households (dwellings). Each month, about 2,300 of these households are interviewed, and information about employment, earnings, and basic demographic characteristics (such as education and marital status, for example) for each member of the family is collected. In addition, the respondent is asked twenty questions about her well being and her perceptions about the economic prospects of the country. The following question regarding price expectations forms the basis of our analysis: "Within the next 12 months, do you think that prices will increase, decrease, or stay the same?" As noted earlier, we create a dummy variable which equals one when a household response to the above question is that they think the prices will increase in the next twelve months.

The survey data have been matched with inflation estimates from the INEC which vary by city and month. Both the incorrect and the revised estimates of inflation have been recorded. Since at the time they are surveyed respondents are only aware of the past month inflation estimates, the pricing data correspond to the annual inflation rate of the previous

[18]The employment survey is used to compute a Consumer Confidence Index (see, for example, Banco Central del Ecuador 2007) and unemployment statistics (see, for example, Banco Central del Ecuador 2006, Table 4.1.7).

month when the survey was made. For example, those households surveyed in March 2006 have been matched with inflation data of February 2006. In addition, the data set provides information about the head of the household's demographic characteristics such as gender, education, age, marital status, income, and number of children. A list and definition of the variables are presented in Table 1. To estimate equation (4), we use survey data from April 2005 to March 2006, the period when the "wrong" public signal was released.[19]

Descriptive statistics are shown in Table 2. The incorrect average annual inflation rate in Quito, Guayaquil and Cuenca published in March 2006 was close to 4.7 percent and dropped to 3.1 percent once the error was found.[20] The average size of the adjustment was smaller in the previous 11 months decreasing from an average incorrect estimate of 2.4 to 2.0 percent. As shown in Figure 4, there is substantial variation in both correct and incorrect inflation estimates in each of these cities. The typical household was headed by a 47 year old male with 9 years of education. Household income averages about $330 per month although income distribution is clearly skewed to the right with a handful of households earning more than $5,000 per month.

(4) Empirical Results

Public Signal and Household Expectations About Price Changes

Table 3 reports the estimation results from probit model (marginal effects evaluated at the sample means) based on equation (4) above. We report estimates from a number of alternative specifications. The first column of this table reports the simplest specification,

[19]INEC's mistake started in January 2005. Unfortunately, we only have survey data from April 2005.

[20]Notice that inflation rate estimates published in March 2006 refer to the inflation of February 2006. These numbers do not exactly match those displayed in Figure 3 because they only refer to the three cities covered in the survey.

and then progressively, we expand the set of controls. The results and conclusions of this paper are robust if we employ linear probability and logit models instead of the probit model. For the sake of brevity, we discuss the results only from the probit model in the text and report the results from linear probability and logit models in an appendix. For all of the different specifications reported in Table 3, we use survey data from April 2005 until March 2006, the period during which both the incorrect and the revised inflation data are available.

If the public signal matters, then the mistake itself (i.e., incorrect inflation - correct inflation) should affect household's expectations and a positive coefficient on the public signal $\left(\tilde{P}_{ic(t)}\right)$ would be expected (i.e., $\hat{\beta}_1 > 0$). Specifications (1) to (4) in Table 3 present robust evidence in favor of an important effect of public signal on households' price expectations. Across all the different specifications, the estimates show a consistently positive coefficient on the public signal $\left(\tilde{P}_{ic(t)}\right)$. The magnitude of the coefficient seems robust, even after controlling for the "true" inflation rate, unemployment rate, household's demographic characteristics, and month and city fixed effects. The estimated effect of the public signal is statistically significant at 1 percent level across specifications 1-4 according to the robust standard errors reported in parentheses below the coefficient. However, when we take into account possible cluster correlations at the city-month level in addition to heteroskedasticity, the standard errors become larger which is consistent with a priori expectations (reported in brackets under the coefficient and referred to as "clustered standard errors" henceforth). It is reassuring that the estimated effects of the public signal in the more general specifications 3-4 remain significant at 5 percent level even after correcting

for possible cluster correlations.[21] The estimated effects of public signal are not small. For instance, using the specification in column 4, our estimates imply that an "incorrect" INEC estimate that overpredicts the true inflation rate by 3 percentage points increases the share of households that expect prices to increase by about 10 percent. [22] As discussed before, the relevance of the public signal depends primarily on its precision (information content) relative to that of the private signals (Amador and Weill, 2008). Thus, our results suggest that, even in a developing country like Ecuador, an institute such as the INEC that enjoys a measure of credibility (see the discussion in section 1.2) can provide valuable public information and help aggregate dispersed information across different regions.[23]

An interesting finding from Table 3 is that the true inflation rate has a statistically significant (at 1 percent level according to the clustered standard errors) effect with a numerical magnitude of the same order as that of public signal. This is consistent with the argument that the unobserved true inflation rate is a good control for the correlated private information of the households. Also, consistent with the available evidence, the unemployment rate has a negative correlation with the price expectations of the households

[21]Since we include the city fixed effects in the estimation, it sweeps off any time invariant source of intra-city correlations among the households. We also employ month fixed effects and thus serial correlation in inflation is not likely to be a problem. We thank Steve Pischke for pointing this out to us.

Also, if we use aggregate data at the city level to estimate the basic model, the central conclusion that the public signal has a statistically significant and economically important impact on household price expectations remain intact. Note that the city level aggregation cannot be used when we relax the restrictive assumption of no heterogeneity in the effects of public signal.

[22]So the percentage of people expecting an increase in future prices goes up from about 79 percent to 89 percent.

[23]Ecuador faced periods of high inflation in the past and, thus, price trends are a topic of general concern. This might lead one to think that our results are relevant only for the countries where inflation had been a problem historically. We, however, believe that the results are of more general interest. In fact, one can argue that the role of periodically published price information (like monthly inflation rate) has little value in a high inflation environment. In an environment of rapidly rising prices, households would rely more on private information generated by their daily market interactions. Thus, periodically published public price signals influence household price expectations more in a relatively stable inflation regime as has been the case in Ecuador in recent years.

although it is not statistically significant.

In addition, the results suggest that the future price expectations depend on the demographic characteristics of the household. For example, estimates displayed in column (4), Table 3, show that a household that is headed by a male is about 1.5 percentage points more likely to think that prices will increase than a household headed by a female.[24] Moreover, the older the age of the head of the household, the higher is the probability that he or she expects future prices to increase, and households with higher income expect lower prices.[25]

The last column of Table 3 introduces the general specification as in equation (4) that allows for heterogeneity in the effects of public information. This heterogeneity is modeled by including interaction terms between the public signal and the household head's characteristics (age, education and gender) and log household income. The results provide evidence that the effects of public price information are heterogeneous, they vary substantially with the household characteristics. The results suggest that the public signal has a substantially stronger effect among those who are more educated. The age of the household head also has a positive effect on the impact of the public signal, although the numerical magnitude of this effect is relatively small and it is also less precisely estimated (significant at 10 percent). The estimates also indicate a numerically important gender difference in the effects of public signal and it is statistically significant if one relies on the robust standard error. However, according to the clustered standard error, the estimated gender difference is not statistically significant.[26] After controlling for the household characteristics through

[24]This is in contrast to the available evidence in the context of USA that the women usually predict higher inflation rates (see, for example, Bryan and Venkatu, 2001).

[25]This is consistent with the evidence on developed countries (see, for example, Bryan and Venkatu, 2001).

[26]One can make an argument that when estimating the interaction effects there is no a priori reasons to expect cluster correlations that arise from the fact that the variations in the inflation is at the city-month

appropriate interaction effects, we do not find any evidence that the household income matters for the impact of the public signal. The estimated coefficient on the public signal itself (the difference between the incorrect and correct inflation) becomes much smaller and statistically insignificant when the interaction effects are included. This implies that the effect of public price information is negligible for uneducated, young women. The evidence (although imprecise) that public signal has a weaker effect on price expectations of women is consistent with the hypothesis that the women tend to acquire more precise information about local price trends as they do most of the shopping for a typical household. To have a better sense of the magnitude of the interaction effects, consider a scenario where the government incorrectly overstates the inflation rate by 3 percentage points. In this case, the probability that a respondent thinks that prices will increase goes up by 0.14 when he/she has 18 years of education. The corresponding number for an uneducated respondent is only 0.047. In terms of gender differences, the estimates imply that the impact of a 3 percentage points increase in the published inflation on the probability that a person expects prices to be higher is 0.11 and 0.06 for an average male and female, respectively. Uneducated young women, on the other hand, do not systematically change their opinions about future prices when the public signal changes.

Robustness Checks

As discussed before, an important part of our identification strategy for the results in Table 3 is that we use "true" inflation estimates (city level) to control for the actual

level. The data variations used for identifying the interaction effects are at the household level, even though the inflation rate varies only at the city-month level. In this sense, the robust standard errors reported in parenthesis may not be entirely misleading for specification 5 in Table 3. We thank Jeffrey Wooldridge for clarifications on this point.

prices that households face in their daily interactions. While we believe that this is an eminently sensible choice, there are other plausible alternatives. For example, one can argue that households care more about the prices of those products that they buy more often (such as food and energy) and less about other products that, nonetheless, are part of the CPI. If this is the case, the prices that households face in their market interactions could be better approximated by prices of food-related products. One can also argue that the unobserved true inflation (both for over-all CPI and Food CPI) for a single period may not capture all the relevant correlated private information. To address this we include the change in true inflation between the two most recent periods in addition to the most recent true inflation rate as controls for correlated private information. We explore these different possibilities in Tables 4a and 4b. The results in Table 4a use the specification without the interaction effects (corresponding to column 4 in Table 3) and those in Table 4b use the general specification including the interaction effects (corresponding to column 5 in Table 3).

First, consider the results reported in Table 4a. The first column shows our baseline results that correspond to those displayed in the fourth column of Table 3. To control for the prices faced by households, in the second column, we use the true but unobserved inflation rate of the food-and-beverage CPI group as a control for correlated private information. The coefficient of public signal is very similar to that in column 1 and remains statistically significant at 5 percent level. The third column adds the change in the true food CPI between the two recent periods to the specification in column 2. The fourth column reports the results when we add the change in correct inflation over the two recent periods along with the correct inflation rate (based on the over-all CPI). The evidence in the columns

3-4 of Table 4a clearly shows that the strong effect of the public signal on households' price expectations is robust to these alternative specifications.

In the specifications discussed so far (Table 3 and first four columns of Table 4a), we use the difference between the incorrect and correct inflation rates as the relevant public signal available in period t. One might worry that by focusing on a single period's public information, we are potentially underestimating the effect of the public signal. The households are likely to take into account public information from more than just the recent past period. To address this issue, the last two columns in table 4a reports the estimated effect of the public price signal when we include the change in the public signal over the two most recent periods along with the public signal (in level) at period t in alternative specifications. The magnitude of change in the public signal would be important in expectation formation if households learn over time and also pay attention to the public signal more when there is a large change from one period to the next. The results are consistent with the conclusion that the public signal has a significant effect on the formation of price expectations of the households. Consider, for example, the most general specification in column 6. The coefficient of public signal at period t is smaller and less precisely estimated in this specification, but the change in public signal over the recent two periods has a coefficient similar to that of public signal at t in column 4 of table 4a and it is significant at 10 percent according to the clustered standard error (at 1 percent if we rely on robust standard errors).

Table 4b shows evidence on the heterogeneity in the effects of the public signal using the alternative controls for private information set discussed above and also different measures of the public signal. The estimated interaction effects are robust and consistent with the results reported earlier in Table 3 and discussed in the preceding subsection.

(5) Conclusions

This paper provides credible evidence that public price signals can have a significant effect on household's price expectations in developing countries, and that this effect is heterogeneous. To estimate the effect of the public signal on households' price expectations, we exploit a natural experiment in Ecuador where, due to an error in the software used to compute the CPI, the published inflation rate from January 2005 to March 2006 deviated significantly from the true inflation rate. We can exploit the variations produced by the software error, and the consequent release of the revised inflation series to identify the causal effect of the public signal (published inflation rate) on the price expectations of the households.

The empirical analysis uses household survey data from the three largest cities in Ecuador. We analyze the relationship between a household's price expectations and the public signal defined as that part of the observed inflation which is due to the programming error (i.e., the difference between the incorrect and true inflation). Our results show that, even after controlling for the true but unobserved inflation rate, household's characteristics and month and city fixed effects, the public signal (INEC's programming error) has a statistically significant and numerically important effect on price expectations of the households. Moreover, the effect of the public signal is heterogeneous and depends on the characteristics of the household head. The impact of the public signal is more pronounced among more educated individuals, older people and men. The price expectations of young and uneducated women are not systematically influenced by the public information.

References

(1) Agénor, Pierre-Richard and Peter J. Montiel, (1999), "Development Macroeconomics" Second Edition.

(2) Amador, M. and P. Weill, (2007), "Learning From Private and Public Observations of Others' Actions," Working Paper, Stanford University and UCLA.

(3) Amador, M. and P. Weill, (2008), "Learning from Prices: Public Communication and Welfare," Working Paper, Stanford University.

(4) Angeletos, G. and A. Pavan, (2007), "Efficient Use of Information and Social Value of Information," *Econometrica*, July, 1103-1142.

(5) Angeletos, G. and A. Pavan, (2008), "Policy With Dispersed Information," Working Paper, MIT.

(6)Banerjee, A (1992), "A Simple Model of Hard Behavior," Quarterly Journal of Economics, August, 1992.

(7) Branch, W., (2007), "Sticky Information and Model Uncertainty in Survey Data on Inflation Expectations," *Journal of Economic Dynamics and Control*, January, 2007.

(8) Branch, W (2004)," The Theory of Rationally Heterogeneous Expectations: Evidence from Survey Data on Inflation Expectations," Economic Journal, July, 2004.

(9) Bryan, M. F. and G. Venkatu, (2001), "The Curiously Different Inflation Perspectives of Men and Women," Federal Reserve Bank of Cleveland.

(10) Banco Central del Ecuador, (2006), "Información Estadística Mensual No. 1850," Electronic publication available at: http://www.bce.fin.ec.

(11) Banco Central del Ecuador, (2007), "Sistema de Información Empresarial No. 27," Electronic publication available at: http://www.bce.fin.ec.

(12) Bowles, S, S. Durlauf, and K. Hoff, (2006), *Poverty Traps*, Princeton University Press.

(13) Carroll, C., (2003), "Macroeconomic Expectations of Households and Professional Forecasters," *Quarterly Journal of Economics*, 118:(1).

(14) Falkinger, J., (2008), "Limited Attention as a Scarce Resource in Information-rich Economies," *Economic Journal*, October, 2008.

(15) Fuhrer, Jeff and George Moore, (1995), "Inflation Persistence," *The Quarterly Journal of Economics*, 110(1), 127-59.

(16) Gali, J and M. Gertler (1999), "Inflation Dynamics: A Structural Econometric Analysis," *Journal of Monetary Economics*, 44, pp. 195-222.

(17) Gali, J, M. Gertler, and Lopez_Salido (2005), "The Robustness of the Estimates of the Hybrid New Keynesian Phillips Curve," Journal of Monetray Economics, 2005.

(18) Hoff, K, and J. Stiglitz, (2001), Modern Economic Theory and Development, in Meier and Stiglitz ed. *Frontiers of Development Economics*, Oxford University Press.

(19) INEC, (2005), "Metodología del Indice de Precios al Consumidor IPC," Electronic publication available at: http://www.inec.gov.ec.

(20) Jha, R., (2003), *Macroeconomics for Developing Countries*, Routledge.

(21) Jonung, Lars, (1981), "Perceived and Expected Rates of Inflation in Sweden," *American Economic Review*, 71(5), December, 961-968.

(22) Klenow, P and J. Willis (2007): "Sticky Information and Sticky Prices," Journal of Monetary Economics, September, 2007.

(23) MacCullum, B., (2002), "The Recent Developments in Monetary Policy Analysis: The Roles of Theory and Evidence," *Federal Reserve Bank of Richmond Economic*

Quarterly, 88 (1).

(24) Mankiw, G., R. Reis and J. Wolfers, (2003), "Disagreement about inflation expectations," *NBER Macroeconomics Annual*, 2003.

(25) Mankiw, G. and R. Reiss, (2006), "Pervasive Stickiness," *American Economic Review*, 96(2), 164-169.

(26) Morris, S and H. S. Shin, (2002), "Social Value of Public Information," *American Economic Review*, December, 2002.

(27) Murphy, K, R. Vishny, and A. Shliefer, (1989), "Industrialization and Big Push," *Journal of Political Economy*, 97 (5).

(28) Pesaran, H., (1987), *Limits to Rational Expectations*, Basil Blackwell, Oxford.

(29) Ray, D., (1998), *Development Economics*, Princeton University Press.

(30) Roberts, J. M (1997): "Is Inflation Sticky?," Journal of Monetary Economics, 39, 173-196.

(31) Rodriguez-Clare, A., (1996), "The Division of Labor and Economic Development," *Journal of Development Economics*, June 1996.

(32) Sargent, T., (1993), *Bounded Rationality in Macroeconomics*, Oxford University Press.

(33) Sims, C., (2006), "Rational Inattention, A Research Agenda," Working Paper.

(34) Woodford, Michael (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press.