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MONEY AS AN INFLATION INDICATOR IN CHILE – DOES P* STILL WORK?

Tobias Broer Rodrigo Caputo

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Agustinas 1180
Teléfono: (56-2) 6702475; Fax: (56-2) 6702231

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MONEY AS AN INFLATION INDICATOR IN CHILE – DOES P* STILL WORK?

Tobias Broer
Banco Central de Chile y Bank of England

Rodrigo Caputo
Banco Central de Chile

Resumen

Este trabajo analiza el contenido de información de agregados monetarios para la inflación en Chile. En particular, se utilizan modelos monetaristas, denominados "P estrella", para separar el efecto del excedente monetario ("money overhang") del efecto de la brecha de actividad. Se utilizan dos versiones del modelo P estrella: primero la clásica de Hallman et al (1991), y luego una versión más reciente de Gerlach y Svensson (2003), la que incluye la meta de inflación, y por eso parece particularmente adecuada para Chile. Se estiman ambas versiones para distintos agregados monetarios y estimaciones alternativas de la brecha de velocidad. Se encuentra que durante la muestra de estimación, desviaciones de la velocidad de equilibrio tanto en agregados estrechos como ampliados tienen efectos significativos sobre la inflación. Este resultado es robusto al tipo de modelo y a la forma en que se estima la velocidad de equilibrio. El agregado usual de dinero, M1A, muestra un desempeño algo menor que, por ejemplo, el Circulante o una definición amplia del dinero. Por último, cabe mencionar que en los últimos años proyecciones fuera de muestra que incorporan la brecha de velocidad no mejoran las proyecciones de inflación. Lo que es más, proyecciones basadas en agregados estrechos y ampliados muestran resultados opuestos. Esto parece el resultado de una apertura de las brechas de velocidad en direcciones opuestas. Lo anterior obliga a pensar en la estabilidad de la demanda de dinero en un período caracterizado por una inflación baja y estable.

Abstract

This paper analyses the information content of monetary aggregates for inflation in Chile. In particular, we adopt the P* framework that separates the effect of an estimated money overhang from those of the output gap. We use two variants of the model, the original Hallman et al (1991), and Gerlach and Svensson (2003), that conditions on an inflation target. We estimate both models for 6 different monetary aggregates, and 2 alternative estimates of equilibrium velocity. We find that over the estimation period, deviations of velocity from its equilibrium have significant effects on inflation, across models and definitions of the money gap, and for both narrow and broad money. The usual Chilean aggregate M1A, although it has some indicator properties, is outperformed by other money aggregates, first of all cash in the hands of the public, and a broad money aggregate containing time and foreign currency deposits. However, out-of sample forecasts show that over the recent past, most money gaps do not improve inflation forecasts. Also, inflation forecasts from broad and narrow money aggregates diverge in opposite directions in recent years, reflecting the estimated gaps that are large both for M1A and broader definitions of money, but opposite in sign. This finding puts a question mark behind the stability of money demand in recent times of stable and low inflation.

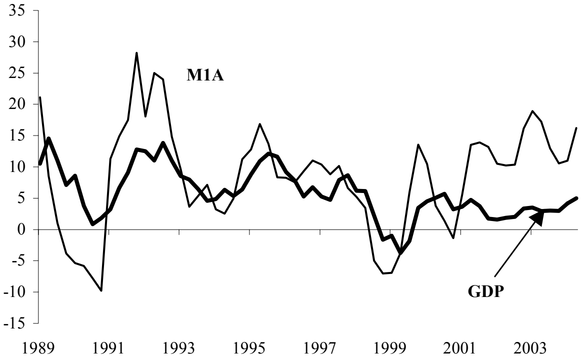
We are grateful for comments by Pablo García and Rodrigo Valdés on an earlier version of this paper. The opinions expressed do not necessarily correspond to those of the Central Bank of Chile or the Bank of England, or their respective monetary policy commitees.
E-mail: pf_tbroer@bcentral.cl; rcaputo@bcentral.cl.

1. Introduction

The defining feature of an inflation targeting monetary policy regime is that it sets a direct numeric goal for inflation, without targets or monitoring ranges for intermediate variables. Therefore, it is often seen in opposition to "money targeting", where targets or monitoring ranges are formulated for some monetary aggregate, due to its supposed medium-term link with prices.

But in setting interest rates appropriately, inflation targeters usually use a broad set of indicators and models to assess inflationary pressures. Monetary aggregates, and models based on them, form one part of these indicators. Their weight in assessing the outlook for inflation is not determined a priori, but depends on their information content for the outlook of inflation in the recent past, and their likely behaviour in the future.

Figure 1 Growth of real GDP and real M1A



Chile, one of the longest-standing inflation targeters, is no exception to this rule. Along many other variables, policymakers regularly look at monetary aggregates in their assessment of the economy. For this, they can draw on a large literature on money demand, and some work on the indicator properties of money for output and inflation (see Mies and Soto 2000).

However, somewhat curiously, most of the literature does not look beyond the intermediate monetary aggregate M1A (defined as cash plus sight deposits). This aggregate had shown good leading indicator properties for output in the past (Bravo and Franken 2001).But M1A does not seem to be a very good predictor of inflation once one controls for output movements (García and Valdés 2004). Moreover, recently M1A has grown much more quickly than GDP (figure 1), and, importantly, also quicker than other money measures. This has been interpreted by different analysts as either a reaction to historically low interest rates, a sign of inflationary pressures, or a break in the link with output.

From this evidence, we conclude that there are three insufficiencies regarding the current literature on monetary inflation indicators in Chile. First, the country lacks an assessment of the indicator properties of money for inflation over and above M1A. This seems to be important especially since broader aggregates, and to a lesser extent the cash content of

M1A, have shown opposite velocity movements to those of M1A in the recent past (see figure 2). What is needed first of all is therefore a comparison of the indicator properties of various money aggregates for inflation. Second, in order to control for the indirect link from money to prices via output, a framework that conditions on output movements is desirable. And finally, one should attempt to separate equilibrium money growth in the move to a low-inflation environment from changes in a "money overhang" that may indicate inflationary pressures. This is important, since there is indeed evidence that an important part of the decrease in M1A velocity can be explained by interest rate movements (see figure 3).

Figure 2
Velocities of Chilean Monetary Aggregates

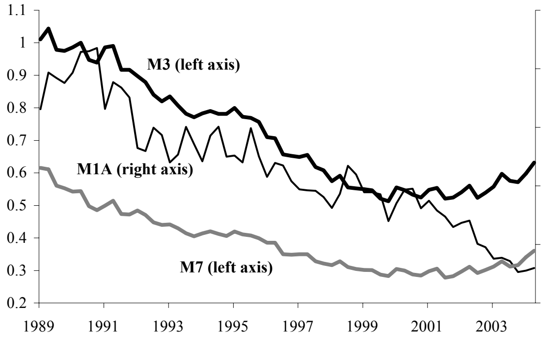
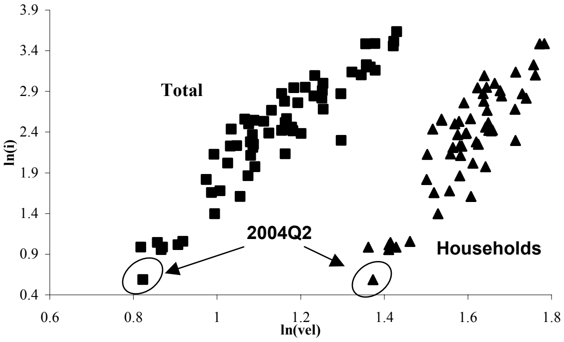


Figure 3
M1A velocity and 30-89 day time deposit interest rates



This paper tries to remedy these insufficiencies. In particular, we use the "P*" framework to identify the information content of monetary disequilibrium for inflation over and above the output gap. The general intuition behind this analysis is that prices adjust towards an equilibrium given by long-run levels of velocity and output. Put differently, deviations of velocity and GDP from their long-run values put pressure on inflation.

The P* framework has been used recently by Orphanides and Porter (2000), and Gerlach and Svensson (2003) to analyse the inflation in the US and the Euro zone respectively. The later authors in fact find that deviations of M3 from its long-run equilibrium have information for inflation over and above the output gap. Their approach introduces new features to the traditional P* framework initiated by Hallman et al. (1991) for the United States, in that it attempts to condition on inflation expectations specified in terms of an inflation target, which in the absence of targets for the Euro zone the authors define somewhat arbitrarily. However, Chile has had an inflation target for almost 15 years, which is why we find the Gerlach and Svensson framework especially useful. As a comparison, we also estimate the original Hallman et al (1991) version of the P* model.

The P* model has in fact been estimated for Chile in the past, in García and Valdés (2003). But while these authors focus on M1A only, estimating more than 100 different specifications, we take a comparative view between different money measures, and compare two models that have received attention in the literature in the past. Also, we try to focus on the most recent period of inflation in Chile, by performing out-of-sample forecasts for the last 4 years.

The main finding of our paper is that over the estimation period, deviations of velocity from its equilibrium have significant explanatory power for inflation in the future. This holds in both models, and independently of the specification of equilibrium money, as a Hodrick-Prescott-trend or the fitted values from an estimated long-run money demand equation. M1A, although it has some indicator properties, is outperformed by other money aggregates, first of all Cash in the hands of the public, and a broad money aggregate containing time and foreign currency deposits. However, out-of sample forecasts show that over the recent past, in general money gaps do not improve inflation forecasts, and inflation forecasts from broad and narrow money aggregates diverge in opposite directions.

The paper is organised as follows. Section 2 presents the P* framework. Section 3 discusses the specification of equilibrium velocity and Section 4 presents the data used in the estimation, including the 6 monetary aggregates. Section 5 shows the estimation results for the money demand equations used to derive equilibrium velocity, and the main estimation results of the P* models. Section 6 presents out-of-sample forecasts relative to those from several benchmark models of inflation. Finally, Section 7 concludes.

2. The P* Model

2.1. The original framework – Hallman et al's (1991) specification

The main assumption behind the P* framework introduced by Hallman, Porter and Small (1991, HPS from now-on) is that prices tend towards an equilibrium, or "*" level. This is determined by monetary equilibrium at long-run levels of output and velocity. Thus, inflation becomes a function of equilibrium deviations and its own lags

$$\pi_{\mathrm{t}} = b(p_{t-1} - p_{t-1}^{*}) + \sum_{s \geq 1} \phi_s \pi_{t-s} \tag{1}$$

where π_{t} is inflación, p_t the price level in logs, and p^*_t the equilibrium price level.

By difference from previous papers that use a similar error correction pricing equation[1], HPS specify the equilibrium price level as that which brings current nominal money holdings $\mathrm{M}_{\mathrm{nom}}$ in line with long-run levels of output (Y*) and velocity (V*) in the classical quantity equation

$$P^* = \frac{M_{nom} V^*}{Y^*}, \tag{2}$$

Letting lower-case letters denote logs, and subtracting from actual prices, this yields

$$\begin{aligned} p - p^* &= (m_{nom} - m_{nom}) + (v - v^*) - (y - y^*) \\ &= (v - v^*) - (y - y^*) \end{aligned} \tag{3}$$

So a stochastic version of (1) can be written in terms of output and velocity gaps

$$\pi_{\mathrm{t}} = b_v (v_{t-1} - v_{t-1}^{*}) + b_y (y_{t-1} - y_{t-1}^{*}) + \sum_{s=1}^{S} c_s \pi_{t-s} + \varepsilon_t \tag{P*HPS}$$

If, as indicated by the model, output and velocity gaps have an effect only via the total price gap, we would expect their effects to be equal in magnitude but opposite in sign, $b_v = -b_y$. In general, this restriction is not imposed, but tested after estimation. It is interesting to note that if we define equilibrium velocity as that which brings real money *m* in line with long-run levels of output, opportunity costs *i*, and other determinants

$$v^* = y^* - m^*(y^*, i^*, \ldots) \tag{5}$$

we can write the velocity gap as the difference between the money gap and the output gap

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[1] HPS quote for example, Mussa (1981) and McCallum (1980).

$$\begin{aligned} p - p^* &= (v - v^*) - (y - y^*) \\ &= y - m - (y^* - m^*) - (y - y^*) \\ &= m - m^* \end{aligned} \tag{6}$$

So the P* model can equally be written in terms of the real money gap, *m-m**. Thus, if the restriction $b_v = -b_y$ is not rejected in (3), the output gap does not have explanatory power for prices over and above the real money gap.

While HPS' specification is certainly ad hoc, they motivate their monetary pricing equation as a special case of an expectation-augmented Phillips Curve

$$\pi_t = b_y(y_{t-1} - y^*_{t-1}) + E_{t-1}[\pi_t] + \varepsilon_t \tag{7}$$

HPS suggest that expected inflation depends on the velocity gap and past inflation

$$E_{t-1}[\pi_t] = b_v(v_{t-1} - v^*_{t-1}) + \sum_{s=1}^{S} c_s \pi_{t-s} \tag{8}$$

which subsituted in (7) yields (P*HPS).

2.2. Svensson and Gerlach´s (2003) model with a target level of inflation

Recently, Svensson and Gerlach (2003, SG from now-on) estimate an equation similar to (P*HPS) for the euro zone. Following Svensson (2000), they start with a Phillips curve which includes the real money gap, rather than the output gap, to capture demand pressures

$$\pi_t = E_{t-1}[\pi_t] + b_m(m_{t-1} - m^*_{t-1}) + \sum_{s=1}^{S} c_s \pi_{t-s} + \varepsilon_t \tag{9}$$

According to (6), this is in fact equivalent to HPS' P* model, apart from the expectations term. SG specify inflation expectations as reversion to a target level of inflation $\hat{\pi}$

$$E_{t-1}[\pi_t] = \hat{\pi}_t + c_0(\pi_{t-1} - \hat{\pi}_{t-1}) \tag{10}$$

which substituted in (9) and also incorporating the output gap yields their estimated equation

$$\pi_t = \hat{\pi}_t + b_m(m_{t-1} - m^*_{t-1}) + b_y(y_{t-1} - y^*_{t-1}) + c_0(\pi_{t-1} - \hat{\pi}_{t-1}) + \sum_{s=1}^{S} c_s \pi_{t-s} + \varepsilon_t \tag{P*SG}$$

which using (6) can be reparameterised in terms of the velocity gap and the output gap as in P*HPS. The coefficient c_0 can be interpreted as an indicator of monetary policy credibility: a large c_0 means deviations from target are very persistent, while a small coefficient means that the target matters for inflation, but not passed deviations from it.

Estimating (10) for the Euro zone runs into the obvious problem of finding a proxy for inflation expectations across countries. Based on the assertion that " the main purpose of the European Monetary System, which was founded in 1979, was to facilitate reduction in members' inflation to levels similar to those in Germany" (p. 1658), and using the imputed inflation objective for the Bundesbank from Bofinger (2000), they specify the inflation target for the other European countries as a process of convergence towards German inflation levels.

Chile was one of the earliest countries to introduce numeric inflation targets. This makes the SG framework especially relevant for the Chilean Economy. Moreover, it means we are in the comfortable situation not having to take a shortcut to inflation expectations in terms of unobserved target levels. Thus we extend the inflation target series in Valdés (1997) in the estimation of P*SG. This allows us to estimate both P*HPS and P*SG for Chile, where for comparison purposes we reparameterise P*SG in terms of the velocity and output gaps.

3. Equilibrium velocities

The crucial indicators of inflationary pressures in the P* model are the gaps of output and velocity. Given the frequent use of output gaps in academic papers and models for policy, the specification of potential output is perhaps less controversial[2]. However, the definition and specification of the equilibrium velocity of circulation is somewhat more difficult.
HPS consider the equilibrium velocity for M2 in the United States as constant during their period of estimation (1954-1988). However, the persistent rise in velocity since 1991 made this assumption untenable for the later period. One of the main challenges in subsequent work using concepts of "money overhang" for the US was thus to plausibly capture the time-variance in equilibrium velocity. Chilean data contains the same challenge, as is easy to see from figure 2 which shows the variability of velocity for the usual definition of money in Chile M1A (cash plus sight deposits), and for the broader aggregates M3 and M7.

There are various ad-hoc methods to capture the time-variation in equilibrium velocity, as one-time shifts, or by a deterministic trend. Orphanides and Porter (2000) consider these methods for the United States, but also use regression tree techniques, that endogeously determine the number of switches in equilibrium velocity conditional on interest rates.
A different way of deriving equilibrium velocity, applied for example by SG, is to use the fitted values from an estimated long-run money demand equation

$$\tilde{m}_t = \alpha + \beta_1 i_t + \beta_2 y_t + \beta_3^{'} x_t + \varepsilon_t \tag{11}$$

where *x* can be any determinant of money demand other than opportunity cost or output. According to the definition of equilibrium levels for prices, the P* literature generally evaluates this money demand equation at long-run values of the determinants, i.e. potential output and possibly filtered interest rates, to get estimates of a conditional equilibrium of money demand.

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[2] We use the series from Contreras et al (2002).

There is an extensive literature on the estimation of long-run relationships between integrated variables such as (11) (for a summary, see Maddala and Kim (1999)). Often, simple OLS estimates are used. However, these, although superconsistent in the sense that they converge to population values faster than with stationary variables, suffer importantly from endogeneity and autocorrelation bias (see for example Maddala and Kim (1999), p. 161). SG use a dynamic regression with correction for autocorrelation and Stock and Watson's (1993) GLS method. We follow Maddala and Kim (1999), and estimate long-run money demand by what the authors call "Hendry´s dynamic regression technique" which consists of adding differences of the regressor to the levels equation. We thus estimate the following money demand equation

$$m_t - p_t = \alpha + \gamma t + \beta_1 i_t + \sum_{i=1}^{m} (\beta_{1,-i} \Delta i_{t-i} + \beta_{2,-i} \Delta y_{t-i}) + \varepsilon_t \qquad (12)$$

where y is a scale variable, t a deterministic trend, and i a vector of interest rates which includes opportunity cost as well as a measure of own return for broader money aggregates that include interest bearing deposits. As a cross-check we also perform all estimations with an atheoretic concept of equilbirium velocity based on a Hodrick-Prescott filter.

4. Data

Monetary Aggregates

Chile, contrary to other countries, has a long history of business-daily data for monetary aggregates, which greatly reduces the volatility found for example in end-of-month observations, where especially narrow money aggregates are not necessarily at their average levels, and which suffer from weekend effects difficult to capture in seasonal adjustment. Thus we seasonally adjust monthly averages of daily levels, and average these over the quarter.

Figure 4 – Definitions of monetary aggregates in Chile

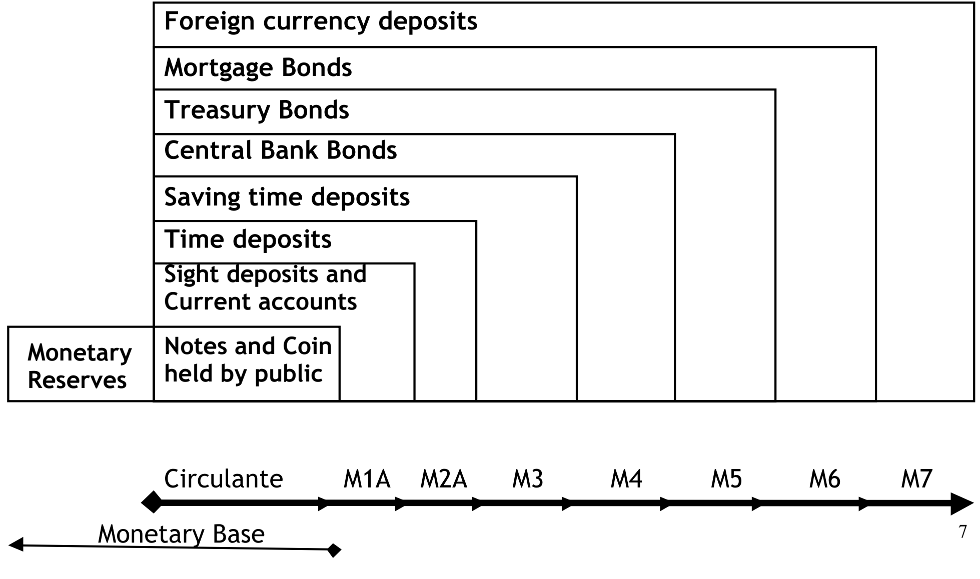

Figure 4 presents definitions of monetary aggregates in Chile. Circulante (cash in hands of the public), M1A (cash plus sight deposits) and M3 (M1A plus time and savings deposits) correspond roughly to narrow, intermediate and broad monetary aggregates found in other countries, perhaps with the difference that M3 does not include foreign currency deposits and money market mutual funds, which have recently gained importance in Chile.[3] However, the Central Bank of Chile regularly publishes data for several other monetary aggregates, of which we include two: M2A (M3 excluding savings deposits), and M7, which is perhaps the most looked-at after M1A and Circulante, and is probably best described as "total liabilities of the banking sector including the Central Bank". Thus, other than the components of M3 it includes foreign currency deposits, mortgage bonds issued by Banks, bonds issued by the Central Bank ("documentos del Banco Central"), and even central government bonds. While the latter are of no importance over most of the sample, given long-standing budget surplusses in Chile, Central Bank Bonds are large (more than 20% of M7 recently), and also suffer from the problem that they are issued in the Unidad de Fomento (UF), the Chilean money unit indexed on aggregate consumer price inflation. Thus, including them in monetary aggregates used as inflation indicators may cause problems. To be robust against this, we inlcude a 6th monetary aggregate, which is M7 excluding Central Bank Bonds. From now-on we refer to Circulante and M1A as "narrow money", and the remaining aggregates as "broad money".

We deflate all monetary aggregates by consumer prices, and seasonally adjust monthly averages using the X12 Arima method with working day adjustment for Chile.

Scale Variable and output gap

Our activity and scale variable is GDP, and its potential level as presented in Contreras et al (2002).

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[3] Traveller´s cheques and short-term bank paper are traditionally unimportant in Chile.

Prices and interest rates

We use the seasonally adjusted total consumer price index (CPI), and a version that excludes seasonal food prices, petrol, and prices of regulated products such as public transport (CPIX1). Interest rates used are those on 30 to 89 day time deposits and their non-linear transformation (log(i/100/(1+i/100)), which has been found to perform well in narrow money demand equations for Chile (Restrepo (2002)). Also, we use the 90 day to 1 year time deposit rate as an own return and the rate on Central Bank Bonds with a duration of 5 years (BRC8 and BCU5 respectively) as an opportunity cost in the equations for broad money demand. The bond rate, which is on UF instruments and thus indexed to inflation, is nominalised by using the inflation target.

All variables come from the Central Bank of Chile database unless otherwise mentioned, and enter in logs apart from the interest rates.

Stationarity

ADF tests on a sample from 1986Q2 to 2004Q2 indicate that all real money measures are I(1) at 5% significance level, apart from M7 which seems I(2)[4]. GDP is also I(1), while CPI and CPIX1 are I(2).

5. The P* model 1987-2004 - estimation results

5.1. Long-run money demand

We estimate equation (12) using GDP as a scale variable, the non-linear 30 to 89 day time deposit rate for Circulante and M1A, and both the 90 day-to-1 year time deposit rate and the bond rate for broader monetary aggregates. Also, we include a deterministic trend and 4 lags of the differenced variables in the estimation.[5]

Table 1 shows the estimation results for the 6 monetary aggregates. The output elasticities are around unity for M1A and all broad money measures, apart from the two M7 measures, where they are quite different. The cash aggregate Circulante has an output elasticity significantly below 1, indicating economies of scale in cash holdings. The opportunity cost effects (of the time deposit rate for Circulante and M1A, and of the bond rate for broad money) always have the expected negative sign, and are significant except for M7[6], although their effect is very small for broader money aggregates. The effect of own returns on broad money, as indicated by the coefficient on 90 day to 1 year deposits, is positive and significant, again except for M7.

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[4] However, it is I(1) using the Phillips-Perron test.

[5] Note that the bond rate is not strictly an opportunity cost for M7, as this includes Central Bank Bonds.

[6] Which was to expect, given that this includes Central Bank Bonds.

Table 1 Long-run money demand elasticities, 1987Q2 to 2004Q2

Circulante		Constant	GDP	i_{3089}*	trend		
	Coefficient	-5.93 *	0.78 *	-0.053 *	0.0017		
	Standard Error	1.05	0.07	0.012	0.001		
M1A		Constant	GDP	i_{3089}*	trend		
	Coefficient	-8.09 *	0.98 *	-0.134 *	0.002		
	Standard Error	1.59	0.10	0.018	0.002		
M2A		Constant	GDP	i_{bond}**	i_{90d1y}***	trend	
	Coefficient	-7.82 *	1.06 *	-0.011 *	0.007 *	0.009 *	0.000
	Standard Error	1.79	0.12	0.003	0.003	0.002	0.000
M3		Constant	GDP	i_{bond}**	i_{90d1y}***	trend	
	Coefficient	-6.83 *	1.01 *	-0.010 *	0.005 *	0.008 *	0.000
	Standard Error	1.58	0.11	0.002	0.002	0.002	0.000
M7		Constant	GDP	i_{bond}**	i_{90d1y}***	trend	
	Coefficient	-16.78 *	1.69 *	0.004	0.001	0.001	0.000
	Standard Error	1.70	0.11	0.003	0.002	0.002	0.000
M7xDBC		Constant	GDP	i_{bond}**	i_{90d1y}***	trend	
	Coefficient	-0.56	0.61 *	-0.010 *	0.007 *	0.015 *	0.000
	Standard Error	2.03	0.14	0.003	0.003	0.003	0.000

A star behind the coefficient denotes significance at 5% level.

* Non-linear transformation of the 30 to 89 day time deposit interest rate log(i/(1+i)).

** Nominalised using the inflation target.

*** Interest rate on 90 day to 1 year time deposits.

We derive the equilibrium money demand used in this paper by evaluating these estimated equations at long-run values of the right-hand-side variables (potential output and hp-filtered interest rates). Figure 1 shows the deviations of actual money holdings from the estimated equilibrium, as indicated by this method. As a cross-check, we also plot the deviations of long-run money demand at actual values of the determinants, and from an Hodrick-Prescott filtered trend. The deviations from the hp filter follow the same dynamic pattern as the other two series, but are notably smaller. Over the last two years of the sample, there are large deviations of actual from equilibrium velocity for M1A, which experienced a marked slow-down of velocity relative to equilibrium, and broader agregates, which are markedly above their equilibrium. Again, the hp filter captures these movements better than the estimated money demand equations, resulting in smaller deviations.

Figure 5 Estimated velocity gaps

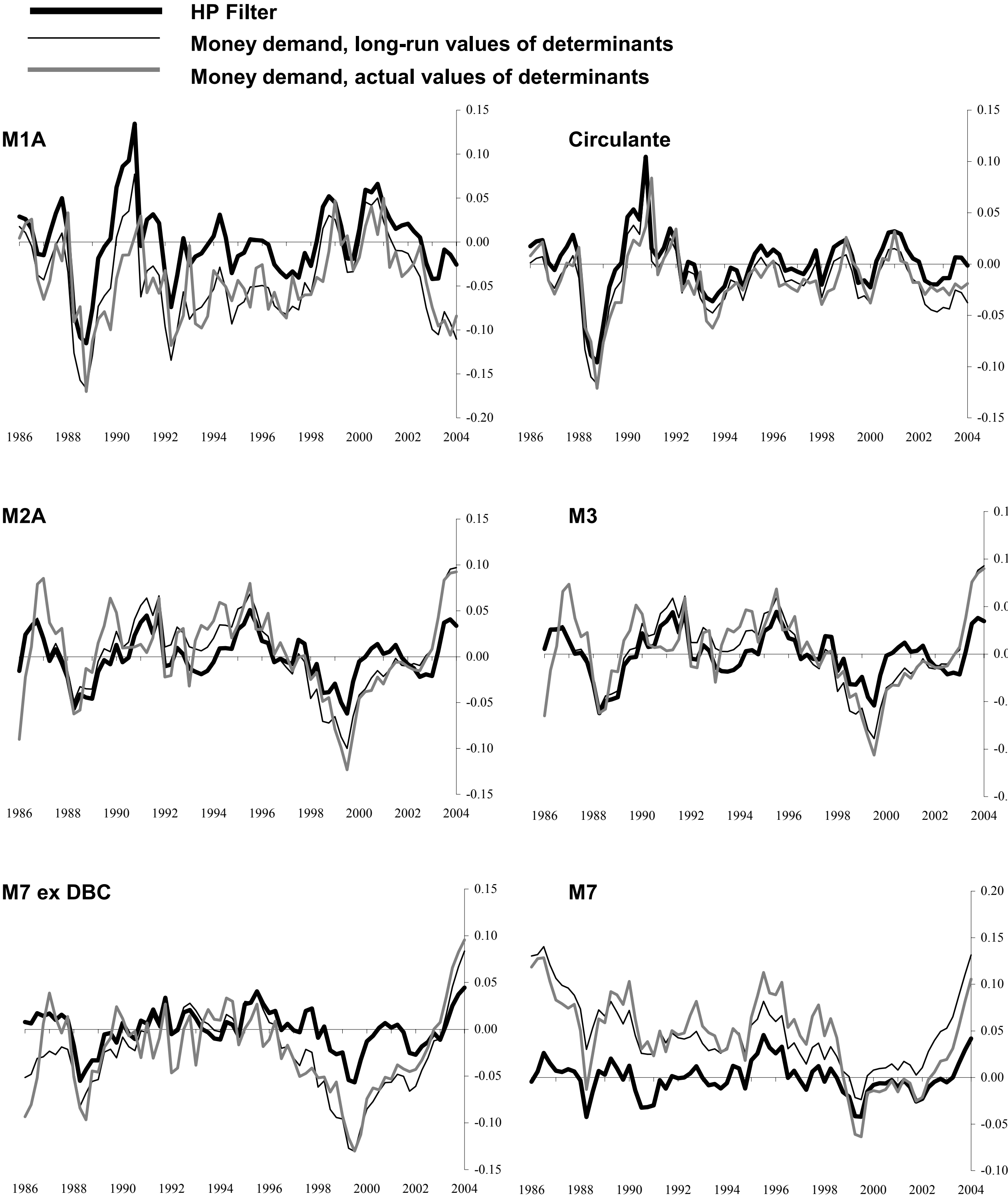

Table 2 Estimations of P* models 1987Q3 to 2004Q2

1	2	3 Velocity gap		4 Output gap		5 Equality of gap coefficients		6 Dynamic homogeneity		7 Lagged dev. from target		8 R squared	9 Durbin Watson
		Coeff.	*t stat.*	Coeff.	*t stat.*	F stat.	*P value*	F stat.	*P value*	Coeff.	*t stat.*		
P*HPS	**Circulante**	-0.11	*-4.84*	0.02	*0.81*	9.18	*0.00*	0.66	*0.42*	-	-	0.70	1.31
	M1A	-0.06	*-3.41*	-0.02	*-0.63*	4.38	*0.04*	3.03	*0.09*	-	-	0.65	1.29
Money demand gap	**M2A**	-0.03	*-1.33*	0.03	*1.05*	0.00	*0.98*	2.14	*0.15*	-	-	0.60	1.30
	M3tot	-0.03	*-1.39*	0.03	*1.05*	0.02	*0.89*	2.12	*0.15*	-	-	0.60	1.30
	M7tot	-0.01	*-0.21*	0.02	*0.85*	0.21	*0.65*	3.15	*0.08*	-	-	0.59	1.30
	M7xDBC	-0.03	*-1.48*	0.03	*1.29*	0.03	*0.87*	2.18	*0.14*	-	-	0.60	1.30
	Circulante	-0.12	*-4.88*	0.00	*0.11*	11.58	*0.00*	0.94	*0.34*	-	-	0.70	1.33
	M1A	-0.08	*-4.31*	-0.02	*-0.81*	8.25	*0.01*	0.84	*0.36*	-	-	0.68	1.32
HP filter gap	**M2A**	-0.05	*-1.71*	0.03	*1.11*	0.56	*0.46*	2.64	*0.11*	-	-	0.60	1.31
	M3tot	-0.06	*-1.73*	0.03	*1.10*	0.66	*0.42*	2.49	*0.12*	-	-	0.60	1.31
	M7tot	0.00	*-0.08*	0.02	*0.73*	0.14	*0.71*	3.42	*0.07*	-	-	0.59	1.30
	M7xDBC	-0.08	*-2.20*	0.04	*1.61*	1.39	*0.24*	3.04	*0.09*	-	-	0.62	1.32
P*SG	**Circulante**	-0.07	*-3.05*	0.03	*1.57*	1.62	*0.21*	5.07	*0.03*	0.17	*0.91*	0.93	1.48
	M1A	-0.02	*-1.43*	0.02	*0.91*	0.01	*0.93*	10.03	*0.00*	0.10	*0.47*	0.92	1.46
Money demand gap	**M2A**	-0.01	*-0.91*	0.04	*1.85*	0.81	*0.37*	10.87	*0.00*	-0.03	*-0.18*	0.92	1.47
	M3tot	-0.02	*-0.98*	0.04	*1.86*	0.59	*0.45*	10.89	*0.00*	-0.03	*-0.17*	0.92	1.47
	M7tot	0.00	*0.05*	0.03	*1.70*	1.60	*0.21*	12.12	*0.00*	-0.03	*-0.14*	0.92	1.47
	M7xDBC	-0.02	*-1.24*	0.04	*2.06*	1.09	*0.30*	11.08	*0.00*	-0.04	*-0.20*	0.92	1.47
	Circulante	-0.07	*-3.17*	0.02	*1.08*	2.68	*0.11*	5.13	*0.03*	0.19	*1.03*	0.93	1.50
	M1A	-0.04	*-2.16*	0.01	*0.61*	0.62	*0.43*	6.83	*0.01*	0.14	*0.72*	0.93	1.46
HP filter gap	**M2A**	-0.02	*-0.81*	0.04	*1.85*	0.26	*0.61*	11.73	*0.00*	-0.01	*-0.08*	0.92	1.47
	M3tot	-0.02	*-0.86*	0.04	*1.85*	0.17	*0.68*	11.59	*0.00*	-0.01	*-0.07*	0.92	1.47
	M7tot	-0.01	*-0.18*	0.04	*1.52*	0.61	*0.44*	12.46	*0.00*	-0.02	*-0.11*	0.92	1.47
	M7xDBC	-0.04	*-1.26*	0.04	*2.10*	0.01	*0.91*	11.91	*0.00*	0.01	*0.03*	0.92	1.47

5.2. P* equations with different definitions of equilibrium velocity

In this section, we present estimations for both P* models, P*HPS and P*SG, and two definitions of monetary disequilibrium, using deviations of actual velocity both from an estimated equilibrium (evaluated at long-term values of determinants), and from an hp trend. In all estimations, we set the lag length to 4 in both models, and also include a dummy to smooth the volatility of inflation in 1990/1991.[7] Following the original HPS paper, we estimate P*HPS in inflation differences, rather than in levels. This imposes the restriction that the lags of inflation levels sum to one, which is accepted in the great majority of cases. Doing this has the advantage that the dependent variable is stationary, given that levels of consumer price inflations in Chile seem to be I(2) (see section 3). In P*SG we use lags of total inflation rather than energy price inflation. This does not affect the results greatly, but lags of total inflation are more significant, perhaps due to the greater importance of indexation in the Chilean Economy than in the Euro Zone. We estimate both models on quarterly data from 1987Q3 to 2004Q2.

Estimation results for CPI

Table 2 presents the results. The upper part of the table presents the estimations of (P*HPS), for 6 different money aggregates and two different definitions of the money gap, while the lower part presents the estimates of (P*SG). The estimated effect of the velocity gap always has the expected sign, and is significant for cash aggregate Circulante, and for M1A in the HPS model. The deviations from an hp filter are more significant in the M1A case, which may be due to the large deviation at the end of the sample when estimating monetary equilibrium with a usual money demand equation. But neither of the broad money velocity gaps is significant in any of the models, independently of the definition of equilibrium.

Does this mean M1A is still the aggregate of choice for Chile? Not necessarily. First, the effect of the Circulante is bigger than that of M1A, and significant even when we specify the P* model in terms of deviations of inflation from target, i.e. in P*SG. More importantly, we do not have much intuition about the average lag at which money has the best indicator properties for inflation. We thus estimate the same models as in Table 2, but allowing the effect of monetary disequlibrium to take up to one year.

Table 3 shows the results for the horizon at which the money gap is most significant for inflation. Put differently, we choose the lag of the velocity gap to maximise its significance, between one to four quarters.

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[7] To do this we include a dummy that takes the values 1 / -1 in 1990Q4 / 1991Q1. This does not affect the results very notably, but reduces the significance of the velocity gaps somewhat.

Table 3 Estimations of P* models 1987Q3 to 2004Q2 – lags of the velocity gap chosen to maximise significance

1	2	3 Lag of velocity gap	4 Velocity gap		5 Output gap		6 Equality of gap coefficients		7 Dynamic homogeneity		8 Lagged dev. from target		9 R squared	10 Durbin Watson
			Coeff.	*t stat.*	Coeff.	*t stat.*	F stat.	*P value*	F stat.	*P value*	Coeff.	*t stat.*		
P*HPS	**Circulante**	1	-0.11	*-4.84*	0.02	*0.81*	9.18	*0.00*	0.66	*0.42*	-	-	0.70	1.31
	M1A	1	-0.06	*-3.41*	-0.02	*-0.63*	4.38	*0.04*	3.03	*0.09*	-	-	0.65	1.29
Money	**M2A**	4	-0.07	*-2.78*	0.06	*2.17*	0.18	*0.67*	0.57	*0.45*	-	-	0.63	1.41
demand gap	**M3tot**	4	-0.09	*-3.19*	0.06	*2.34*	0.94	*0.34*	0.31	*0.58*	-	-	0.65	1.42
	M7tot	3	-0.04	*-1.56*	0.03	*1.19*	0.20	*0.65*	1.35	*0.25*	-	-	0.60	1.30
	M7xDBC	3	-0.07	*-2.89*	0.06	*2.27*	0.04	*0.84*	0.95	*0.33*	-	-	0.64	1.30
	Circulante	1	-0.12	*-4.88*	0.00	*0.11*	11.58	*0.00*	0.94	*0.34*	-	-	0.70	1.33
	M1A	1	-0.08	*-4.31*	-0.02	*-0.81*	8.25	*0.01*	0.84	*0.36*	-	-	0.68	1.32
HP filter	**M2A**	3	-0.10	*-3.01*	0.04	*1.65*	2.88	*0.10*	1.94	*0.17*	-	-	0.64	1.38
gap	**M3tot**	3	-0.11	*-3.42*	0.04	*1.65*	4.54	*0.04*	1.46	*0.23*	-	-	0.65	1.39
	M7tot	3	-0.11	*-2.18*	0.05	*1.77*	2.11	*0.15*	3.86	*0.05*	-	-	0.62	1.32
	M7xDBC	3	-0.17	*-4.28*	0.06	*2.63*	8.60	*0.00*	2.08	*0.15*	-	-	0.68	1.44
P*SG	**Circulante**	1	-0.07	*-3.05*	0.03	*1.57*	1.62	*0.21*	5.07	*0.03*	0.17	*0.91*	0.93	1.48
	M1A	1	-0.02	*-1.43*	0.02	*0.91*	0.01	*0.93*	10.03	*0.00*	0.10	*0.47*	0.92	1.46
Money	**M2A**	4	-0.04	*-1.90*	0.05	*2.49*	0.36	*0.55*	6.22	*0.02*	0.00	*0.00*	0.93	1.51
demand gap	**M3tot**	4	-0.05	*-2.17*	0.06	*2.62*	0.02	*0.89*	5.28	*0.03*	0.01	*0.04*	0.93	1.51
	M7tot	3	-0.02	*-0.94*	0.04	*1.89*	0.18	*0.67*	7.56	*0.01*	0.01	*0.03*	0.92	1.48
	M7xDBC	4	-0.05	*-2.40*	0.07	*2.92*	0.67	*0.42*	6.48	*0.01*	-0.01	*-0.07*	0.93	1.49
	Circulante	1	-0.07	*-3.17*	0.02	*1.08*	2.68	*0.11*	5.13	*0.03*	0.19	*1.03*	0.93	1.50
	M1A	1	-0.04	*-2.16*	0.01	0.61	0.62	*0.43*	6.83	*0.01*	0.14	*0.72*	0.93	1.46
HP filter	**M2A**	3	-0.04	*-1.49*	0.04	*2.09*	0.00	*0.99*	8.93	*0.00*	0.04	*0.23*	0.92	1.46
gap	**M3tot**	3	-0.05	*-1.80*	0.04	*2.12*	0.14	*0.71*	7.89	*0.01*	0.05	*0.29*	0.93	1.46
	M7tot	3	-0.09	*-2.00*	0.05	*2.53*	0.73	*0.40*	11.33	*0.00*	0.10	*0.51*	0.93	1.51
	M7xDBC	3	-0.09	-2.55	0.06	2.74	1.24	0.27	7.27	0.01	0.15	0.79	0.93	1.48

The first interesting thing to note is that narrow money measures M1A and Circulante have their maximum impact at short horizons of one quarter. But all broader money aggregates contain most information for inflation further out, between 3 to 4 quarters. Focussing first on the traditional HPS version of the P* model, it is obvious that at these lags, the velocity gaps for broad money have large and highly significant coefficients, apart from the M7 gap derived from a money demand function, which is insignificant. This is likely to reflect the relatively bad fit of the equation for M7, especially at the end of the sample, leading to a higher variability of the gap than with hp filter deviations. In general these hp deviations have again a bigger, and more significant impact on inflation.

Regarding the output gap in the HPS model (column 5), its effect is often significant when included along with broad money gaps, but never for narrow money. Thus, the prediction of the P* model that the two gaps should have coefficients that are equal but different in sign (column 6), is rejected for all narrow money aggregates, but always accepted for broad money gaps derived from money demand. However, the larger coefficients of hp-gaps make the difference with the smaller output gap coefficients significant for M3 and M7 excluding government bonds (M7xDBC). The test of dynamic homogeneity (column 7), never rejects the hypothesis that lags 1 to 5 of inflation sum to one when we estimate P*HPS in levels, which legitimises our estimation in first differences.

How do these results change once we estimate the P* model specified in terms of deviations of inflation from target, that is use (P*SG)? The bottom part of table 3 shows that the information content of velocity gaps for inflation remains significant, even when we condition on the inflation target. But the estimated coefficients are generally smaller, and also in more cases insignificant. Most importantly, the Circulante remains highly significant, but M1A is insignificant. The effect of broad money aggregates continues to be strongest at lags of 3 to 4 quarters, but is significant in only half the cases. However, the measure of M7 excluding Central Bank Bonds has a sizeable and significant coefficient for both of its gaps. Again, the output gap is generally significant for equations with broad money gaps only, and it is interesting to note that given the smaller velocity gap coefficients, we never reject the hypothesis that the effect of both is equal. The fit of the SG version is much higher (column 8), but interestingly the specification in terms of the gap does not make much difference to the Durbin-Watson statistic of first-order serial correlation in the residuals.

The (P*SG) equation gives us an idea about the persistence of deviations of inflation from target. It is interesting to note that the lagged deviation from target is indeed significant, but not anymore once we include lags of the levels of inflation (column 7). These lagged levels in turn are significant (column 6), and thus seem to explain the dynamics of deviations from target better.

Estimation results for CIPX1

The appendix presents the same results for the CIPX1 measure of consumer prices, that excludes some products of especially volatile, and regulated prices. Overall, the results are similar (tables A1 and A2). One difference to note is that now the information content of narrow money gaps seems highest at a lag of two quarters. Also, the fit of the HPS model is less when using the CPIX1 measure. Importantly, in none of the 4 cases we can reject the hypothesis that the information content of the M1A velocity gap for inflation is zero at a significance level of 5%. This result is interesting as it allows us to compare it to those obtained by García and Valdés (2003), who use the CPIX measure in their estimation. Like those authors, we find M1A velocity gaps not significant for inflation. However, other money aggregates do seem to contain some information for CPIX inflation over the estimation sample.

This section thus presents the first main result of this paper. Our estimations of the P* model indicate that deviations of narrow and broad money aggregates from their equilibrium velocity have significant information content for inflation in Chile during the past 17 years, once we allow this effect to take up to one year. In fact, broad aggregates seem to be an indicator of inflation further out than narrow money aggregates. This holds across definitions of prices or the velocity gap, and even once we account for the inflation target, in a more modern version of the P* model. However, including the inflation target reduces the effect of the velocity gap. And the large deviations of velocity from its equilibrium indicated by money demand equations observed lately, mean that the gap thus defined has a smaller and less significant impact than deviations from an hp filtered trend. Finally, the restriction implicit in the model, that the determinant of inflation are deviations from an equilibrium price level such that its components, deviations of output and velocity from their equilibria, have effects of the same magnitude, are accepted in most equations with broad money but not generally for narrow money.

6. The P* model in recent times – out-of sample forecasts 2000-2004

Policy-makers assess inflation indicators for their predictive power for future inflation, more than for their average information content for inflation over some period in the past. This seems especially important in our case of monetary indicators, because many of these have seen notable, and sometimes opposite, movements in velocity during the recent past (see figure 2).

Thus, in order to assess the predictive power of our equations for inflation over the more recent period, we conduct a recursive out-of-sample forecasting exercise over the period 2000Q1 to 2004Q2, at horizons of up to 4 quarters. Due to the single-equation character of our model, and the need for (conditional or filtered) estimates of equilibrium velocity, this endeavour has some problems attached. SG also present recursive out-of-sample forecasts, but avoid this problem by only considering a horizon of one quarter. But the horizon important for policy-makers is usually much longer than one quarter. Also, our paper has shown that, at least in Chile, the information content of broad money measures appears strongest at longer horizons. But to forecast with the P* model at longer horizons, we need exogenous forecasts for velocity, output, and their equilibrium values. For the money demand definition of the velocity gap, we also need out-of sample forecasts for interest rates, and for the filtered velocity a forecast of the hp trend. Including an ad-hoc model to forecast all these variables however, would make the inflation forecast highly dependent on the quality of these other forecasts, and thus, in our eyes at least, meaningless.

The usual conclusion from this is to do out-of-sample forecast for the latter part of the estimation sample conditional on actual values for exogenous variables, which in our case would be velocity and output gaps. But we think given the uncertainty about equilibrium levels of velocity, and about money behaviour in the future, this would understate the uncertainty that surround P* forecast. Thus, we take a two-step approach. First, we perform forecasts that take into account only the uncertainty around equilibrium levels of velocity and the coefficient uncertainty of the P* model. In this approach we start by estimating recursively a system of equation (12) and either (P*HPS) or (P*SG). Based on this we forecast equilibrium velocity conditional on actual out-turns of the determinants in the money demand equation, and calculate velocity gaps using actual data for money. To forecast the hp filtered trend we use a Kalman filter version of the Hodrick-Prescott filter, with the linear trend component as the state variable. This allows us to forecast the hp filter into the future, but means that the forecast is of linear growth of equilibrium money. Having thus derived forecast for equilibrium money, we finally perform recursive out-of-sample forecasts for inflation based on the P* equations, and conditional on the most recent estimate of the output gap. We call this method "recursive forecasts with exogenous money".

This procedure, by conditioning on actual outturns of money out-of-sample, of course understates the uncertainty around future money growth and velocity. Our second approach thus uses a simple forecast of money growth, based on an autoregressive error-correction equation

$$\Delta m_t = \alpha_0 + \alpha_1 (m_{t-1} - m^*_{t-1}) + \sum_{i=1}^{4} \beta_i \Delta m_{t-i} + \varepsilon_t \qquad (13)$$

where m* is equilibrium money recursively estimated by the same method as for the P* equation, i.e. either (12), or an hp filter. We incorporate (13) into a model containing (12) and either P*HPS or P*SG, plus identities linking money and velocity and their respective equilibria. We estimate the model recursively, and perform recursive out-of-sample forecasts conditional on most recent estimates of the output gap and actual outturns of money demand determinants when money demand velocity gaps are used. This procedure thus understates the uncertainty about the output gap, but probably overstates the uncertainty around future velocity gaps, as the Central Bank is likely to have better models to forecast money than (13). This method we call "recursive forecasts with endogenous money".

Having derived these forecasts, we calculate, for each horizon and using all forecasts available[8], the root mean square error (RMSE) and the bias (B)[9]. We base our forecasts on

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[8] This means we use more observations for short-term forecasts than for long-term forecasts. We have also implemented the model to calculate statistics based on periods chosen by the two alternatives:

1) forecasts for the same periods. This is best if we think that uncertainty about future shocks, and their time-varying magnitude, dominate forecast errors, as one uses the same periods for forecasts at different horizons, i.e. coming from different equation estimates.
2) forecasts coming from the same equation estimates. This is preferable if one thinks coefficient uncertainty is dominant, as one calculates forecasts at different horizons based on the same set of equation estimates.

Given the short sample of observations we have, we chose to use all forecasts available.

[9] To calculate RMSEs, we use the unadjusted measure, i.e. without correction for degrees of freedom. This gives us for horizon *k*:

$$RMSE_k = \sqrt{\frac{\sum_{2000.1+k}^{2004.1} \left(\Delta p - \Delta p_{fc,k}\right)^2}{n-k}}$$

where n is the number of periods. Our measure for bias is the ratio of mean error to mean absolute error, i.e. for horizon k the equation specifications presented in table 4, i.e. with flexibility for the lag of the velocity gap.

We compare these two sets of forecasts to those from three benchmark models. The first is an ARIMA (1,1,1) which has been shown to perform well for inflation in Chile in the past (see Garcia and Pasten (2004)). Also, in order to identify the effect of the velocity gaps for inflation forecasts in our P* models, we report forecasts from versions of P*HPS and P*SG without the velocity gaps. The resulting equation can be interpreted as a simple Phillips Curve specified in differences of inflation or deviations from the inflation target respectively.

$$B_k = \frac{MEr_k}{MAbsEr_k} = \frac{\sum_{2000.1+k}^{2004.1} (\Delta p - \Delta p_{fc,k})}{\sum_{2000.1+k}^{2004.1} \left| \Delta p - \Delta p_{fc,k} \right|}$$

The resulting figure lies between –1 (all forecasts too high), and 1 (all forecasts lower than actual inflation).

Table 4 Recursive out-of-sample forecasts with exogenous money 2000Q1 – 2004Q2

1	2	3	4	5	6	7	8	9
		Lag of velocity gap	RMSE			Bias (-1<B<1)		
			1 quart.	2 quart.	4 quart.	1 quart.	2 quart.	4 quart.
P*HPS	**Circulante**	1	0.51	0.74	1.18	-0.23	-0.37	-0.58
	M1A	1	0.71	1.27	2.73	-0.59	-0.77	-0.87
Money demand gap	**M2A**	4	0.74	1.12	2.05	0.81	0.90	1.00
	M3tot	4	0.74	1.10	1.96	0.81	0.91	1.00
	M7tot	3	0.50	0.69	0.99	0.66	0.79	0.94
	M7xDBC	3	0.77	1.20	2.16	0.99	1.00	1.00
	Circulante	1	0.48	0.69	1.08	-0.20	-0.36	-0.78
	M1A	1	0.70	1.26	2.85	-0.70	-0.91	-1.00
HP filter gap	**M2A**	3	0.70	1.06	1.87	0.82	0.87	0.98
	M3tot	3	0.68	1.01	1.73	0.80	0.86	0.98
	M7tot	3	0.60	0.94	1.67	0.91	0.97	1.00
	M7xDBC	3	0.76	1.20	2.27	0.96	0.99	1.00
P*SG	**Circulante**	1	0.42	0.51	0.59	-0.09	-0.14	-0.22
	M1A	1	0.50	0.70	0.93	-0.43	-0.55	-0.75
Money demand gap	**M2A**	4	0.51	0.64	0.79	0.69	0.76	0.84
	M3tot	4	0.51	0.64	0.78	0.70	0.78	0.85
	M7tot	3	0.37	0.41	0.42	0.30	0.31	0.23
	M7xDBC	4	0.46	0.57	0.69	0.73	0.81	0.92
	Circulante	1	0.38	0.47	0.55	-0.10	-0.18	-0.38
	M1A	1	0.48	0.66	0.96	-0.52	-0.67	-0.85
HP filter gap	**M2A**	3	0.46	0.57	0.66	0.62	0.68	0.72
	M3tot	3	0.46	0.58	0.66	0.63	0.70	0.75
	M7tot	3	0.40	0.49	0.56	0.66	0.78	0.88
	M7xDBC	3	0.48	0.63	0.81	0.79	0.87	0.93
Benchmark models	**ARIMA(1,1,1)**		0.44	0.62	0.72	-0.15	-0.24	-0.47
	P*HPS without vel. gap		0.47	0.61	0.76	0.45	0.52	0.67
	P*SG without vel. gap		0.37	0.41	0.42	0.17	0.15	0.07

In table 4 we present forecasts with exogenous money. The results somewhat attenuate the enthusiasm about P* in Chile. The first, perhaps not too surprising, thing to note is that specifying the model in terms of deviations of inflation from target results in much smaller errors. More importantly, the P*SG errors also increase much less as the forecast horizon increases. Across monetary aggregates, the Circulante generally performs best, with smaller errors than the others. But surprisingly also forecasts based on total M7 velocity perform somewhat better than the rest. In any case, M1A-based forecast errors are always larger.

But other than in the magnitude of forecast errors, we are also interested in their biasedness, that is we want forecast errors to be equally distributed below and above outturns. Here we see that most of the P* models show an unsatisfactory performance. Bias coefficients are generally large and positive for broad money aggregates. This indicates a systematic underprediction of actual inflation. Forecasts based on M1A-velocity on the other hand overpredict on average, reflecting the large negative velocity gap estimated during the years considered in the exercise. Somewhat more satisfactory is the circulante, which shows only slight overprediction bias in the P*SG specification.

But how do these forecasts fare against our benchmarks? The last three lines of table 4 show that including the velocity gaps in general does not improve our forecasts. First, the ARIMA model generally predicts inflation more accurately and with less bias then the the HPS version of the P* model, while the SG models show root mean squared errors of comparable size. In the case of Circulante and M7 the errors are actually somewhat smaller, and less biased downwards, than the ARIMA benchmark.
But does this slight improvement come from the inclusion of the velocity gap? The last line of table 4 shows that this is not actually the case. Excluding the velocity gap, and forecasting inflation from the remaining, essentially Phillips curve, equation, shows forecast errors that are slightly bigger than the best P*SG specification at the horizon of 1 quarter, but that increase much less quickly in size and biasedness.

Table A3 of the Annex presents the results of forecasts from our larger model with a forecast equation for money and velocity. As expected, the results are not very different for broad money, as the long lag of the effect from money to inflation means differences show only in the figures for 4 quarter ahead forecasts, if at all. But surprisingly, for narrow money the endogeneity of money does not lead to a large and quick deterioration of our forecasts. In fact for M1A, the forecasts are actually slightly better than when conditioning on actuall outturns. Figure 1 provides some rationale for this. The large surprising growth rates of real M1A since 2002 did not correspond to increases in output or prices. So the forecasts for inflation with endogenous money, not incorporating these shocks of actual M1A but expected values based on lagged money growth, overpredict inflation slightly less.

Is this phenomenon just due to the particularities of the last years, namely low inflation and portfolio reallocation from broad money to sight deposits? Table A4 and A5 in the appendix show that this is at least partly the case. Evaluating forecasts over the 1999Q1-2002Q4 period, we see that narrow money P* models forecast better, and less biased than broad money. The P*HPS version including the Circulante velocity gap performs especially good, but there are also good results for M1A. All four narrow money models show slightly smaller root mean square errors than their counterparts without velocity gaps (with only very small differences for the P*SG model however). The biases are less than in the benchmark models, but greater than those of the ARIMA. But this does not hold for broad money models, that also perform worse than the non-monetary benchmarks over this period, although again models including the M7 velocity gap are a bit better.

Finally, the forecast statistics for CPIX1 confirm the results for the CPI (see table A6 in the appendix). Including the velocity gaps does not reduce the size of forecast errors, but often introduces a bias in the forecast in recent times. The Circulante again shows a better performance than the other aggregates in the HPS model, but not necessarily in the SG model.

Thus, overall, the in-sample enthusiasm about P* in Chile vanishes when looking at its forecast performance in recent times. Only the Circulante shows forecast performance similar to the ARIMA or non-monetary benchmarks, which holds in both of our evaluation periods. Models based on M1A, the usual money aggregate of choice in Chile, strongly overpredict inflation in recent times.

7. Conclusions

This paper looked at the indicator properties of money for inflation, conditioning on the output gap and estimated equilibrium money movements in a P* framework. We estimated the traditional Hallman et al (1991) model, and the more recent version of Gerlach and Svensson (2003) estimated in terms of inflation deviations from target, and find significant effects of both broad and narrow money velocity gaps, once we allow for a lag in the effect from money to inflation. Also, the restrictions implicit in the P* model, that the effects of both gaps is equal in size, are accepted for the majority of broad money models, while the output gap is generally insignificant in the equations for narrow money aggregates Circulante and M1A.

Within the family of P* models we look at, the indicator properties of money for inflation are somewhat reduced, but by no means eliminated, by taking deviations from inflation as the independent variable, according to the SG model. And deviations from an hp filtered trend have on average more explanatory power than velocity gaps based on estimaged money demand equations. This is likely to be due to the opening of large deviations of velocity from their estimated equilibrium in recent times.

Despite these positive results for the P* model in Chile, a forecast exercise showed that in recent years, the P* models do not actually produce any better forecasts than a simple ARIMA equation or P*-based Phillips curves without money. Only Circulante-based P* models show forecast errors of size and bias comparable to the benchmarks. M1A forecasts seem to have deteriorated rapidly in recent years.

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Appendix

Table A1 Estimation results for CIPX1 1987Q3-2004Q2, lag of velocity gap chosen to maximise significance

1	2	3	4		5		6		7		8		9	10
		Lag of velocity gap	Velocity gap		Output gap		Equality of gap coefficients		Dynamic homogeneity		Lagged dev. from target		R squared	Durbin Watson
			Coeff.	*t stat.*	Coeff.	*t stat.*	F stat.	*P value*	F stat.	*P value*	Coeff.	*t stat.*		
P*HPS	**Circulante**	2	-0.04	*-1.79*	0.02	*0.98*	0.63	*0.43*	0.95	*0.33*	-	-	0.36	1.91
	M1A	2	-0.01	*-0.98*	0.01	*0.41*	0.03	*0.87*	1.30	*0.26*	-	-	0.34	1.91
Money demand gap	**M2A**	3	-0.04	*-1.99*	0.04	*1.83*	0.00	*0.97*	0.28	*0.60*	-	-	0.37	1.84
	M3tot	3	-0.05	*-2.10*	0.04	*1.85*	0.13	*0.72*	0.25	*0.62*	-	-	0.37	1.84
	M7tot	3	0.01	*0.36*	0.02	*1.01*	0.91	*0.34*	1.05	*0.31*	-	-	0.33	1.91
	M7xDBC	3	-0.04	*-1.92*	0.04	*1.94*	0.09	*0.76*	0.37	*0.54*	-	-	0.37	1.87
	Circulante	2	-0.05	*-1.66*	0.01	*0.62*	0.81	*0.37*	0.75	*0.39*	-	-	0.36	1.92
	M1A	2	-0.03	*-1.67*	0.00	*0.17*	0.63	*0.43*	0.57	*0.45*	-	-	0.36	1.92
HP filter gap	**M2A**	3	-0.06	*-2.03*	0.03	*1.70*	0.82	*0.37*	0.98	*0.33*	-	-	0.37	1.83
	M3tot	3	-0.07	*-2.14*	0.03	*1.68*	1.25	*0.27*	0.81	*0.37*	-	-	0.37	1.84
	M7tot	1	0.00	*-0.13*	0.02	*0.99*	0.30	*0.59*	1.26	*0.27*	-	-	0.33	1.90
	M7xDBC	3	-0.08	*-2.10*	0.04	*1.99*	1.35	*0.25*	1.17	*0.28*	-	-	0.37	1.88
P*SG	**Circulante**	2	-0.05	*-2.58*	0.05	*3.23*	0.00	*0.99*	2.26	*0.14*	0.30	*2.28*	0.95	1.91
	M1A	2	-0.01	*-1.10*	0.04	*2.25*	1.11	*0.30*	1.74	*0.19*	0.35	*2.53*	0.94	1.89
Money demand gap	**M2A**	3	-0.04	*-2.31*	0.07	*4.04*	2.68	*0.11*	-0.22	*1.00*	0.32	*2.41*	0.95	1.87
	M3tot	3	-0.05	*-2.52*	0.07	*4.13*	1.25	*0.27*	-0.28	*1.00*	0.31	*2.34*	0.95	1.86
	M7tot	3	-0.02	*-1.04*	0.06	*3.33*	1.85	*0.18*	0.96	*0.33*	0.35	*2.52*	0.94	1.91
	M7xDBC	3	-0.03	*-1.66*	0.07	*3.72*	5.32	*0.02*	0.10	*0.75*	0.35	*2.56*	0.94	1.87
	Circulante	2	-0.07	*-2.93*	0.04	*2.56*	0.62	*0.43*	2.10	*0.15*	0.26	*1.97*	0.95	1.93
	M1A	2	-0.03	*-1.78*	0.04	1.95	0.10	*0.75*	0.75	*0.39*	0.34	*2.51*	0.94	1.89
HP filter gap	**M2A**	3	-0.06	*-2.60*	0.07	*4.10*	0.03	*0.86*	2.21	*0.14*	0.33	*2.49*	0.95	1.88
	M3tot	3	-0.07	*-2.75*	0.07	*4.10*	0.05	*0.83*	1.68	*0.20*	0.31	*2.38*	0.95	1.87
	M7tot	3	-0.05	*-1.63*	0.07	*3.71*	0.40	*0.53*	2.20	*0.14*	0.37	*2.69*	0.94	1.94
	M7xDBC	3	-0.07	-1.97	0.07	3.89	0.03	0.87	1.83	0.18	0.39	2.81	0.95	1.90

Table A2 Forecast statistics with endogenous money, 2000Q1-2004Q2

1	2	3	4	5	6	7	8	9
		Lag of velocity gap	RMSE			Bias (-1<B<1)		
			1 quart.	2 quart.	4 quart.	1 quart.	2 quart.	4 quart.
P*HPS	**Circulante**	1	0.51	0.79	1.14	-0.23	-0.31	-0.54
	M1A	1	0.71	1.19	1.97	-0.59	-0.64	-0.77
Money demand gap	**M2A**	4	0.74	1.12	2.05	0.81	0.90	1.00
	M3tot	4	0.74	1.10	1.96	0.81	0.91	1.00
	M7tot	3	0.50	0.69	0.94	0.66	0.79	0.93
	M7xDBC	3	0.77	1.20	2.00	0.99	1.00	1.00
	Circulante	1	0.48	0.78	1.19	-0.20	-0.36	-0.96
	M1A	1	0.70	1.27	2.69	-0.70	-0.88	-1.00
HP filter gap	**M2A**	3	0.70	1.06	1.83	0.82	0.87	0.97
	M3tot	3	0.68	1.01	1.69	0.80	0.86	0.97
	M7tot	3	0.60	0.94	1.61	0.91	0.97	1.00
	M7xDBC	3	0.76	1.20	2.15	0.96	0.99	1.00
P*SG	**Circulante**	1	0.42	0.53	0.55	-0.09	-0.12	-0.16
	M1A	1	0.50	0.66	0.68	-0.43	-0.45	-0.44
Money demand gap	**M2A**	4	0.51	0.64	0.79	0.69	0.76	0.84
	M3tot	4	0.51	0.64	0.78	0.70	0.78	0.85
	M7tot	3	0.37	0.41	0.41	0.30	0.31	0.21
	M7xDBC	4	0.46	0.57	0.69	0.73	0.81	0.92
	Circulante	1	0.38	0.50	0.56	-0.10	-0.21	-0.59
	M1A	1	0.48	0.66	0.89	-0.52	-0.66	-0.97
HP filter gap	**M2A**	3	0.46	0.57	0.66	0.62	0.68	0.66
	M3tot	3	0.46	0.58	0.67	0.63	0.70	0.69
	M7tot	3	0.40	0.49	0.54	0.66	0.78	0.87
	M7xDBC	3	0.48	0.63	0.77	0.79	0.87	0.92
Benchmark models	**ARIMA(1,1,1)**		0.44	0.62	0.72	-0.15	-0.24	-0.47
	P*HPS without vel. gap		0.47	0.61	0.76	0.45	0.52	0.67
	P*SG without vel. gap		0.37	0.41	0.42	0.17	0.15	0.07

Table A4 Forecast statistics 1999Q1-2002Q4, exogenous money

1	2	3	4	5	6	7	8	9
		Lag of velocity gap	RMSE			Bias (-1<B<1)		
			1 quart.	2 quart.	4 quart.	1 quart.	2 quart.	4 quart.
P*HPS	**Circulante**	1	0.39	0.43	0.55	0.35	0.50	0.69
	M1A	1	0.47	0.64	1.29	0.03	0.04	-0.01
Money demand gap	**M2A**	4	0.78	1.20	2.13	0.91	0.97	1.00
	M3tot	4	0.78	1.18	2.04	0.92	0.98	1.00
	M7tot	3	0.53	0.77	1.25	0.86	1.00	1.00
	M7xDBC	3	0.70	1.12	2.07	0.98	1.00	1.00
	Circulante	1	0.38	0.42	0.51	0.13	0.09	-0.11
	M1A	1	0.47	0.71	1.58	-0.44	-0.66	-0.85
HP filter gap	**M2A**	3	0.70	1.10	2.02	0.95	0.98	1.00
	M3tot	3	0.66	1.02	1.84	0.95	0.97	1.00
	M7tot	3	0.60	0.95	1.68	0.97	1.00	1.00
	M7xDBC	3	0.69	1.10	2.13	0.93	0.96	1.00
P*SG	**Circulante**	1	0.43	0.49	0.59	0.57	0.68	0.75
	M1A	1	0.43	0.52	0.62	0.18	0.22	0.26
Money demand gap	**M2A**	4	0.57	0.72	0.88	0.86	0.90	1.00
	M3tot	4	0.57	0.71	0.87	0.87	0.92	1.00
	M7tot	3	0.43	0.51	0.54	0.62	0.75	0.83
	M7xDBC	4	0.51	0.62	0.74	0.81	0.85	1.00
	Circulante	1	0.42	0.47	0.53	0.45	0.50	0.56
	M1A	1	0.42	0.51	0.63	0.00	-0.06	-0.16
HP filter gap	**M2A**	3	0.52	0.66	0.83	0.90	0.96	1.00
	M3tot	3	0.52	0.66	0.83	0.92	0.97	1.00
	M7tot	3	0.45	0.56	0.66	0.84	0.93	1.00
	M7xDBC	3	0.51	0.67	0.90	0.90	0.94	1.00
Benchmark models	**ARIMA(1,1,1)**		0.46	0.59	0.52	0.05	0.14	0.09
	P*HPS without vel. gap		0.54	0.77	1.13	0.81	0.96	1.00
	P*SG without vel. gap		0.43	0.50	0.53	0.60	0.72	0.78

Table A5 Forecast statistics 1999Q1-2002Q4, endogenous money

1	2	3	4	5	6	7	8	9
		Lag of velocity gap	RMSE			Bias (-1<B<1)		
			1 quart.	2 quart.	4 quart.	1 quart.	2 quart.	4 quart.
P*HPS	**Circulante**	1	0.39	0.51	0.77	0.35	0.47	0.68
	M1A	1	0.47	0.60	0.99	0.03	0.13	0.23
Money demand gap	**M2A**	4	0.78	1.20	2.13	0.91	0.97	1.00
	M3tot	4	0.78	1.18	2.04	0.92	0.98	1.00
	M7tot	3	0.53	0.77	1.21	0.86	1.00	1.00
	M7xDBC	3	0.70	1.12	1.95	0.98	1.00	1.00
	Circulante	1	0.38	0.50	0.67	0.13	0.12	-0.10
	M1A	1	0.47	0.69	1.51	-0.44	-0.72	-0.92
HP filter gap	**M2A**	3	0.70	1.10	1.98	0.95	0.98	1.00
	M3tot	3	0.66	1.02	1.82	0.95	0.97	1.00
	M7tot	3	0.60	0.95	1.65	0.97	1.00	1.00
	M7xDBC	3	0.69	1.10	2.05	0.93	0.96	1.00
P*SG	**Circulante**	1	0.43	0.52	0.69	0.57	0.63	0.78
	M1A	1	0.43	0.51	0.57	0.18	0.28	0.46
Money demand gap	**M2A**	4	0.57	0.72	0.88	0.86	0.90	1.00
	M3tot	4	0.57	0.71	0.87	0.87	0.92	1.00
	M7tot	3	0.43	0.51	0.54	0.62	0.75	0.82
	M7xDBC	4	0.51	0.62	0.74	0.81	0.85	1.00
	Circulante	1	0.42	0.50	0.61	0.45	0.48	0.55
	M1A	1	0.42	0.49	0.58	0.00	-0.07	-0.36
HP filter gap	**M2A**	3	0.52	0.66	0.83	0.90	0.96	1.00
	M3tot	3	0.52	0.66	0.85	0.92	0.97	1.00
	M7tot	3	0.45	0.56	0.65	0.84	0.93	1.00
	M7xDBC	3	0.51	0.67	0.88	0.90	0.94	1.00
Benchmark models	**ARIMA(1,1,1)**		0.46	0.59	0.52	0.05	0.14	0.09
	P*HPS without vel. gap		0.54	0.77	1.13	0.81	0.96	1.00
	P*SG without vel. gap		0.43	0.50	0.53	0.60	0.72	0.78

Table A6 Forecast statistics for CPIX1 2000Q1-2004Q2, exogenous money

1	2	3	4	5	6	7	8	9
		Lag of velocity gap	**RMSE**			**Bias (-1<B<1)**		
			1 quart.	2 quart.	4 quart.	1 quart.	2 quart.	4 quart.
P*HPS	**Circulante**	2	0.46	0.53	0.77	-0.03	-0.17	-0.20
	M1A	2	0.48	0.64	1.13	-0.11	-0.31	-0.44
Money demand gap	**M2A**	3	0.57	0.82	1.68	0.83	0.98	1.00
	M3tot	3	0.56	0.79	1.61	0.82	0.97	1.00
	M7tot	3	0.44	0.50	0.78	0.45	0.56	0.80
	M7xDBC	3	0.56	0.79	1.64	0.83	0.98	1.00
	Circulante	2	0.44	0.48	0.61	0.15	0.06	0.10
	M1A	2	0.48	0.64	1.18	-0.28	-0.52	-0.77
HP filter gap	**M2A**	3	0.53	0.74	1.48	0.76	0.95	1.00
	M3tot	3	0.52	0.71	1.39	0.73	0.93	1.00
	M7tot	1	0.46	0.55	0.94	0.51	0.62	0.81
	M7xDBC	3	0.53	0.75	1.55	0.78	0.95	1.00
P*SG	**Circulante**	2	0.44	0.49	0.58	-0.58	-0.71	-0.76
	M1A	2	0.46	0.55	0.77	-0.61	-0.74	-0.88
Money demand gap	**M2A**	3	0.46	0.52	0.80	0.73	0.85	0.96
	M3tot	3	0.45	0.50	0.75	0.73	0.84	0.97
	M7tot	3	0.37	0.36	0.42	0.24	0.24	0.50
	M7xDBC	3	0.42	0.46	0.66	0.59	0.73	0.92
	Circulante	2	0.40	0.44	0.49	-0.48	-0.63	-0.73
	M1A	2	0.43	0.51	0.72	-0.62	-0.78	-0.93
HP filter gap	**M2A**	3	0.42	0.47	0.70	0.59	0.71	0.90
	M3tot	3	0.41	0.45	0.65	0.56	0.68	0.89
	M7tot	3	0.38	0.38	0.49	0.33	0.43	0.72
	M7xDBC	3	0.40	0.44	0.63	0.52	0.68	0.88
Benchmark models	**ARIMA(1,1,1)**		0.43	0.46	0.54	-0.09	-0.23	-0.21
	P*HPS without vel. gap		0.45	0.51	0.84	0.50	0.66	0.92
	P*SG without vel. gap		0.37	0.36	0.40	0.11	0.07	0.28

Table A7 Forecast statistics for CPIX1 2000Q1-2004Q2, endogenous money

1	2	3	4	5	6	7	8	9
		Lag of velocity gap		RMSE			Bias (-1<B<1)	
			1 quart.	2 quart.	4 quart.	1 quart.	2 quart.	4 quart.
P*HPS	**Circulante**	2	0.46	0.53	0.75	-0.03	-0.17	-0.09
	M1A	2	0.48	0.64	1.08	-0.11	-0.31	-0.27
Money demand gap	**M2A**	3	0.57	0.82	1.62	0.83	0.98	1.00
	M3tot	3	0.56	0.79	1.53	0.82	0.97	1.00
	M7tot	3	0.44	0.50	0.78	0.45	0.56	0.82
	M7xDBC	3	0.56	0.79	1.58	0.83	0.98	1.00
	Circulante	2	0.44	0.48	0.60	0.15	0.06	-0.01
	M1A	2	0.48	0.64	1.20	-0.28	-0.52	-0.79
HP filter gap	**M2A**	3	0.53	0.74	1.46	0.76	0.95	0.99
	M3tot	3	0.52	0.71	1.38	0.73	0.93	0.99
	M7tot	1	0.46	0.55	0.92	0.51	0.63	0.88
	M7xDBC	3	0.53	0.75	1.51	0.78	0.95	1.00
P*SG	**Circulante**	2	0.44	0.49	0.54	-0.58	-0.71	-0.62
	M1A	2	0.46	0.55	0.68	-0.61	-0.74	-0.73
Money demand gap	**M2A**	3	0.46	0.52	0.77	0.73	0.85	0.90
	M3tot	3	0.45	0.50	0.70	0.73	0.84	0.88
	M7tot	3	0.37	0.36	0.42	0.24	0.24	0.46
	M7xDBC	3	0.42	0.46	0.64	0.59	0.73	0.88
	Circulante	2	0.40	0.44	0.54	-0.48	-0.63	-0.83
	M1A	2	0.43	0.51	0.74	-0.62	-0.78	-0.94
HP filter gap	**M2A**	3	0.42	0.47	0.71	0.59	0.71	0.81
	M3tot	3	0.41	0.45	0.66	0.56	0.68	0.79
	M7tot	3	0.38	0.38	0.48	0.33	0.43	0.65
	M7xDBC	3	0.40	0.44	0.62	0.52	0.68	0.82
Benchmark models	**ARIMA(1,1,1)**		0.43	0.46	0.54	-0.09	-0.23	-0.21
	P*HPS without vel. gap		0.45	0.51	0.84	0.50	0.66	0.92
	P*SG without vel. gap		0.37	0.36	0.40	0.11	0.07	0.28

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