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Fernando de Holanda Barbosa and Tito Nícias Teixeira da Silva Filho July, 2008

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Testing Hyperinflation Theories Using the Inflation Tax Curve: a case study^{*}

Fernando de Holanda Barbosa^{***} Tito Nícias Teixeira da Silva Filho^{***}

Abstract

The Working Papers should not be reported as representing the views of the Banco Central do Brasil. The views expressed in the papers are those of the author(s) and do not necessarily reflect those of the Banco Central do Brasil.

This paper tests hyperinflation theories using the inflation tax curve. This curve is estimated directly instead of the usual approach which is a byproduct of demand for money empirical estimates. The inflation tax functional form encompasses several specifications as particular cases and allows to test whether or not money is inelastic. This strategy is applied to the Brazilian annual data covering almost half a century. The money inelasticity hypothesis is rejected. Thus, both the bubble and the strict hyperinflation hypotheses are rejected. The weak hyperinflation hypothesis is not rejected and the Brazilian economy could have been in the 'wrong' side of the Laffer curve for some time during hyperinflation. This outcome, contrary to conventional wisdom, is predicted by the weak hypothesis.

Keywords: inflation, inflation tax, demand for money, money essentiality, financial innovation.

JEL Classification: E31; E41; E42.

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^{**} Getulio Vargas Foundation. E-mail: fholanda@fgv.br.

^{****} Research Department, Central Bank of Brazil. E-mail: tito.nicias@bcb.gov.br

1. Introduction

The inflation tax curve has been estimated as a by-product of demand for money equations estimates, which, in general, assume Cagan's (1956) functional form. In that specification the semi-elasticity (α) of the demand for money with regard to the inflation rate is constant and its inverse (times 100) equals the inflation rate that maximizes the government revenue from the inflation tax.

Monthly Inflation Rate that Maximizes the Inflation Tax			
Author Semi-Elasticity		Continuous Monthly Inflation	
	(α)	Rate	
		(100/α)	
Cagan (1956)	5.46	18.3	
Barro (1970)	3.79	26.4	
Frenkel (1977)	3.51	28.5	
Sargent (1977)	2.34	42.7	
Goodfriend (1982)	5.27	19.0	
Burmeister, Wall (1987)	1.66	60.3	
Cristiano (1987)	1.76	56.8	
Webb (1989)	3.33	30.0	
Casella (1989)	0.87	115.0	
Taylor (1991)	5.31	18.8	
Engsted (1993)	4.96	20.2	
Imrohoroglu (1993)	1.08	92.6	
Michael et al. (1994)	0.70	143.0	

Table 1Monthly Inflation Rate that Maximizes the Inflation Tax

Table 1 shows semi-elasticity estimates for the German hyperinflation made by several economists. The monthly inflation rate estimates that maximize the inflation tax range from 18.3% to 143%, with inflation being measured in continuous terms. Table 1 estimates, with the exception of those made by Casella (1989) and Michael *et al.* (1994), lead one to conclude that the German government could have obtained more tax revenue with lower inflation rates, during the hyperinflation. The estimates of Casella (1989) and Michael *et al.* (1989) and Michael *et al.* (1994) correspond to discrete monthly inflation rates of 216%

and 318%, respectively. Those rates were observed only in the last months of the German hyperinflation.

This paper tests hyperinflation theories using the inflation tax curve. This curve can be used to discriminate among hyperinflation theories because a bubble or a strict hyperinflation occurs only if money is inelastic and a weak hyperinflation occurs only if money is non-inelastic, as will be shown in Section 2. The empirical evidence presented here rejects both the bubble and the strict hyperinflation hypotheses, but does not reject the weak hyperinflation hypothesis. The weak hypothesis is consistent with the fact that the economy will be in the 'wrong' side of the Laffer curve for some time during a hyperinflation. This outcome, contrary to conventional wisdom, is predicted by the weak hypothesis and solves an old puzzle of the hyperinflation literature raised by Cagan's (1956) seminal paper.

We follow a different strategy from other papers in the literature, as those listed above and estimate the inflation tax curve directly from a functional form that encompasses several specifications as particular cases. This approach also allows one to test whether or not the demand for money specification used by Cagan is appropriate. This methodology is applied to the Brazilian data and rejects money inelasticity. The inflation tax data are annual and were calculated by Cysne and Lisboa (2004) for the 1947–2003 period. This period includes the Brazilian hyperinflation, which started in the second half of the 1980s and ended in 1994 with the Real Plan. In contrast to other empirical studies on the subject, which use small samples covering only hyperinflation periods, the sample here covers almost half a century, in which both inflation and the inflation tax showed great variability.

The paper is organised as follows: Section 2 presents an abridged survey of hyperinflation theories; Section 3 lays out two functional forms for the inflation tax, one in which money is inelastic and another in which it is non-inelastic, as well as a functional form that encompasses both forms as particular cases; Section 4 presents graphical evidence on the link between the inflation rate and the inflation tax for Brazil; Section 5 provides the empirical results and Section 6 concludes by summarizing the results.

2. Hyperinflation Theories

Hyperinflation theories explain this phenomenon either through fundamentals or bubbles. In both cases the government finances its deficit (f) issuing money (M):

$$\frac{\dot{M}}{P} = f \quad , \quad f = f(t) \tag{1}$$

where a dot represents a time derivative and *P* is the price level. The public deficit increases through time under a fiscal crisis. We define m = M/P. Its derivative with respect to time and the hypothesis that the fiscal deficit is financed issuing money yields:

$$\dot{m} = f - m \,\pi = f(t) - \tau(m) \tag{2}$$

where π is the rate of inflation and $\tau(m) = \pi m$ is the inflation tax.



Figure 1 shows the diagram of differential equation (2) where money is essential, e.g., the absolute value of the elasticity of the real quantity of money with

respect to the interest rate is less than or equal to one [$\tau'(m) \le 0$]. The horizontal arrow towards the origin shows that a bubble may exist. On the other hand, if there is a fiscal crisis, the fiscal deficit increases through time, and the arrows on the inflation tax curve depicts a hyperinflation path (*HH*), starting at the point where the real quantity of money is m(0).¹ The rate of inflation goes to infinite and the real quantity of money approaches zero ($m(t_h) = 0$). This is a strict hyperinflation [Barbosa *et al.* (2006), p. 188-192].



Figure 2 shows the case where money is non-inelastic, e.g., the absolute value of the elasticity of the real quantity of money with respect to the interest rate can be non-inelastic [τ (m) is a bell-shaped curve]. The horizontal arrow away from the origin indicates that there is no bubble when money is non-inelastic. If there is a fiscal crisis, the fiscal deficit increases, the rate of inflation increases and eventually will reach the 'wrong' side of the Laffer curve, as shown by the arrows on the inflation tax curve (*HH*), with the initial value of the real quantity of money being given by m(0) and the

¹ The fiscal deficit at the beginning of the fiscal crisis is f(0) and t_h represents the time that the hyperinflation may last. Thus $f(t_h)$ is the fiscal deficit at this moment. The initial real quantity of money, for both cases [Figures 1 and 2] satisfies the inequality; $\dot{m} = f(0) - \tau(m(0)) < 0$. For more details see Barbosa et al (2006).

final value by $m(t_h)$. This is a weak hyperinflation [Barbosa et al (2006), p.192-193], since the rate of inflation does not go to infinite and the real quantity of money does not approach zero. Thus, there is nothing wrong with being in the 'wrong' side of the Laffer curve, since this is the outcome of the dynamics of a weak hyperinflation.

The weak hyperinflation hypothesis is akin to Sargent and Wallace (1987) model with one caveat. In their model the public deficit is constant and the hyperinflation process is the transition path from the unstable steady state with low inflation to the stable one with high inflation, e.g., the path from point A to point B along the inflation tax curve in Figure 2. Sargent and Wallace do not provide a rationale for this path to come into existence. The weak hyperinflation path (*HH* in Figure 2) is generated by an increasing fiscal deficit financed by issuing money.

For the sake of completeness we shall present a standard hyperinflation model of a fiscal crisis with rigidity, either on expectations or adjustment on the money market, which can be found in textbooks such as [Romer (2001), p.514-519]. This model is based on Cagan's demand for money,

$$\log m = k - \alpha \pi^e \quad , \ \alpha > 0 \tag{3}$$

where π^{e} , the expected rate of inflation, follows the adaptive mechanism:

$$\dot{\pi}^e = \beta \left(\pi - \pi^e \right) \ , \ \beta > 0 \tag{4}$$

By combining equations (1), (3) and (4) we obtain the following differential equation:

$$\dot{m} = -\frac{\alpha\beta}{1-\alpha\beta}f(t) + \frac{\beta km}{1-\alpha\beta} - \frac{\beta}{1-\alpha\beta}m\log m, \ 1-\alpha\beta > 0$$
(5)

Figure (3) shows the phase diagram of equation (5). When the fiscal deficit is constant, there are two points of equilibrium, one stable and the other one unstable. Thus, a bubble may occur. If there is a fiscal crisis and the fiscal deficit, which is money financed, jumps to an unsustainable level (from A to B) the economy enters a hyperinflation path (HH), the rate of inflation goes to infinite and the real quantity of money approaches zero. This model yields a strict hyperinflation. However, it should be

pointed out that during this path, when the rate of inflation is skyrocketing, the inflation tax increases, e.g., money is inelastic.



Figure 3 Strict Hyperinflation with Rigidity

From this survey we may conclude that a bubble or a strict hyperinflation may occur only if money is inelastic; a weak hyperinflation may occur only if money is noninelastic. Thus, the inflation tax curve can be used as a device to discriminate among hyperinflation theories.

3. The Inflation Tax Curve

The inflation tax (τ) equals the inflation rate (π) – the tax rate – times the real quantity of money (m) – the tax base. That is: $\tau = \pi m$. Both the tax and the real quantity of money are defined in relation to real GDP, assuming a unity income elasticity of money. It is more convenient to write the inflation tax in its logarithmic form:

$$\log \tau = \log \pi + \log m \tag{6}$$

Note that the specification of equation (6) depends on the demand for money functional form. The two specifications below correspond, respectively, to the semi-

logarithmic and logarithmic cases. In the first case the semi-elasticity is constant and the absolute value of the real demand for money inflation elasticity $|\eta|$ is proportional to the inflation rate. In the second case the elasticity is constant.

$$\log m = k_1 - \alpha \pi , \qquad |\eta| = \alpha \pi , \ \alpha > 0 \tag{7}$$

$$\log m = k_2 - \beta \log \pi , \quad |\eta| = \beta < 1 \tag{8}$$

Hence the inflation tax functional forms for each case are as follows:

$$\log \tau = k_1 + \log \pi - \alpha \pi \tag{9}$$

$$\log \tau = k_2 + (1 - \beta) \log \pi \tag{10}$$



Figure 4a shows the inflation tax curve produced by equation (9), in which the semi-elasticity is constant. That curve has a maximum for a given inflation rate, that is, the inflation tax initially increases with inflation and after a certain rate it begins to decrease. Figure 4b shows the inflation tax curve yielded by equation (10), in which the demand for money curve has a logarithmic specification. The curve is a straight line, that is, the inflation tax increases as the inflation rate increases. In this case money is essential since the elasticity of the demand for money w.r.t. the inflation rate is always less than one [Barbosa and Cunha (2003) and Barbosa *et al.* (2006)].

Note that the two functional forms of the inflation tax curve are obtained as particular cases of the following function:

$$\log \tau = a_0 + a_1 \log \pi - a_2 \pi$$
 (11)

The two particular cases are as follows: a) constant semi-elasticity: $a_1 = 1$, $a_2 > 0$; constant elasticity: $a_2 = 0$. The functional form (11) also encompasses other possibilities that are not restricted to the above two cases. The inflation tax elasticity w.r.t. the inflation rate (ε) is given by:

$$\varepsilon = \frac{\partial \log \tau}{\partial \log \pi} = a_1 - a_2 \pi \tag{12}$$

This elasticity may be either negative or positive, depending upon the tax curve parameters and the inflation rate. That is, the functional form (11) is flexible enough to allow the data to show the most adequate shape of the inflation tax curve.

4. The Inflation Tax Curve in Brazil

The inflation tax was an important source of government financing in Brazil up to 1994, when the monetary policy regime changed and the Central Bank began to have inflation control as its objective. During the 1994–1999 period the Brazilian Central Bank adopted a system of administered exchange rate in order to curb inflation, and since 1999 it has been operating under an inflation targeting framework.

Figure 5 shows how the inflation tax and the (continuous) inflation rate evolved in Brazil during the 1947–2003 period. The former increased from 1947 until middle 1960s, when it began to decrease until the beginning of the 1970s. Afterwards a new growth phase began, which ended with the Real Plan in 1994. Note that while the inflation tax peaked during the 1960s, inflation actually peaked during the 1990s. Indeed, inflation was substantially higher during the latter period, when hyperinflation was underway. This evidence strongly suggests the occurrence of important financial innovations during the period under analysis, which sharply decreased the base of the inflation tax for a given inflation rate.

Figure 5 The Inflation Rate and the Inflation Tax in Brazil²



Figure 6 displays four different scatter plots between the (continuous) inflation rate (x-axis) and the associated inflation tax (y-axis), according to the way each variable is measured. Note that the two graphs in the left half side do not show any obvious relationship between both variables. However, the graphs placed in the right half side are more revealing concerning the shape of the inflation tax curve. In both cases inflation is measured in log terms and a clear positive relationship arises. The double-log specification seems to provide a slightly better fit, although it also suggests the possibility of a non linear relationship.

² The series are adjusted by their sample means for maximum fit.



Figure 6

5. Empirical Results

Table 2 shows ADF unit root tests results for the relevant variables and their transformations. Recall that inflation is measured in continuous terms. The test on the level of each variable does not reject the hypothesis of a unit root in all cases. However, the null is rejected when the variables are expressed in first differences, which means that all of them seem to be I (1). Those results open the possibility of estimating the inflation tax curve within a cointegration framework.

In order to uncover the inflation tax curve for Brazil a general-to-specific model selection strategy is used. The general unrestricted equilibrium correction model is as follows:

$$\Delta \ln Tax_{t} = \alpha_{0} + \alpha_{1}T + \alpha_{2}ST_{xx} + \dots + \alpha_{k}ST_{xx} + \beta_{0}\ln Tax_{t-1} + \beta_{1}\ln\pi_{t-1} + \beta_{2}\pi_{t-1} + \sum_{i=1}^{n}\delta_{i}\Delta \ln Tax_{t-i} + \sum_{i=0}^{n}\gamma_{i}\Delta \ln\pi_{t-i} + \sum_{i=0}^{n}\lambda_{i}\Delta\pi_{t-i} + \varepsilon_{t}$$
(13)

where *n* is usually set at 2 and ST_{xx} stands for the split trend. For example, ST_{70} indicates a time trend beginning in 1970.

Table 2						
	ADF Unit Root Tests³					
Variable	β	<i>t</i> _{ADF}	lags	$\boldsymbol{\delta}_{t\text{-test}}$	$\boldsymbol{\delta}_{t-prob}$	
	LEVELS					
Tax	0.73	-2.81	0	-	-	
π	0.85	-1.61	2	-2.00	0.05	
ln (π)	0.76	-2.17	1	-2.13	0.04	
ln (Tax)	0.81	-2.17	0	_	-	
	FI	RST DIFFER	RENCE	S		
ΔΤαχ	-0.24	-8.9**	0	-	-	
$\Delta\pi$	0.14	-6.11**	0	-	-	
Δln (Tax)	-0.41	-10.52**	0	_	-	
$\Delta \ln (\pi)$	-0.25	-8.45**	0	-	-	

Note that the trends are essential parts of the model, since they act, altogether, as a proxy for financial innovation.⁴ Indeed, they are likely to play a crucial role during modelling and estimation since, as Figure 5 strongly suggests, financial innovation was substantial during the period under analysis. Moreover, financial innovation is a key factor behind the link between inflation and inflation tax, given that it decreases the tax base for a given inflation rate. Therefore, it could cause a structural break in that link, and its absence from the model can be read as a sign of serious misspecification. Finally, note that (13) encompasses the possibility of a split trend with several segments. This makes sense since financial innovation could have evolved at different paces during the sample. For instance, the higher the inflation rate, the bigger the incentive for agents to come up with more money-demand-saving innovations.

Indeed, from the outset it should be called to attention that cointegration was

³ The test equation is given by $\Delta y_t = c + \alpha t + (\beta - 1)y_{t-1} + \sum_{i=1}^2 \delta_i \Delta y_{t-i} + \varepsilon_t$. Significant levels of 5% and 10% are expressed, respectively, as * and **.

⁴ It should be pointed out that theoretically they pick all the factors that influence the desire to hold money for a given inflation rate, whether those are due to financial innovations or not (e.g. changes in taxes). Nonetheless, for simplicity, from now on we should refer to them as a proxy for financial innovation.

found only in those specifications that included time trends, attesting their utmost relevance. However, even in those cases models showed signs of structural break quite often, revealing the importance of "getting the trend right". In fact, one major difficulty in searching for congruent models was precisely to uncover the "the right path" for financial innovation.

Equations 14 and 15 show the two final selected specifications (called models 1 and 2 in Table 3, respectively). All diagnostic statistics are satisfactory in both cases. Moreover, recursive estimates as well as recursive Chow tests – placed in the Appendix – show that parameters are stable and no obvious structural breaks are found. Those are significant results not only due to the long sample involved, but also due to the fact that during the period under analysis the Brazilian economy underwent significant changes and was subjected to large shocks, including several stabilisation plans, most of them with heterodox features.

$$\Delta \ln Tax_{t} = 3.36 - 0.03T - 0.04ST_{71} - 0.12ST_{80} + 0.14ST_{85} + 0.18ST_{95} + 0.42LD_{86} - 1.14D_{94} + 0.78D_{98} - 1.26\ln Tax_{t-1} + 1.32\ln \pi_{t-1} - 0.361\pi_{t-1} + 1.20\Delta \ln \pi_{t} - 0.42\Delta \pi_{t}$$

$$(14)$$

T = 52 (1952–2003); $\hat{\sigma}$ = 9.79%; R² = 0.98; DW = 1.99; AR 1–2: F(2,36) = 0.57 (0.75); ARCH 1–1: F(1,36) = 0.57 (0.46); Hetero: F(23, 14) = 0.32 (0.99); Normality: $\chi^2(2) = 1.36$ (0.51); RESET: F(1, 37) = 0.10 (0.75). Long-run elasticities: ln π = 1.05, π = 0.28

$$\Delta \ln Tax_{t} = 3.40 - 0.03T - 0.05 ST_{72} - 0.10 ST_{80} + 0.62 ST_{86} - 0.49 ST_{87} + 0.18 ST_{95} - 1.14 D_{94} + 0.80 D_{98} - 1.26 \ln Tax_{t-1} + 1.34 \ln \pi_{t-1} - 0.371 \pi_{t-1} + 1.21 \Delta \ln \pi_{t} - 0.42 \Delta \pi_{t}$$
(15)

T = 52 (1952–2003); $\hat{\sigma}$ = 9.93%; R² = 0.98; DW = 2.04; AR 1–2: F(2,36) = 0.32 (0.73); ARCH 1–1: F(1,36) = 0.65 (0.42); Hetero: F(23, 14) = 0.32 (0.99); Normality: $\chi^2(2) = 1.59$ (0.45); RESET: F(1, 37) = 0.07 (0.79). Long-run elasticities: ln π = 1.06, π = 0.29 Overall, the two models are remarkably similar, mainly regarding the questions raised in this paper, which are related to the inflation tax/demand for money functional forms and the inelasticity of money. In both cases the functional form given by (7) seems to be the most appropriate, so that money inelasticity hypothesis is rejected. Note also that in both models not only the coefficients attached to log inflation have virtually the same magnitude, but the hypothesis of a unity elasticity (i.e. $a_1 = 1$) could not be rejected. Moreover, the value of the coefficient attached to the level of inflation (i.e. semi-elasticity) and, therefore, the implied inflation rate that maximises the inflation tax, are very close to each other.⁵ Finally, in both models strong cointegration between the variables is found, suggesting a genuine long run relation among them.⁶

Model	Semi-	Continuous	Discrete
	Elasticity (α)	Rate (100/α)	Rate
Model 1	0.28	354%	3,358%
Model 2	0.29	344%	3,030%
Model 3 (Smooth)	0.27	374%	4,137%
Model 4 (St. Level/Slope)	0.29	345%	3,055%

 Table 3

 Annual Inflation Rate that Maximises the Inflation Tax

Table 3 shows the implied tax maximising inflation rates, which seem to lie around 350% on continuous terms.⁷ This translates into discrete rates a little bit above 3,000% on an annual basis. That level is above the maximum calendar-year inflation rate reached during the sample, which took place in 1993, when inflation reached 2708%, according to the IGP–DI price index. However, it is well below the twelve-month rates observed in several months, such as those from February 1990 to August 1990 and February 1994 to July 1994. The highest rate in those two periods occurred in

⁵ Note, however, that small variations in the semi-elasticity could mean large discrepancies in the associated discrete inflation rates. Therefore, inferences regarding the tax maximising inflation rate based solely on the difference between coefficients could be misleading.

⁶ Note that it is very unlikely the existence of simultaneity in both cases. Moreover, the strategy used here – where the long run solution and the short run dynamics are estimated at the same time – has the advantage of dealing with the large finite-sample biases found in practice when the Engle-Granger method is used, despite super-consistency. For Monte Carlo evidence on the large bias in the estimation of the static long run solution see Banerjee *et al.* (1986). See also Banerjee *et al.* (1993).

⁷ Note that although the semi-elasticities are expressed with two decimal places, the implied inflation rates shown in Table 3 were calculated from figures having four decimal places, since small changes in the former lead to big changes in the latter.

April 1990 (6602%) and June 1994 (5153%). The tax maximising inflation rates implied by the models are lower than those actually observed during the worst months of hyperinflation. Thus, the Government was on the decreasing part of the inflation tax curve. This fact is consistent with the weak hyperinflation hypothesis presented in Barbosa et al (2006)). In either case the Government did not seem to have maximised the inflation tax during hyperinflation.





Although both models are very similar, it is worthwhile to point out one minor but revealing discrepancy between them, which concerns the shape of the trend (Figure 7). Note that both trends practically overlap each other – evolving virtually at the same pace – until mid-1980s, continuously trending downward, which suggests the occurrence of substantial money-demand-saving financial innovation during that period. Financial innovation was certainly intense during those years and, apparently, accelerated both after 1970 and 1980. That dynamics seems in accordance with one's intuition. Indeed, the Brazilian open-market was created in early 1970s and could be the major factor behind the first break, since it offered a new channel through which agents could protect themselves against inflation. In its turn, in 1980 inflation exceeded 100% for the first time, and began to increase very rapidly thereafter, increasing the incentives for further innovations.⁸

However, the trends begin to diverge from each other in 1986, which is precisely the year when the first stabilisation Plan – The Cruzado Plan – took place.⁹ More specifically, while Model's 1 trend continues decreasing until 1994, Model's 2 trend jumps upwards in 1986 and then continues to fall until 1994, when both trends' slope become positive until the end of the sample.¹⁰ Nonetheless, note that after 1986 both trends began to evolve at virtually the same pace once again, trending parallel to each other. Thus, there only is a level discrepancy between them since 1986, a difference that was built entirely in that year. That discrepancy seems to be due to the Cruzado Plan, which apparently caused a large (permanent) break in the relation between the inflation tax and the inflation rate, and this fact is being captured in two different ways by the models. While Model 1 captures it using a (level) dummy as of 1986, which adds to the constant, Model 2 captures it through a one-period jump in the trend itself. Even though both specifications are equivalent, note that in the first case one is explicitly assuming that the break had nothing to do with financial innovation itself. Also note that both models contain two (impulse) dummies in common, which are linked to clear economic events. The first refers to the year of 1994, when inflation dropped sharply due to the Real Plan. The second dummy refers to 1998, when inflation reached its lowest record level so far (1.7%), just before the floating of the currency in 1999, which was followed by an increase in inflation.

Finally, the positive slope after 1994 coincides with the post-stabilisation period. Although at first this result is unexpected since inflation has been much lower since then, a more detailed analysis shows that there actually are two factors that could help explain this outcome. First, the so-called "cheque tax" (called CPMF later on) was created on 1st January 1994 and ended in December 2007. That tax applied every time money was withdrawn from one's bank account. The result was an increase in demand for money, since money invested for very short periods of time began to have negative yield. Secondly, after the stabilisation there was indeed some reversal in financial innovation. For example, during hyperinflation all money left in one's bank account

⁸ In addition to reacting to higher inflation, financial innovation has surely an exogenous component, which reflects non-inflation related technological advances, such as the increasing use of computers along time and overall improvements in technology.

⁹ The Cruzado Plan tried to reduce inflation using several heterodox measures such as price freezes, interventions in contracts, etc.

¹⁰ In 1994 the Real Plan, which finally defeated inflation, was implemented.

above a certain (very low) level was automatically invested by the banks themselves in overnight funds, and was automatically withdrawn when the account balance was insufficient to face obligations (e.g. to pay a cheque). That financial innovation kept money demand at minimum levels. However, since the stabilisation of the economy such kind of mechanism has disappeared, increasing money demand.

Although the use of split trends provides a flexible framework within which financial innovation could be modelled, and the resulting models seem to be coherent with the data, it is worthwhile to ask to what extent the unexpected positive trend after 1994 and, more generally, the overall shape of the curve were determined by this particular way of measuring financial innovation. One could argue that a more flexible and appealing strategy is to use the unobserved components (UC) framework and estimate a stochastic trend. Moreover, it could provide a robustness test for earlier results. With that goal two kinds of stochastic trends were estimated using the Kalman Filter. In the first case – indicated by (16) – one assumes that financial innovation can be modelled as a smooth trend, which makes sense since it should evolve like a diffusion process over time. In the second, one assumes a more flexible specification – where both the level and the slope are allowed to evolve stochastically – according to (17).

$$y_{t} = \mu_{t} + \boldsymbol{\beta}' \mathbf{x}_{t} + \varepsilon_{t} \qquad \varepsilon_{t} \sim N(0, \sigma_{\varepsilon}^{2})$$

$$\mu_{t} = \beta_{t-1} + \mu_{t-1} \qquad (16)$$

$$\beta_{t} = \beta_{t-1} + \xi_{t} \qquad \xi_{t} \sim N(0, \sigma_{\xi}^{2})$$

$$y_{t} = \mu_{t} + \boldsymbol{\beta}' \mathbf{x}_{t} + \varepsilon_{t} \qquad \varepsilon_{t} \sim N(0, \sigma_{\varepsilon}^{2})$$

$$\mu_{t} = \beta_{t-1} + \mu_{t-1} + \eta_{t} \qquad \eta_{t} \sim N(0, \sigma_{\eta}^{2})$$

$$\beta_{t} = \beta_{t-1} + \xi_{t} \qquad \xi_{t} \sim N(0, \sigma_{\xi}^{2})$$
(17)

where μ_t stands for the stochastic trend, \mathbf{x}_t is a vector of explanatory variables and $E(\varepsilon_t \eta_t) = E(\varepsilon_t \xi_t) = E(\eta_t \xi_t) = 0$,

Using a general-to-specific model selection strategy two specifications, one for each case above, was selected. Equation (18) – labelled Model 3 in Table 3 – refers to specification (16), while equation (19) – labelled Model 4 – represents specification (17). In the former case the level is fixed, while in the latter it is allowed to vary

stochastically. Before proceeding, one should note that while the stochastic trend is indeed a flexible framework, that flexibility should be put into context, since one is also assuming a particular structure for the trend.

$$\Delta \ln Tax_{t} = \frac{1.84}{(7.03)} \mu_{T} - \frac{1.11}{(-7.56)} D_{94} + \frac{0.66}{(4.14)} D_{98} - \frac{1.25}{(-13.02)} \ln Tax_{t-1} + \frac{1.21}{(-13.02)} \ln \pi_{t-1} - \frac{0.33}{(-2.91)} \pi_{t-1} + \frac{1.13}{(17.62)} \Delta \ln \pi_{t} - \frac{0.40}{(-5.25)} \Delta \pi_{t}$$
(18)

T = 52 (1952–2003); $\hat{\sigma}$ =15.46%; R² = 0.98; DW = 1.72; Q (7, 6) = 10.91 (0.09); H (16) = 0.55 (0.88); Normality: $\chi^2_{DH}(2) = 1.34$ (0.51) Long-run elasticities: $\ln \pi = 0.97$, $\pi = 0.27$

$$\Delta \ln Tax_{t} = \underset{(7.06)}{1.93} \mu_{T} - \underset{(-7.52)}{1.08} D_{94} + \underset{(4.14)}{0.65} D_{98} - \underset{(-13.32)}{1.28} \ln Tax_{t-1} + \underset{(9.17)}{1.26} \ln \pi_{t-1} - \underset{(-3.09)}{0.37} \pi_{t-1} + \underset{(17.63)}{1.14} \Delta \ln \pi_{t} - \underset{(-5.18)}{0.41} \Delta \pi_{t}$$
(19)

T = 52 (1952–2003);
$$\hat{\sigma}$$
 = 14.71%; R² = 0.98; DW = 1.79;
Q (8, 6) = 5.50 (0.48); H (16) = 0.72 (0.74); Normality: $\chi^2_{DH}(2) = 0.61$ (0.74)
Long-run elasticities: $\ln \pi = 0.98$, $\pi = 0.29$

where μ_T stands for the value of the stochastic trend at the end of the sample. Q (p,q) is the Box-Ljung statistic for residual autocorrelation based on the first *p* autocorrelations. H (h) is a heteroscedasticity test and $\chi^2_{DH}(2)$ is a normality test based on the Bowman-Shenton statistic with a correction due to Doornik and Hansen (1994). See Koopman *at al.* (2000) for further details.

All diagnostic tests are satisfactory, and the final models are very similar to the ones obtained before. Likewise the OLS case, the relevant inflation tax functional form seems to be given by equation (7) and, therefore, money inelasticity is rejected as well. Moreover, the elasticity of the inflation tax w.r.t. log inflation is around one as before, and the value of inflation semi-elasticity is practically the same as those obtained from models 1 and 2 (although the implied discrete inflation rate of model 3 is not so close).¹¹ Table 3 gives the associated tax maximising inflation levels.

¹¹ See footnote 5.

Note that – akin to equation (15) – both specifications do not include explicitly the level dummy from 1986 onwards, since the stochastic trend is already capturing that break. However, the last figure in the Appendix shows how both stochastic trends look like when the level dummy is included in the models – as in equation (14). The effect is exactly the same of what was found before, that is, the (stochastic) trend continues to fall until 1994, instead of increasing temporarily in the second half of the 1980s.

Finally, note that not only both specifications produce stochastic trends with virtually the same shape – although Model's 4 trend is more "nervous" than Model 3 – but their shape is very similar to what was obtained before, including the positive slope after 1994 (see Appendix). That evidence shows that our previous modelling effort seems to have been very successful. Indeed, the standard error of specifications (14) and (15) is much smaller than those of specifications (18) and (19), suggesting that the simpler OLS method does a better job in modelling the inflation tax than the fancier UC framework. More importantly, the results presented here seem to be robust to the choice of how to model financial innovation.

6. Conclusion

The value added of this paper can be summed up as follows: i) the hypothesis that money is inelastic is rejected, since Cagan's demand for money specification is not rejected for Brazilian annual data covering the period 1947/2003; ii) the bubble and strict hyperinflation hypotheses are rejected; iii) the weak hyperinflation hypothesis is not rejected, and the Brazilian economy could have been in the wrong side of the Laffer curve for some period of time during hyperinflation; iv) the empirical evidence on German hyperinflation presented on Table 1 is consistent with the weak hyperinflation hypothesis; v) the statement usually made that the government could have obtained more tax revenue with lower inflation rates, during a hyperinflation, is not correct under the weak hyperinflation hypothesis. This fact is the outcome of the dynamics of the fiscal crisis that yields a hyperinflation path.

References

- Banerjee, A., J. J. Dolado, D. F. Hendry and G. W. Smith (1986). "Exploring Equilibrium Relationships in Econometrics through Static Models". Oxford Bulletin of Economics and Statistics 48, p. 253-277.
- Banerjee, A., J. Dolado, J. W. Galbraith and D. F. Hendry (1993). Cointegration, Error Correction and the Econometric Analysis of Non-Stationarity Data. Oxford: Oxford University Press.
- **Barbosa, Fernando de Holanda and Alexandre Barros da Cunha (2003)**. Inflation Tax and Money Essentiality. Economics Letters 78, p. 187-195.
- Barbosa, Fernando de Holanda, Elvia Mureb Sallum and Alexandre Barros da Cunha (2006). Competitive Equilibrium Hyperinflation under Rational Expectations. Economic Theory 29, p. 185-195.
- **Barro, Robert J. (1970)**. Inflation, the Payments Period, and the Demand for Money. Journal of Political Economy 78, p. 1228-1263.
- **Burmeister, Edwin and Kent D. Wall (1987)**. Unobserved Rational Expectations and the German Hyperinflation with Endogenous Money Supply. International Economic Review 28, p. 15-32.
- **Cagan, Phillip** (1956). The Monetary Dynamics of Hyperinflation. In Milton Friedman (org.), Studies in the Quantity Theory of Money. Chicago: University of Chicago Press.
- **Casella, Alessandra (1989)**. Testing for Rational Bubbles with Exogenous or Endogenous Fundamentals: the German Hyperinflation Once More. Journal of Monetary Economics 24, p.109-122.
- **Christiano, L. J. (1987).** Cagan's Model of Hyperinflation Under Rational Expectations. International Economic Review 28, p. 33-49.
- Cysne, Rubens P. and Paulo C. Coimbra Lisboa (2004). Imposto Inflacionário e Transferências Inflacionárias no Brasil:1947-2003. Ensaios Econômicos EPGE # 539. EPGE/FGV.
- **Cukierman, Alex (1988)**. Rapid Inflation-Deliberate Policy or Miscalculation. Carnegie-Rochester Conference Series on Public Policy 29, p.11-76.
- **Doornik, Jurgen and Henrik Hansen (1994).** "An Omnibus Test for Univariate and Multivariate Normality". Nuffield College Working Paper. Paper available at http://www.nuff.ox.ac.uk/Economics/papers/index1995.htm.
- Easterly, William R., Paolo Mauro and Klaus Schmidt-Hebbel (1995). Money Demand and Seigniorage-Maximizing Inflation. Journal of Money, Credit and Banking 27, p.583-603.
- **Engsted, Tom (1993).** Cointegration and Cagan's Model of Hyperinflation under Rational Expectations. Journal of Money, Credit and Banking 25, p. 350-360.

- **Frenkel, Jacob A. (1977)**. The Forward Exchange Rate, Expectations, and the Demand for Money: The German Hyperinflation. American Economic Review 67, p. 653-670.
- **Goodfriend, Marvin S. (1982).** An Alternate Method of Estimating the Cagan Money Deamand Function in Hyperinflation Under Rational Expectations. Journal of Monetary Economics 9, p. 43-57.
- **Imrohoroglu, Selahattin** (**1993**). Testing for Sunspot Equilibria in the German Hyperinflation. Journal of Economics Dynamics and Control 17, p. 289-317.
- Koopman, S. J., A. C. Harvey, J. A. Doornik and N. Shephard (2000). *Stamp: Structural Time Series Analyser, Modeller and Predictor*. Timberlake Consultants Ltd.
- Michael, P., A. R. Nobay and D. A Peel (1994). The German Hyperinflation and the Demand for Money Revisited. International Economic Review 35, p. 1-22.
- Romer, David (2001). Advanced Macroeconomics. 2ed. Edition.boston: McGraw Hill.
- Sargent, Thomas J. (1977). The Demand for Money Under Rational Expectations: I. International Economic Review 77, p. 279-283.
- Sargent, T. and Neil Wallace (1987). Inflation and the Government Budget Constraint. In: Razin, A., Sadka, E. (eds) Economic Policy in Theory and Practice. New York: Macmillan.
- Taylor, Mark P. (1991). The Hyperinflation Model of Money Demand. Journal of Money, Credit and Banking 23, p. 327-351.

Appendix



Recursive estimates, 1-Step Residuals +/- 2 S.E., 1-Step Chow Test, Break-Point Chow Test



Model 2 (Equation 15)

Recursive estimates, 1-Step Residuals +/- 2 S.E., 1-Step Chow Test, Break-Point Chow Test





Model 3 (Equation 18) Smooth Trend (Fixed Level and Stochastic Slope)

Model 4 (Equation 19) Stochastic Level + Stochastic Slope





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