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# Monetary Policy with Declining Deficits: Theory and an Application to Recent Argentine Monetary Policy

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### Abstract

We study the nature of the optimal monetary policy in a regime of “fiscal dominance” when the monetary authority -that can print money or issue interest earning debt- is required to finance an exogenous sequence of transfers to the Treasury. We show that the degree of commitment on the part of the monetary authority has a significant impact on the details of the optimal policy. We apply this model to the recent experience of Argentina and we find that the inflation rate experienced by Argentina during the first year of the monetary program is close to the predictions of the weakly time consistent solution. Moreover, consistent with both versions of the model, the Argentine central bank has increased the ratio of interest earning debt to monetary base.

**Keywords:** *Money, Monetary Policy*

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# 1 Introduction

In January 2016 the newly elected government of Argentina announced a policy of decreasing government budget deficits. It also specified what fraction of the deficit would have to be financed by the monetary authority. In the case of Argentina, this is a significant amount. For the year 2016 the Argentinean central bank (BCRA) was required to transfer to the Treasury approximately 2% of GDP out of a total government deficit of 4.8% of GDP. In addition, the BCRA decided to increase the monetary base by close to another 2.5% to increase the stock of foreign reserves.

The Argentinean monetary authority finds itself in one of the versions of the economy that Sargent and Wallace (1981) studied in the well know “Unpleasant Monetarist Arithmetic” paper, namely, the case in which the fiscal authority moves first and the monetary authority passively accommodates the fiscal demands. However, the problem faced by the BCRA differs from the problem studied by Sargent and Wallace in that the BCRA can issue interest earning debt. Thus, the choice of monetary policy faced by the BCRA boils down to the choice of the mix between debt and money with the understanding that the only tax that it can use to service the debt is the inflation tax.<sup>1</sup>

In this paper we study the policies that a monetary authority that is faced with such a *temporary* fiscal dominance situation —temporary in the sense that it is required to transfer a *declining* amount of resources to the fiscal authority— should pursue. In a very general sense this is an optimal taxation problem and, like most problems of this type, the answer depends on the mix of taxes available and the degree of commitment on the part of the policy makers. In this particular application the only tax available is the inflation tax so that the problem boils down to the choice of distortionary inflation taxes over time. One possibility is to allow the stocks of money to be determined by the time path of the expenditures that the central bank must finance. Another option is control the quantity of money in the economy by issuing interest-earning securities. This allows the central bank to choose a timing of increases in the money supply that need not be the same as the timing of transfers.

We consider the case of a central bank that can issue its own interest earning securities of a given maturity and that, in the language of Del Negro and Sims (2015),

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<sup>1</sup>It is impossible to determine why if issuing bonds is part of the optimal policy, the fiscal authority chooses to delegate this to the monetary authority. The first best optimal policy is one in which the mix of all taxes —including the inflation tax— is pinned down and the consolidated government budget constraint determines the evolution of the public debt. The analysis of the institutional arrangements that gives rise to this situation is beyond the scope of this paper.

it “does not have fiscal support,” that is, it cannot assume that the Treasury will recapitalize with genuine resources the bank if it incurs losses in its portfolio. Thus, the only option available to the central bank is to collect seigniorage to remain solvent. Unlike the Federal Reserve Bank, it is not uncommon for central banks to issue actively tradable interest earning bills of different maturities<sup>2</sup>. Moreover, in many countries, they are held by both financial and non-financial institutions. According to Gray and Pongsaparn (2015) at least one third of their sample of central banks issue their own interest earning securities with a median maturity of a month but with individual maturities as high as five years.<sup>3</sup>

The second element of our study is the temporary nature of the expenditures that the central bank incurs. As with the case of the interest earning securities, there is no obvious analog of this situation in the U.S. as the Fed is not *required* to make transfers to the Treasury. However, this possibility is common in emerging countries as central bank financing is an important share of government revenue and the model applies to any temporary increase in spending. For example, it includes not only the situation in which the central bank is required to make temporary transfers to the Treasury but also the case in which the central bank responds to a banking crises by increasing its liabilities to recapitalize financial institutions.<sup>4</sup>

What is the optimal monetary policy (or, equivalently, optimal debt policy) for a central bank in the situation that we described above and given the available instruments? It turns out that the answer depends on the degree of commitment on the part of the monetary authority as well as on the details of the amount of resources that the monetary authority has to transfer to the fiscal authority which, from now on, we will label the deficit.

To make progress understanding optimal policies we study a very simple economy in which the path of deficits and macro aggregates are known. This is similar to the economy that Uribe (2016) studies except that we only investigate the role of central bank financing of a given deficit.

We view the deficit as decreasing over time and eventually reaching zero. If the monetary authority can precommit to any policy, then a relatively standard optimal

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<sup>2</sup>The Federal Reserve Bank also issues a bill-like security since reserves earn interest. However, these securities are like callable bonds since the holders can turn them into money on demand.

<sup>3</sup>Nyawata (2012) Table 2 includes data on maximal maturities. In some cases, the upper bound is very long. Thailand’s central bank can issue 20 year bonds while the Armenian monetary authority can issue 15 year bonds.

<sup>4</sup>Gray and Pongsaparn (2015) cite the case of the central bank of Chile that in the early 1980s issued a large amount of debt to sterilize increases in the money supply associated with bail outs of domestic banks. Stella and Lonnberg (2008) provide other examples.

taxation argument, as described in Uribe (2016), implies that the central bank should use a mixture of monetary injections and debt to finance the required transfers. The basic idea is to smooth tax distortions—in this case the distortions associated with the inflation tax—and to use interest earning debt to finance the difference between the declining transfers and the revenue from the inflation tax. This is an extension of the tax smoothing argument in Barro (1979) and the principles of financing of government spending in Lucas and Stokey (1983). The optimal policy is such that even after the central bank is no longer required to finance a deficit it chooses to inflate so that it can service the existing debt and the present discounted value of the revenue from the inflation tax is equal to the present discounted value of the required transfers.

The assumption that the monetary authority is able to commit to positive inflation in the presence of zero deficits is somewhat problematic since the central bank has an incentive to implement a one time open market operation issuing non interest-earning money to buy the interest-earning debt. In the absence of commitment, and depending on the stock of debt, such an open market operation can potentially result in a jump in the price level but it allows the monetary authority to implement a zero inflation policy from then on.

We will label policies that impose that inflation be zero when the deficit is zero *weakly time consistent* policies. We show that weakly time consistent policies impose tight restrictions on the amount of debt that can be issued. In particular, they imply that the total value of nominal assets relative to output cannot exceed the ratio of money to output under zero inflation. Our notion of weak time consistency amounts to requiring standard time consistency only when the fiscal situation is such that the monetary authority does not have to make any more transfers to the Treasury. As is well known in an economy with nominally denominated debt a time consistent policy is such that it engineers a large inflation as soon as possible to minimize the real value of the debt. We do not find such an extreme version of time consistency a useful way of thinking about policy since it ignores other consequences of such an extreme policy. Thus, weak time consistency is a compromise that assumes that all economic participants—private sector and government alike—understand that the government will be restricted about the policies that can implement in the future.

We use this model to study the optimal monetary policy for Argentina, taking as given the path of the deficit. We find that, consistent with both solutions, the Argentine monetary authority has increased the debt-money ratio over the first year of the program. The key difference between the commitment and the weak time consistent solutions are the implications for the inflation rate. The commitment solution

estimates an average inflation of 2.6% while the weakly time consistent predicts a value close to 25%. The recent Argentine experience —33% inflation in the first year of the program and a market expectation of 20% for the second year— appears to be much closer to the latter than to the former.

The paper most closely related to ours —in addition to Uribe (2016)— is the work by Diaz-Gimenez et. al. (2008) where it is also shown that time consistency limits the ability of the monetary authority to implement optimal policies. The key difference with our paper is that the path of deficits is not decreasing and that there is coordination between the fiscal and monetary authorities which implies that taxes other than the inflation tax are used to finance the service of the debt. Martin (2013) has a thorough discussion of optimal policies in economies with different frictions. He restricts himself to the case in which bonds have payoffs in real terms. In the context of the New Keynesian models, Leeper et. al. (2016) discuss optimal monetary and debt policy imposing time consistency. For a recent survey of monetary models and optimal policies see Canzoneri (2011).

There is a large literature that recognizes the fiscal dimension of monetary policy. See, for example, Bassetto and Messer (2013), Berriel and Bhattarai (2009) and Del Negro and Sims (2015).

## 2 Model

We study the simplest economy that can be used to explore the role of lack of commitment. We take an off-the-shelf model similar to that used by Uribe (2016). We assume that output,  $y$ , and government spending,  $g$ , are constant. This implies that, in equilibrium, consumption is constant as well. The fiscal authority picks a sequence  $\tau_t$  of taxes and it demands from the monetary authority transfers  $x_t = g - \tau_t$ . We view  $x_t$  as a decreasing function of time with the property that  $x_t = 0$  for all  $t \geq T$ .

It is convenient to separately describe the budget constraint for the monetary authority and the rest of the government (which we will label the Treasury).<sup>5</sup>

- Treasury’s budget constraint:

$$\dot{B}_t^T + P_t x_t + P_t \tau_t = i_t B_t^T + P_t g,$$

where a dot over a variable indicates the time derivative. The income side of this constraint includes the sources of funds: bond issuance,  $\dot{B}_t^T$ , tax revenues,

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<sup>5</sup>See Bassetto and Messer (2013) and Berriel and Bhattarai (2009) for example of analyses that distinguish between the two budget constraints so as to keep track of monetary and fiscal interactions.

$P_t\tau_t$  and transfer from the monetary authority,  $P_tx_t$ . The expenditure side is the sum of interest payments,  $i_tB_t^T$ , and government purchases,  $P_tg$ .

- Monetary authority's budget constraint:

$$\dot{M}_t + \dot{B}_t^M = i_tB_t^M + P_tx_t.$$

The expenditure side of the central bank' budget constraint includes transfer to the Treasury,  $P_tx_t$  and interest payments on the debt it has issued,  $i_tB_t^M$ . The only sources of funds are increases in the money supply,  $\dot{M}_t$ , —defined as the monetary base: currency in circulation plus non-interest earnings reserves— and interest earning debt,  $\dot{B}_t^M$ .

- The notation makes it clear that in the economy under study there is interest earning debt issued by the Treasury —which we denote by  $B_t^T$  which has to be distinguished from central bank issued debt,  $B_t^M$ , since the latter is backed only by future increases in the real value of the money stock (seigniorage) as, in the economy that we study, we restrict  $P_tx_t$  to be non-negative.
- Putting together these two budget constraints we arrive at the consolidated budgetary restriction for the government given by

$$\dot{M}_t + \dot{B}_t^T + \dot{B}_t^M + P_t\tau_t = i_t(B_t^T + B_t^M) + P_tg.$$

Given our focus in this paper —the optimal choice by the monetary authority how to finance the transfer  $P_tx_t$ — this consolidated budget constraint plays a minor role

We assume that there is a representative dynasty that has preferences over consumption and real money balances given by

$$U = \int_0^\infty e^{-\rho t} [u(c_t) + v(m_t)] dt,$$

where  $c_t$  is consumption at time  $t$  and  $m_t = M_t/P_t$  is real money balances<sup>6</sup>. The functions  $u$  and  $v$  are assumed strictly concave and twice continuously differentiable. The private sector budget constraint is given by

$$\dot{M}_t + \dot{B}_t^T + \dot{B}_t^M = i_t(B_t^T + B_t^M) + P_t y - P_t c - P_t \tau_t.$$

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<sup>6</sup>Effectively we are consolidating households and the non-governmental private sector. Thus, we view  $m_t$  as the real value of the monetary base and this includes the portion held by commercial banks.

On the income side the representative dynasty earns interest at the nominal rate  $i_t$  on its holdings of treasury-issued debt,  $B_t^T$ , as well as the stock of monetary authority-issued debt,  $B_t^M$ . In addition, the representative agent earns income, spends resources purchasing consumption and pays taxes (if  $\tau_t < 0$ , the consumer receives a transfer).

In what follows the key relationship is one between real money balances, consumption and the nominal interest rate. It can be shown that the representative agent's demand for real money balances satisfies

$$\frac{v'(m_t)}{u'(c_t)} = i_t, \quad (1)$$

where

$$m_t = \frac{M_t}{P_t}$$

We assume that output is fixed and that government spending is constant. This implies that private consumption is constant and, hence, that the real interest rate is equal to the discount factor. In equilibrium, the interest rate is

$$i_t = \rho + \pi_t$$

which is the standard Fisherian result. The monetary authority understands the tradeoff between inflation and real money balances as captured by equation (1) which can be more conveniently written as

$$\frac{v'(m_t)}{u'(c)} = \rho + \pi_t. \quad (2)$$

As mentioned before, the budget constraint of the monetary authority (not the consolidated government budget constraint) is given by

$$\dot{M}_t + \dot{B}_t^M = i_t B_t^M + P_t x_t,$$

which in real terms is

$$\dot{m}_t + \dot{b}_t^M = \rho b_t^M + x_t - \pi_t m_t,$$

where

$$b_t^M = \frac{B_t^M}{P_t},$$

and seigniorage is

$$s_t = \dot{m}_t + \pi_t m_t.$$

### 3 Optimal Monetary Policy

#### 3.1 Optimal Policy Under Full Commitment

In this section we study the optimal monetary policy without imposing any restrictions on the monetary authority other than those required to satisfy the budget constraint in equilibrium. Since output (and consumption) are fixed the optimal monetary policy is the solution to the following problem

$$\max_{b_t^M, m_t} \int_0^\infty e^{-\rho t} v(m_t) dt, \quad (3)$$

subject to

$$\dot{m}_t + \dot{b}_t^M = \rho b_t^M + x_t - \left( \frac{v'(m_t)}{u'(c)} - \rho \right) m_t, \quad (4)$$

and the appropriate transversality condition. The optimal monetary policy (see Uribe (2016)) is summarized in the following result.

**Proposition 1 (Optimal Policy Under Commitment [Uribe (2016)])** *The optimal policy is characterized by a constant level of real money balances,  $m$ , and a constant inflation rate,  $\pi$  given by*

$$\pi = \frac{v'(m)}{u'(c)} - \rho,$$

where  $m$  is chosen so that

$$\int_0^\infty e^{-\rho t} \left[ \frac{v'(m)}{u'(c)} m - x_t \right] dt = b_0^M + \bar{m}_0.$$

and a debt policy given by

$$b_t^M = e^{\rho t} \left( \int_0^t e^{-\rho s} \left[ x_s - \left( \frac{v'(m)}{u'(c)} - \rho \right) m \right] ds + b_0^M + \bar{m}_0 - m \right).$$

**Proof.** (See the Appendix) ■

Under the optimal policy with commitment inflation is constant, and the stock of debt initially increases and then decreases and it converges to zero as  $t \rightarrow \infty$ .

### 3.2 Weakly Time Consistent Optimal Policy

The optimal policy with commitment is such that after time  $T$ , the inflation tax is used to finance repayment of principal and interest on the debt issued by the monetary authority. This policy is not weakly time consistent. To see this consider what happens at time  $T$ . Let the stock of money at that time be denoted  $M_T$  and the stock of bonds (in nominal terms) is  $B_T^M$ . The problem faced by the central bank is to choose monetary policy to solve the continuation problem. Formally, the problem is

$$\max_{b_t^M, m_t} \int_T^\infty e^{-\rho(t-T)} v(m_t) dt,$$

subject to equation (4) which is

$$\dot{m}_t + \dot{b}_t^M = \rho b_t^M + x_t - \left( \frac{v'(m_t)}{u'(c)} - \rho \right) m_t.$$

and subject to a given initial amount of total liabilities of the central bank,  $M_T + B_T$ .

**Proposition 2 (Optimal Policy After Time  $T$ )** *Assume that the central bank cannot issue negative debt, then the optimal monetary policy engineers an open market operation so that the resulting stocks of money and bonds are*

$$M_T' = M_T + B_T,$$

and the price level is

$$P_T = \frac{M_T'}{m^*}$$

and  $m^*$  is such that the optimal inflation rate is zero, that is,

$$\frac{v'(m^*)}{u'(c)} = \rho$$

**Proof.** (See the Appendix) ■

When the central bank is not required to finance any more deficits, there is no longer any optimal taxation argument that requires any smoothing of distortions over time and the economy reverts to the (constrained) first best. The optimal monetary policy solves a finite horizon version of the previous problem with the additional terminal condition that the stock of central bank liabilities at time  $T$  must be equal to the level of *real* money balances under zero inflation. This condition amounts to

a restriction that the price level cannot jump at time  $T$ . This is one of the principles of “honest government” as defined by Auernheimer (1974)

The problem faced by the monetary authority is given by

$$\max_{b_t^M, m_t} \int_0^T e^{-\rho t} v(m_t) dt,$$

subject to

$$\dot{b}_t^M = \rho b_t^M + x_t - \left( \frac{v'(m_t)}{u'(c)} - \rho \right) m_t,$$

and subject to

$$m_T + b_T^M = m^*.$$

**Proposition 3 (Optimal Policy until T)** *The optimal policy is such that real money balances are constant and they satisfy*

$$\frac{v'(m)m}{u'(c)} = \frac{\rho}{1 - e^{-\rho T}} \left[ (\bar{m}_0 + b_0^M) + \int_0^T e^{-\rho t} x_t dt - e^{-\rho T} m^* \right]$$

**Proof.** (See the Appendix) ■

Let  $R_t$  be the ratio of interest earnings bonds to real money balances. Thus,

$$R_t = \frac{b_t^M}{m_t}.$$

Given that the optimal level of real money balances is  $m$  it follows that

$$R_t = \frac{e^{\rho t} \left[ (\bar{m}_0 + b_0^M) + \int_0^t e^{-\rho s} \left( x_s - \left( \frac{v'(m)}{u'(c)} \right) m \right) ds \right]}{m}.$$

Since we are interested in the case in which deficits are declining, then the term

$$\left( x_s - \left( \frac{v'(m)}{u'(c)} \right) m \right)$$

is initially positive and it turns negative as  $t \rightarrow T$ . Thus,  $R_t$  is initially increasing and then decreasing.

Inflation is given by

$$\pi = \left( \frac{v'(m)}{u'(c)} - \rho \right)$$

which is decreasing in real money balances.

The key implication of the weak time consistency requirement is that the value of the stock of liabilities of the monetary authority cannot exceed the level of the demand for money under zero inflation.

## 4 Argentine Monetary Policy Through the Lens of the Model

In this section we briefly describe the recent monetary policy followed by the Argentine central bank, calibrate the model and study the implications under both commitment and weak time consistency for the Argentine experience.

### 4.1 Recent Argentine Monetary Policy

**The Institutional Framework** The Argentine Central Bank’s charter specifies that its mission is “to promote, within its competencies and *in agreement with the policy framework set forth by the national government*, monetary stability, financial stability, employment and economic development in a framework of social fairness” (emphasis added).<sup>7</sup> The board—including the president and vice-presidents—is appointed by the Executive branch with Senate agreement and it can be removed by the Executive if a special commission of Congress agrees. In practice, it has not been difficult for the Executive to replace the authorities of the central bank and that, for practical purposes the Argentine central bank is not independent.<sup>8</sup>

The BCRA issues interest earning securities—as of this writing the only type is denominated Lebac—with a maturity that ranged from 28 to 273 days. These central bank bills and repos are used to conduct open market operations to regulate the quantity of money. The BCRA also operates a discount window and manages the reserves of foreign currency.

When the Argentine monetary authority transfers resources to the Treasury it increases the liability side of its balance sheet by the amount of the transfers (an increase in the monetary base) and, simultaneously, it increases the asset side by viewing the transfer as a loan labeled “Transitory Advances.” According to current legislation these “Transitory Advances” are capped at the max of 12% of the monetary base or 10% of the annual government revenue. These loans have a duration of a

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<sup>7</sup>The original in Spanish is “El banco tiene por finalidad promover, en la medida de sus facultades y en el marco de las políticas establecidas por el gobierno nacional, la estabilidad monetaria, la estabilidad financiera, el empleo y el desarrollo económico con equidad social”.

<sup>8</sup>Even though by statute the president’s mandate lasts six years, the median duration of a mandate over the last 30 years has been less than 9 months. It has been standard for incoming Treasury ministers to “choose” their own BCRA president. In many cases in which the BCRA president’s and the Treasury’s positions do not agree the conflict is solved by the removal of the authorities of the BCRA. For example, in 2012 the president was removed after he refused to use international reserves to honor debts.

year but continuous increases in the monetary base allow for indefinite renewals and increases in the stock. In fact, these are never repaid.<sup>9</sup> Since the BCRA has the ability to issue its own interest earning debt it can conduct an open market operation in this security —conduct an auction— to absorb some or all of the increase in the money supply.

To illustrate the mechanism consider the following example: Suppose that the BCRA wants to make a one time transfer to the treasury in the amount  $Z$ . This creates an increase in the liability side of its balance sheet (an increase in the monetary base) equal to  $Z$ . On the asset side the Transitory Advances account is increased by  $Z$ . If the central bank does not want to change the money supply this would be the end of the story.

Consider now the case in which the central bank —for whatever reason— decides that the monetary base should be only  $Z/2$ . Then, to absorb liquidity it auctions off interest earning securities in the amount  $Z/2$ . After a period —say, a year— the central bank increases the money supply to pay off the interest earning bills. Thus, after one period the money supply (and the liabilities of the central bank) equal  $Z + (Z/2) \times i$ . On the asset side it is standard for the central bank to give the rest of the government a new loan in the amount  $Z$ . Thus, the Transitory Advances account still has a balance equal to  $Z$ . Since the BCRA has funded this “investment” in a zero interest government loan with a mix of money (that pays no interest) and central bank bills (that earn a positive interest) the result is an operational loss. This reduces bank capital and has to be compensated somehow. The details of how this is done vary across the world. In some cases central banks simply “activate losses.” In other cases the Treasury issues a non-negotiable zero interest long duration (e.g. over 50 years) bond that is used to recapitalize the bank.<sup>10</sup> In the case of Argentina, the BCRA also has foreign exchange reserves among its assets and it revalues them according to standard accounting practices. This creates a paper profit that has sufficed to compensate for the losses on the BCRA’s investment portfolio.

**Recent Developments** Even though a discussion of the monetary policy of Argentina is beyond the scope of this paper, it is useful document the magnitude of the

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<sup>9</sup>The law allows for doubling of the limits when economic conditions warrant such a change. This flexibility has been used in the recent past.

<sup>10</sup>For example, the government of Honduras transferred a bond that, in nominal terms, increased the capital of the central bank by 1.1% of GDP in 1997. However, Stella and Lonnberg (2008) estimate that the market value of that bond was 0.0006% of GDP.

transfers that the BCRA has made (and continues to make) to the Treasury. In terms of the model described before, the transfer corresponds to what we labeled  $P_t x_t$ . The size of the transfers since 2004 is in Table 1 below.

<b>Table 1:</b>	<b>Transfers to the Treasury</b>
Year	(percentage of GDP)
2004	1.4
2005	0.5
2006	4.6
2007	0.5
2008	0.8
2009	1.2
2010	3.3
2011	3.1
2012	3.9
2013	4.2
2014	5.2
2015	4.4
2016	2.0

Source: Central Bank of Argentina

In the last few years central bank financing of deficits has been very large. The source of this financing has been twofold. First, in the period until 2010-2015 about half of the transfers were financed by selling assets. Basically, the BCRA used part of its stock of foreign currency reserves to finance the Treasury. The other half consisted of transfers.

This policy has resulted in generally high and variable inflation. Figure 1 below shows the relationship between inflation and seigniorage for the period 2004-2016 <sup>11</sup>.

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<sup>11</sup>Seigniorage is computed as the year-over-year difference in the monetary base relative to the average nominal GDP in those twelve months. Inflation is measured as the 12-month average of the month-over-month inflation rate over the same period.

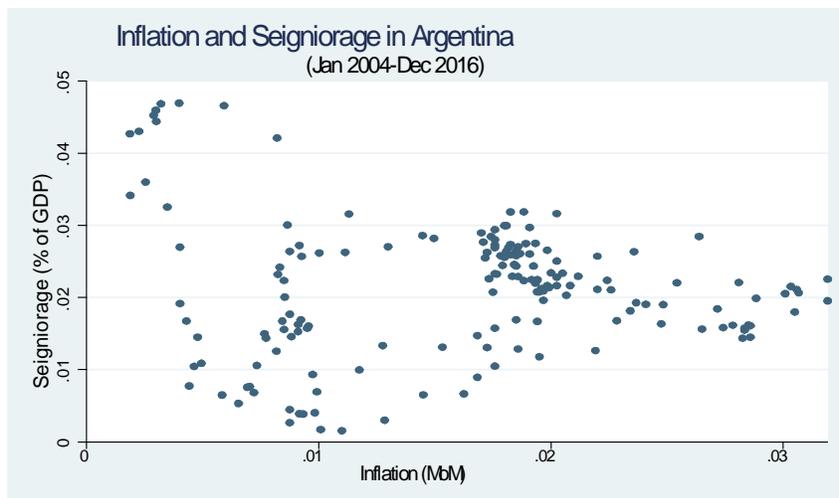


Figure 1: Inflation and Seigniorage

Although the traditional Laffer-curve-type pattern<sup>12</sup> does not emerge for the sample period under study, the resources obtained via seigniorage are clearly non-negligible, averaging 2% of GDP for an average annualized inflation rate close to 21%. The figure shows a relatively high degree of instability in the demand for money which implies that the same inflation rate is associated with a wide range of seigniorage values.

The more recent monetary experience is summarized in Table 2. The base of the inflation tax —the monetary base— fluctuates around 8% of GDP while in the recent past inflation has averaged about 33%.<sup>13</sup> This implies that revenue from seigniorage has been approximately 2% of GDP. As mentioned before, during the year 2016 the BCRA has transferred to the Treasury approximately 2% of GDP and has purchased foreign currency reserves amounting to 2.6% of GDP.<sup>14</sup>

<sup>12</sup>The Laffer Curve shows the relationship between tax rates (inflation) and the amount of tax revenue (seigniorage) collected by governments. Traditionally, it exhibits an inverse u-shaped pattern.

<sup>13</sup>The value for the first quarter of 2016 is somewhat misleading as the new government eliminated some price controls that resulted in measured prices —those entering the price index— catching up to market clearing prices.

<sup>14</sup>Taking into account transfers to the Treasury only, the Central Bank of Argentina transferred to the Treasury an equivalent of 2.0% of GDP in 2016 and has committed to transfer an amount equivalent to 1.5% of GDP in 2017.

Table 2: Money and Inflation								
Period	2015				2016			
Concept	I	II	III	IV	I	II	III	IV
$M/Y$	.09	.08	.09	.09	.08	.07	.08	.08
$B/M$	.56	.85	.54	.47	.67	.79	.82	.89
Inflation	.25	.27	.27	.34	.57	.31	.24	.20

Over the last year, the BCRA has been increasingly relying on interest earning debt as an alternative to outright increases in the monetary base. Table 1 shows that there has been an increase in the ratio of central bank debt to money over the last two years, and, in particular, since the beginning of the new monetary program in 2016. During this last period the ratio of interest earning debt to the monetary base has increased from 67% to almost 90%.

We now develop a quantitative version of the model that is suitable to studying optimal monetary policy in the context of the Argentine situation.

## 4.2 Theoretical Restrictions

We assume that

$$v(m) = \frac{(my)^{1-\gamma}}{1-\gamma} z, \quad u(c) = \frac{(cy + \alpha y)^{1-\gamma}}{1-\gamma},$$

where  $m$  is money demand relative to output, and  $c$  is the ratio of consumption-to-output, while  $\alpha$  is a preference shifter that captures minimal levels of consumption.<sup>15</sup> Following Lucas and Nicolini (2013), we take that the relevant concept of transactions demand for money is  $M1$ .

The demand for money,  $m$ , satisfies

$$m = (c + \alpha) (zi)^{-1/\gamma}.$$

This specification implies that seigniorage is given by

$$s(m) = \left[ z \left( \frac{m_1}{c + \alpha} \right)^{-\gamma} - r \right] m_0,$$

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<sup>15</sup>We experimented with a formulation that has a minimum level of money balances given by  $v(m) = \frac{(my+vy)^{1-\gamma}}{1-\gamma} z$  but the estimate of  $v$  was not significant.

where  $m_0$  is the monetary base (the base of the inflation tax). If the ratio of  $m_1/m_0$  is denoted  $1 + \zeta$  then define

$$K \equiv z \left( \frac{1 + \zeta}{c + \alpha} \right)^{-\gamma}.$$

With this notation seigniorage is

$$s(m) = [K(m)^{-\gamma} - r] m$$

where, from now on,  $m$  denotes the stock of monetary base. Since we use seigniorage to estimate the relevant parameters it is clear that we can only identify  $K$  and not its individual components.

For the time path of the deficit we assume the following functional form

$$x_t = \begin{cases} \psi_0 - \psi_1 t e^{-\kappa(T-t)} & t \leq T \\ 0 & t > T \end{cases}.$$

Let,

$$\hat{x} = \int_0^T e^{-\rho t} x_t dt.$$

Given our choice of functional forms the optimal level of money balances in the commitment case,  $m_c$ , is the solution to

$$K m_c^{1-\gamma} = \rho (w_0 + \hat{x}). \quad (5)$$

From Proposition 3 real money balances under weak time consistency,  $m_w$ , satisfy

$$K m_w^{1-\gamma} = \frac{\rho}{1 - e^{-\rho T}} (w_0 + \hat{x} - e^{-\rho T} m^*)$$

where  $m^*$  is the solution to

$$K (m^*)^{-\gamma} = \rho.$$

The level of real money balances under the weakly time consistent solution as

$$m_w = \left[ \frac{\rho}{K(1 - e^{-\rho T})} \left( w_0 + \hat{x} - e^{-\rho T} \left( \frac{K}{\rho} \right)^{1/\gamma} \right) \right]^{\frac{1}{1-\gamma}} \quad (6)$$

and the implied inflation rate is

$$\pi_w = \frac{K}{m_w^\gamma} - \rho,$$

and the ratio of the two inflation rates is

$$\frac{\pi_w}{\pi_c} = \left[ \frac{w_0 + \hat{x} - e^{-\rho T} \left( \frac{K}{\rho} \right)^{1/\gamma}}{(1 - e^{-\rho T}) (w_0 + \hat{x})} \right]^{\frac{\gamma}{\gamma-1}}$$

To summarize, the optimal level of real money balances in the commitment and weak time consistent versions of the optimal monetary policy solve equations (5) and (6), respectively.

From a qualitative perspective increases in the present value of the central bank liabilities,  $w_0 + \hat{x}$ , not only increase the inflation rates in each of the two scenarios (as more seigniorage is needed to finance the interest on the liabilities of the monetary authority) but also increases the gap between the inflation rates in the commitment and weak time consistent solution. An increase in the demand for money, as measured by an increase in  $K$ , decreases inflation in both regimes but more so in the weak time consistent case as it lifts up the demand for real money balances under zero inflation.<sup>16</sup> Finally, increases in the time horizon reduce  $\pi_w/\pi_c$ .

### 4.3 Calibration

We use monthly data<sup>17</sup> to estimate the following regression by Non-Linear Least Squares (NLLS)

$$s_t = [K m_t^{-\gamma} - r] \times m_t + \varepsilon_t$$

where  $s_t$  is seigniorage in period  $t$  defined as the change in the monetary base relative to the flow of output,  $m_t$  is the monetary base, and  $\varepsilon_t$  is an error term. We assume that  $r = \rho = 0.04$ .

Since monetary policy in Argentina has been extremely variable with long periods in which financial institutions were forced to hold reserves in relatively large proportions, we use monthly data for 2005-2015, a period with a relatively more stable monetary policy regime. One major disadvantage of using monthly data for Argentina (see Burdisso et. al. (2010)) is that seasonal fluctuations are large. In

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<sup>16</sup>In May 2016 the BCRA announced an increase in the mandatory reserve requirements of the financial system that roughly corresponds to a 4% increase in the demand for money which, in our case corresponds to a 12% increase in  $K$ .

<sup>17</sup>Using monthly data requires a monthly measure of private consumption and GDP. We construct these series by performing a cubic spline interpolation of their quarterly counterparts.

our model, these seasonal fluctuations translate directly into seasonal changes in the seigniorage. We address this issue by seasonally adjusting both the seigniorage and the real money balances series. For our purpose, the critical coefficient to estimate is  $\gamma$ . Our estimated value is  $\gamma = 3$  with a robust standard error equal to (1.3).<sup>18</sup> This implies that the semielasticity of the demand for money is  $-0.33$ .

The literature has not arrived at a consensus value for the semielasticity of the demand for money with respect to the interest rate. The estimates of Mogliani et. al., Gay and Basco et. al. suggest a value between  $-1.24$  and  $-2.79$ . Kiguel and Neumeyer (1995), find a much lower elasticity equal to  $-0.05$ . Uribe (2016) uses the Kiguel and Neumeyer results to estimate a semi-elasticity of  $-0.13$ . Our estimate is on the low side but not out of line with other estimates of the demand for money as reported in Canzoneri and Diba (2011).<sup>19</sup>

Finally to pin down the scale parameter  $K$  we used the average real money balances relative to output during the year 2015 ( $m = 0.086$ ) and the nominal interest rate on time deposits ( $i = 0.22$ ). The estimate is

$$K = i \times m^\gamma = .00014.$$

This implies that real money balances under zero inflation (relative to output) equal 0.15, a large but not unreasonable value.

We now describe how we select the parameters for the time path of the deficit. First, since we assume that the deficit is zero in  $T = 4$  it follows that

$$\psi_0 - \psi_1 \times 4 = 0.$$

To calibrate the other two parameters  $(\kappa, \psi_1)$ , we assume that the average deficit during the first year of the program is 4.6% of GDP and the average for the second year is 2% of output. The value that we assume for the first year is based on an estimate of the transfer that the BCRA agreed with the Treasury (about 2% of output) and the increase in the stock of foreign reserves (which amounts to 2.6% of

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<sup>18</sup>The appendix describes the estimation procedure.

<sup>19</sup>In the Appendix we report the results of several recent studies of the demand form money in Argentina.

GDP).<sup>2021</sup> Thus,  $\kappa, \psi_1$  solve

$$\begin{aligned} \psi_1 \times \frac{(4 + (4 - e^{-3\kappa}))}{2} &= .046 \\ \psi_1 \times \frac{(4 - e^{-3\kappa} + 4 - 2e^{-2\kappa})}{2} &= 0.02. \end{aligned}$$

The solution is  $\kappa = -0.24$  and  $\psi_1 = 0.0155$ . Given our estimates the present discounted value of the deficit—which we denoted  $\hat{x}$  in the previous section—is 6.9% of GDP.<sup>22</sup>

Taking December 2015 as  $t = 0$ , the path of the deficit is shown in Figure 2.

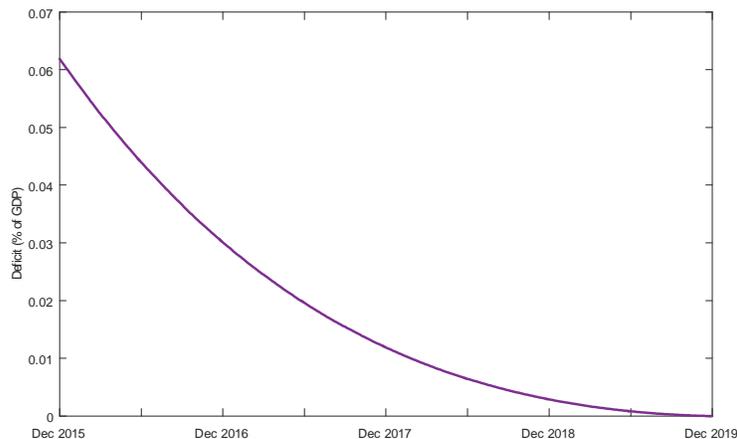


Figure 2: Time Path of the Deficit

<sup>20</sup>The BCRA also inherited another liability in the form of underpriced exchange rate futures. Thus, our estimate is probably an understatement of the true initial cost.

<sup>21</sup>As mentioned before, the previous administration used a significant portion of the foreign exchange reserves to fund Treasury operations. Thus, we assume that the increase in reserves brings them to the level that the BCRA considers adequate. Since the domestic real interest rate in Argentina is significantly higher than the return on its foreign currency holdings we ignore this source of income and we take the buildup of reserves as akin to an expenditure that earns no return and, hence, it is part of  $P_t x_t$ .

<sup>22</sup>This implies that, in the last two years of the program, the average annual deficit is 0.6% and 0.1% of GDP which is probably on the low end.

As required by the theory, we impose that the initial value of the liabilities of the central bank equal to existing stock in December 2015 which was approximately 14% of output.

#### 4.4 Implications of the Model and the Experience of Argentina

Our quantitative model implies that in the *full commitment* case the monetary base is about 13% of output and the average annual inflation rate is 2.6%. The debt of the central bank increases monotonically until mid-2018. The initial value is 1.5% of GDP in December 2015, it reaches a maximum of 9.5% of GDP by mid-2018. In order to better compare with the situation in Argentina, Figure 3 displays the time path of the ratio of central bank debt relative to the (constant under the optimal policy) monetary base.

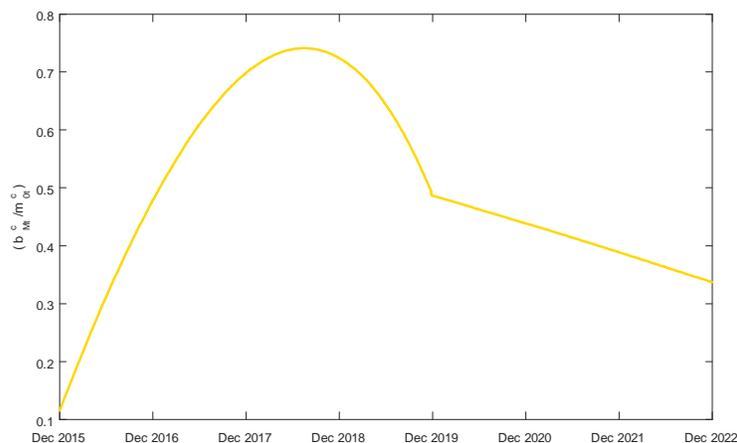


Figure 3. *Commitment*: Ratio of Debt to Monetary Base

The debt-to-monetary base ratio increases from its initial level of around 0.12 up to around 0.75 by mid-2017 and starts decreasing afterwards.

What is the optimal policy if the monetary authority cannot precommit to positive inflation with zero deficits? In this case (*weak time consistency*) the optimal level of the monetary base is lower than under full commitment and equals 7.9% of output. The consequence is a much higher average inflation equal to 24.7%.

Weak time consistency implies that the optimal policy is to retire the debt —the only option if revenue from inflation is going to be zero— at the end of the positive deficit period. Thus, the optimal policy calls for a large open market operation at time  $T$ . The time path of the debt-monetary base ratio is displayed in Figure 4.

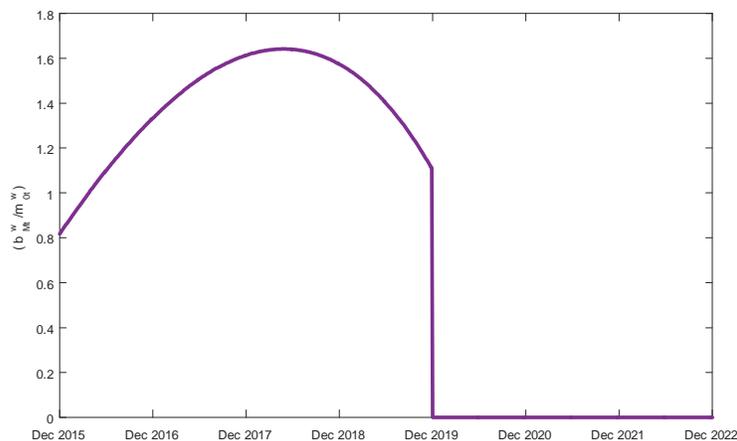


Figure 4: *Weak Time Consistency*: Ratio of Debt to Monetary Base

This version of the optimal policy implies that in mid-2018 the ratio of debt-to-money peaks at about 160%, significantly higher than under the full commitment solution.

How should one evaluate the recent monetary policy of the BCRA in light of the prescriptions of the model about the optimal monetary policy given the fiscal dominance regime in Argentina? It is clear that relative to the prescription of the model, Argentine monetary policy has not been optimal. The model predicts —both in the commitment case and the weak time consistent solution— that inflation must be constant over the period of the program. The inflation rate in Argentina during the first year has been decreasing. However, it is interesting to explore which of the two scenarios (commitment or weak time consistency) more closely resembles the Argentine experience during 2016. To this end we consider two indicators: the ratio of interest earning debt to money and the inflation rate.

The intuition from the optimal taxation exercise is that the BCRA should be using debt increasingly during this period for two related reasons. First, the deficit

is viewed only as temporary. Second, because of the decision to increase the stock of foreign reserves during 2016, it is frontloaded. Both versions of the model — commitment and weak time consistent— prescribe that the debt-money ratio should have increased during 2016. This is consistent with the evidence. The quantitative model implies that the debt-money ratio at the end of the first year of the program should be between 47% (under commitment) and 133% (if the policy is weakly time consistent). The corresponding value for Argentina is 89%, roughly in the middle of the two estimates. Given the simplicity of the model it does not seem that using this indicator can determine the degree of commitment implicit in the recent policy.

The two versions of the model differ significantly in terms of their implications for the inflation rate. Under commitment the inflation is estimated to be less than 3% (average for the duration of the program) while the weak time consistent solution estimates inflation to be much higher, close to 25%. The recent Argentine experience seems to be much closer to the latter. As mentioned before, the inflation rate during the first year of the program was 33% and the market expectations for the second year are around 20%.<sup>23</sup> Even if the BCRA succeeds in significantly lowering inflation during the rest of the program it appears that the actual policy is better approximated by the weak time consistent solution.

In a recent paper, Uribe (2016) uses a similar model to analyze the Argentine experience. He studies only the full commitment solution and includes in his analysis a much larger class of government debt as he is interested in how to finance the overall deficit and not just the fraction that must be financed by the central bank.<sup>24</sup> His estimates of the demand for money are different than ours as he assumes that semi-elasticity with respect to the interest rate is significantly lower than ours. He concludes that the inflation rate associated with the optimal policy is slightly below 5% and the consolidated government’s debt-GDP ratio peaks above 40%.

We view the more limited scope of our analysis that includes only the liabilities of the central bank as a more appropriate use of the model. A comparison with the evidence suggests that this is the case.

At the end of 2016 the total liabilities of the BCRA amounted to 16.2% of output. Given our estimate of the present value of the deficit for the remaining three years of the program — $\hat{x}$  for the continuation is 2.6% of output— the weakly time consistent version of the model implies that the average inflation rate will be close to 18%. There

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<sup>23</sup>The latest available version of the BCRA’s Market Expectations Survey (REM) corresponds to January 2017

<sup>24</sup>It does not appear that in his calculations Uribe takes into account the expenditures associated with the purchase of foreign reserves.

are two forces that influence the estimate of inflation. On the one hand, the present discounted value of the deficit is substantially smaller (2.6% vs. 6.9%) reflecting the frontloaded path of the deficit. This reduces required inflation. On the other hand, the stock of liabilities is higher (16.2% vs. 14%), and this requires a higher inflation rate. In a sense, our estimate is consistent with the view that inflation should be decreasing in Argentina but —viewed as an average over the life of the program— it is higher than the official forecasts.<sup>25</sup>

## 5 Concluding Comments

This note shows that the quantitative implications of the optimal monetary policy under fiscal dominance depend on the assumed ability of the monetary authority to commit. Under full commitment a standard optimal taxation argument shows that the monetary authority should issue both bonds and money. When the central bank cannot commit to a policy of positive inflation when the deficit is zero, then the ability to smooth the distortion associated with the inflation tax is reduced and there is a tight cap associated with the maximum amount of debt that the monetary authority can issue.

In an example calibrated to capture the basic details of the recent monetary policy of Argentina the model implies that the Argentine monetary authority has followed a policy that, to a first rough approximation, results in an inflation rate that is close to that implied by the optimal policy under weak commitment. However, the actual policy deviates from the optimal in that the inflation rate is not constant.

To what extent the issues that we discussed in this note apply to the U.S.? It is important to note the differences in institutional setups between the type of central bank that we analyzed —and, in particular, the Argentinean central bank— and the Federal Reserve Bank. First, and most important, the Federal Reserve Bank is truly independent and, therefore, it does not have to agree to finance the rest of the government at a prespecified level.<sup>26</sup> Second, the Fed does not issue longer term interest earning securities and, hence, does not face the prospect of raising seigniorage

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<sup>25</sup>The results of the model have to be taken as an approximation. There are at least two dimensions that can account for the difference in forecasts. First, the path of the deficit relative to GDP is best viewed as random. Second, the BCRA has indicated that the long run inflation rate is 5% rather than zero as we assumed.

<sup>26</sup>In the last few years the Fed has made substantial transfers to the Treasury as a result of the profits associated with the management of its portfolio. However, these were not legally *mandated transfers* and it is unclear to us what would happen if the Fed starts incurring losses on its portfolio.

to service the debt.<sup>27</sup>

Are there lessons for the conduct of monetary policy in the U.S. that can be drawn from this exercise? The answer is a qualified yes. The Fed, just like the BCRA can issue a security —remunerated reserves— that can be used to drain liquidity from the system. Are there possible scenarios that the Fed could face that resemble the one analyzed in this paper? Ignoring some legal issues the Fed could find itself in a situation in which it has to transfer resources to the financial system, for example during a banking crisis. In this case the Fed can choose to increase the money supply in the form of non-interest bearing reserves to absorb part of the increase by paying interest on some portion of the total reserves. This would come close to issuing interest earning securities to partially absorb excess liquidity. This type of arrangement is different from the current situation in which all reserves receive the same return. We view creating two types of reserves as the simplest way of creating a bond that, in this example, would be held only by financial institutions.

There is a sense in which the activities of the Fed since 2008 when it increased its holdings of assets could fit in this framework. Ignoring for now the quality of the assets in the Fed's portfolio (that were mostly high quality MBS and Treasuries) one could argue that the ideas we discussed in this paper might apply to a central bank that acquires private sector assets if, subsequently, the market value of those assets drops significantly. In that case the situation is analogous to the Fed making a one time transfer to the private sector which is close to what we discussed.

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<sup>27</sup>In the extreme case of losses in its asset portfolio the Fed can choose to pay no interest on reserves and, hence, cannot technically be required to increase the money supply in response to developments in its portfolio.

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## 6 Appendix

### 6.1 Proofs

**Proof of Proposition 1.** The Hamiltonian of the problem is

$$H^C = v(m) + \lambda_m \left[ \rho b^M + x - \left( \frac{v'(m)}{u'(c)} - \rho \right) m - z \right] + \lambda_b(z).$$

where as a matter of notation we define

$$\dot{b}^M = z.$$

The first order conditions associated with the maximum problem are

$$\begin{aligned} \lambda_m &= \lambda_b, \\ \dot{\lambda}_m &= \rho \lambda_m - v'(m) + \lambda_m \left[ \frac{v'(m)}{u'(c)} - \rho - \frac{mv''(m)}{u'(c)} \right], \\ \dot{\lambda}_b &= \rho \lambda_b - \rho \lambda_m. \end{aligned}$$

It follows that  $\dot{\lambda}_b = \dot{\lambda}_m = 0$  and real money balances are given by

$$v'(m) = \lambda_m \left[ \frac{v'(m)}{u'(c)} - \frac{mv''(m)}{u'(c)} \right].$$

Thus, real money balances and the inflation rate are constant. The government budget constraint implies that the real stock of central bank debt evolves according to

$$\dot{b}_t^M = \rho b_t^M + x_t - \left( \frac{v'(m)}{u'(c)} - \rho \right) m,$$

and the solution that satisfies the transversality condition is such that

$$b_t^M = e^{\rho t} \left( \int_0^t e^{-\rho s} \left[ x_s - \left( \frac{v'(m)}{u'(c)} - \rho \right) m \right] ds + (b_0 + m_0) - m \right)$$

In particular, the amount of debt issued by the monetary authority at  $t = 0$  is

$$\int_0^\infty e^{-\rho t} \left[ \left( \frac{v'(m)}{u'(c)} - \rho \right) m - x_t \right] dt = b_0^M + \bar{m}_0.$$

■

**Proof of Proposition 2.** The Hamiltonian for the central bank's maximization problem is

$$H^P = v(m) + \lambda_m \left[ \rho b^M + x - \left( \frac{v'(m)}{u'(c)} - \rho \right) m - z \right] + \lambda_b(z),$$

which is similar to the one for the commitment case. The same argument then shows that real money balances are constant and, under the policy that monetized the debt, inflation can be chosen so that

$$\int_T^\infty e^{-\rho(t-T)} \left[ \left( \frac{v'(m)}{u'(c)} - \rho \right) m - x_t \right] dt = 0,$$

but since  $x_t = 0$  for all  $t \geq T$  then  $m = m^*$ . ■

**Proof of Proposition 3.** An argument similar to the previous proposition shows that the optimal  $m$  is constant. Then central bank debt is given by

$$b_t^M + m = e^{\rho t} \left[ (\bar{m}_0 + b_0^M) + \int_0^t e^{-\rho s} \left( x_s - \left( \frac{v'(m)}{u'(c)} \right) m \right) ds \right].$$

Imposing the terminal condition  $m_T + b_T^M = m^*$  we get the result. ■

## 6.2 Estimation

One issue with NLLS estimation is that, in some cases, estimates are very sensitive to the initially chosen parameters. We provide to the estimation procedure an initial value for the money demand shifter  $K$  consistent with the average real money balances relative to output during the year 2015 ( $m = 0.086$ ) and the nominal interest rate on time deposits ( $i = 0.22$ ). We obtain  $K = 0.00014$ . In the case of  $\gamma$ , we provide as initialization point a set of values in the ranges suggested by the money demand estimation literature (from 0.5 to 20)

In all cases we obtain  $K = 0.00018$  (0.000585) and  $\gamma = 2.97$  (1.32), where the heteroskedasticity- and autocorrelation-consistent standard errors are reported between parenthesis. Although the estimate for  $K$  is not statistically significant, a joint significance test suggests that the estimated coefficients are statistically significant at the 1% level. For the quantitative simulation, and given that for  $K$  the confidence interval of the estimation suggests a wide range of possible values, we calibrate it in such a way that it matches its average value for 2015.

### 6.3 Estimates of the Demand for Money

There are a number of estimates of the demand for money in Argentina. The different estimates vary in terms of their coverage, the notion of money and how they handle dynamic adjustment. These are the results from a cursory review of the literature:

1. Mogliani et. al. (2009?) find that in their estimation of the long run demand for money allowing for structural breaks, real money balances —using M1 as the notion of money— display a unit elasticity with respect to income while the semi-elasticity with respect to the interest rate is -1.6.
2. Kiguel and Neumeyer (1995) define money as M1 and also estimate the demand for money in different subperiods. They find that the coefficient of income is not significantly different from zero and their estimates of the semi-elasticity with respect to the interest rate range from -0.02 to -0.05.
3. Gay (2005) estimates the demand for money (does not say what he means by money) and he uses as his right hand side variable  $\ln(i_t/(1 + i_t))$ . To turn his estimate into a semielasticity requires taking a stand on the value of  $i_t$ . If Gay's estimated coefficient is denoted  $\beta$  then the semielasticity is

$$\frac{\beta}{(1 + i_t)i_t}.$$

If we assume that  $i_t = 0.1$  then the resulting semi-elasticity is (taking an average of his estimates) -2.79, while if the interest rate is 20% ( $i_t = 0.2$ ), the estimate is -1.24.

4. Basco et. al. (2012) estimate that the income elasticity of the demand for money is slightly above 1 (not clear that one can reject that it is equal to one) and the interest semielasticity is -1.8.

It is not surprising that since Argentine monetary policy has been very unstable over the last half century with several episodes of hyperinflation it is not possible to find robust estimates of the demand for money. In this paper we use some information about the semi-elasticity of the demand for money from the existing studies and we complement it with a very simple statistical model to obtain a reasonable parameterization of the relevant functions that allows us to make progress understanding the recent experience.

## 6.4 The Evolution of Debt Levels

Here we report the implications of the two versions of the model for the ratio of central bank debt to GDP.

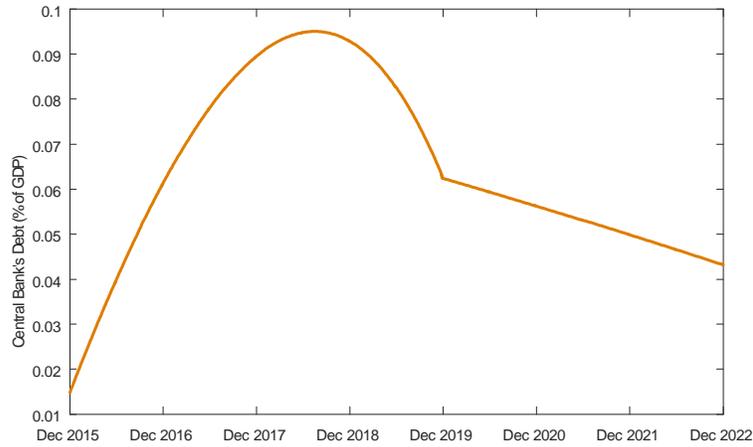


Figure A.1: Debt/GDP Under Commitment

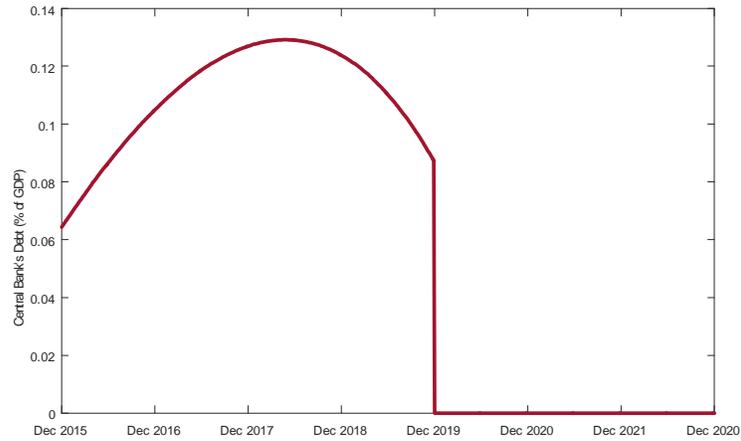


Figure A.2: Debt/GDP Under Weak Time Consistency