Maximising Seigniorage and Inflation Tax: The Case of Belarus

Dr. (elect.) Julia Korosteleva[1]

Department of Economics & International Development,
University of Bath

Abstract

While most Central European countries, realising the inflationary potential of money creation, had by the mid-1990s switched to market instruments based monetary policy, Belarus continued to use money emission, so gaining seigniorage and inflation tax. The productivity of the inflation tax can be analysed by comparing the revenue actually raised from inflation tax with the revenue that could be raised if the quantity of money had risen at a constant rate. The present paper, based on Cagan's (1956) seminal work 'Monetary Dynamics of Hyperinflation', analyses the effect of inflation on seigniorage revenue in Belarus and draws conclusions about the effectiveness of monetary policy in 1995-2002, and about the consequences of inflationary financing.

JEL classification: C12, C22, E42, E52, G28.
Keywords: monetary policy, seigniorage, inflation tax.

[1] The author acknowledges the comments and help of Dr. Colin Lawson, Dr. Andrew Andrews and Dr. Susan Johnson in the preparation of this article.

Introduction

Money creation remained the main source for financing budget deficits in all transition economies during the early stages of transformation. Consequently, the economic gains from money creation came in the form of seigniorage and inflation tax. Despite the *de jure* independence of the central banks created in the transition economies, *de facto* they remained under the control of governments during the early stage of transition. This permitted them to print money to finance government expenditures with seigniorage.

Emission policy has remained the dominant monetary instrument in some transition economies like Belarus and Turkmenistan over the years of transition. However, many other transition economies, including the majority of Central European countries, realising the inflationary nature of money creation, have switched to using more market instruments to carry out monetary policy. Consequently, by reducing money emission, these countries have limited the gains form seigniorage and the inflation tax.

Governments are often tempted to resort to inflationary financing due to the public finance motive, implying that the revenue losses from direct taxes can be offset by introducing implicit forms of taxation in the form of inflation tax (IT). However, some empirical studies show that inflationary financing does not fully explain cases of chronic high-inflation. In transition economies, at least at the early stages of transformation or in some countries even at present, the distinction between public and private is blurred, which implies that along with a budget deficit it is common to have a quasi-budget deficit. This explains the phenomenon of low budget deficit in some transition economies when one would expect it to be much higher. In the countries with a high share of the state ownership, with slow pace of reforms and a high degree of state interference in economic activity (e.g. Belarus, Uzbekistan, Turkmenistan) quasi-budget activities in the form of directed and preferential credits to state-owned enterprises become a very common practice.

Since inflation tax is a tax, there exists a maximum point at which it is optimised under a certain rate of money growth that can be called the revenue-maximising rate.

The paper is structured as follows. Section 1 defines the revenue-maximising rate of money growth. The productivity of the tax is then analysed by comparing the revenue actually raised with the revenue that could have been raised if the quantity of money had risen at a constant rate. Section 2 specifies the model of demand for money that is used to estimate the maximum revenue the government can gain from money emission under steady-state conditions. Section 3 reports the results. A unique data approach is used. We show that the standard Augmented Dickey-Fuller test for unit root is not able to capture the impact of structural breaks in the data. Hitherto research on money demand in Belarus does not account for structural breaks. That leads to the incorrect treatment of the data - regarding them as I(1) rather than I(0). Zivot and Andrews' methodology (1992), which allows searching for endogenous breaks in series, is used to test for unit root. A Partial Adjustment Model (PAM) is employed to estimate final results. The main findings follow in the conclusion.

1. Conceptual Framework of Defining the Optimal Seigniorage

Seigniorage is the revenue that government collects from printing money. It can be expressed as:

$$\mathrm{SE} = \frac{M - M_{-1}}{P} = \left[\frac{M - M_{-1}}{M}\right]\left(\frac{M}{P}\right) = g_m\left(\frac{M}{P}\right), \tag{1}$$

where M – nominal monetary base (M_0) and P- price level, measured as the consumer price index.

The inflation tax is literally a tax on nominal assets. Since most of government debt takes the form of non-indexed nominal assets, the value of that debt is eroded when prices rise. In turn debt-holders suffer a capital loss. Thus, the inflation tax is measured as:

$$\mathrm{IT} = \left[\frac{(P - P_{-1})}{P}\right]\left(\frac{M}{P}\right), \tag{2}$$

where the tax rate is the inflation rate.[2]

Seigniorage can be expressed as the sum of the inflation tax on the monetary base and the increase in the real stock of monetary base (see for example Cagan 1956 and Easterly et al. 1995). That is,

$$\frac{\partial M}{\partial t}\frac{1}{P} = \frac{M}{P}\left(\frac{\partial P}{\partial t}\frac{1}{P}\right) + \frac{\partial\left(\frac{M}{P}\right)}{\partial t}, \qquad (3)$$

When real money balances are constant over time, that is $M/P=M_{-1}/P_{-1}$, seigniorage and inflation tax are equal.

Both seigniorage and inflation tax are regarded as forms of implicit discriminatory taxation of the economy, and particularly of the financial system. In the literature on financial development seigniorage and inflation tax appear to complement financial repression (FR)[3], regarded as another form of implicit taxation. The complementarities between them lie in the following: 1) interest savings on government liabilities an be obtained through inflation policy that given nominal interest rate ceilings implies very low real interest rates; 2) imposition of reserve requirements, one of the instrument of FR, increases directly the IT base; 3) a limited choice of financial instruments and low or negative real interest rates increase money demand, in this way augmenting the IT base (Giovanni and De Melo 1993, p. 955).

(2) embodies the classical approach to IT. However, in some empirical studies, other monetary aggregates are used as the IT tax base. For example, should distortions in real interest rates (under condition of nominal interest-ceilings) due to inflation be included as part of IT or as FR. Giovannini and de Melo (1993) argue that it is incorrect to relate them to IT because the inflation tax base is high-powered money, while financial repression affects the portfolio of non-monetary assets held by domestic residents.

---

[2] Here it should be borne in mind that the inflation tax base is high-powered money (M_0). For a discussion of this issue see below.

[3] This term was first introduced by McKinnon (1973) and Shaw (1973) who defined financial repression as a set of 'ill-conceived' policies and controls, primarily in the forms of interest rates ceilings, requirements for banks to hold government bonds and/or finance government budget deficits, directed credit schemes to support 'selective' industries, high reserve requirements, administratively regulated foreign exchange rates, imposed by governments on financial sector, that restrain financial intermediaries' activities.

Assuming that the economy is initially in a steady state, seigniorage can be represented graphically as a Laffer curve (figure 1) with respect to the rate of money growth. It initially rises and then falls with higher money growth. There is a maximum point at which seigniorage is optimised under a certain rate of money growth that can be called the revenue-maximising rate of money growth. Essentially there is a trade-off between a higher rate of money growth increasing seigniorage and the associated inflation decreasing it by lowering demand for money. When government needs can be financed with seigniorage lower then the maximum rate, there exists a dual steady state equilibrium implying that the same amount of seigniorage can be obtained at low and high inflation steady state points.

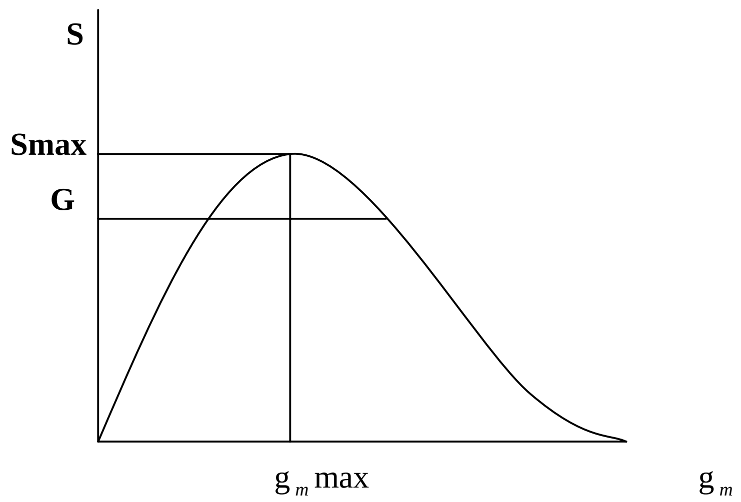

Figure 1: The Seigniorage (S) Laffer curve[4]

There exists a body of work on the issue of seigniorage and its optimal value. Most empirical studies are based on Cagan’s (1956) paper. Given that wealth in real terms and real income are relatively stable under hyperinflation, Cagan (1956) assumes that in a period of high inflation, changes in demand for real balances largely result from the extreme fluctuation in prices. That is, money demand is a function of the expected rate of inflation rather than of the nominal interest rate.[5] The optimal seigniorage is calculated by applying the steady-state conditions to the revenue-maximising rate of money growth. Under steady-state conditions, when the quantity of money rises at a constant rate, expected inflation is assumed to be equal to actual inflation, and the quantity of real balances does not change over time. This implies the rate of money

[4] The figure is adapted from Romer (1996, p.422).
[5] For more details see Cagan (1956, pp.25-117).

growth equals inflation. To consider the relation between inflation and seigniorage under steady-state conditions recall the money demand function under high inflation suggested by Cagan (1956, pp.33-37):

$$\ln\frac{M}{P} = -\alpha E - \gamma\,, \tag{4}$$

where M is an end-of-month index of the quantity of money in circulation, and P is an end-of-month index of the price level. α is a positive constant denoting the semielasticity in the demand for money with respect to the rate of inflation ; γ is a constant; E stands for the expected rate of change in prices and is assumed to be a function of the actual rate of change, C, that is in turn equal to the difference between the logarithms of successive values of the index of prices. The expected rate of inflation is:

$$\left(\frac{\partial E}{\partial t}\right)_t = \beta(\pi_t - E_t)\,, \tag{5}$$

Converting equation (4) from logs and substituting into (2) gives:[6]

$$R = \pi e^{-\alpha\pi-\gamma}\,, \tag{6}$$

where π – inflation

The maximum seigniorage conditions are:

$$\frac{\partial R}{\partial \pi} = (1-\alpha\pi)e^{-\alpha\pi-\gamma} = 0 \tag{7}$$

$$\frac{\partial^2 R}{\partial \pi^2} = (\alpha^2\pi - 2\alpha)e^{-\alpha\pi-\gamma} < 0 \tag{8}$$

These conditions are satisfied for $\pi < 1/\alpha$. Here it is very important to note that this maximum revenue can be maintained indefinitely. No maximum revenue exists when the tax is first imposed; the higher the tax rate, the higher the revenue due to underestimation of inflation and consequently gradual adjustment in real cash balances. This is the case when the government can obtain seigniorage greater than the long term maximum value. After households start correctly estimating expected inflation, the adjustment to their real cash balances tends to be instantaneous. Higher

[6] See Cagan (1956, pp.80).

money growth leads to higher inflation and correspondingly to a decrease in the demand for real money balances and a fall in the revenue from seigniorage.

To see this, model the adjustment of real money demand to its desired level a partial adjustment hypothesis:

$$\ln\left(\frac{M_t}{P_t}\right) - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right) = \delta\left[\ln\left(\frac{M_t}{P_t}\right)^* - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right)\right], \tag{9}$$

where

δ is the adjustment coefficient, and $\left(\frac{M_t}{P_t}\right)^*$ is the desired level of real money balances. Rearranging (9):

$$\ln\left(\frac{M_t}{P_t}\right) = \delta \ln\left(\frac{M_t}{P_t}\right)^* + (1-\delta)\ln\left(\frac{M_{t-1}}{P_{t-1}}\right), \tag{10}$$

That is the real money balances at time t is a weighted average of the desired real money balances at that time and the real money balances in the previous period, with the respective weights δ and $(1\text{-}\delta)$.

Since

$$\ln\left(\frac{M_t}{P_t}\right) - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right) = \frac{\partial\left(\frac{M}{P}\right)}{\partial t} = \frac{\dot{m}}{m}, \tag{11}$$

where $\frac{\dot{m}}{m}$ is a growth rate of real money balances, it gives us:

$$\frac{\dot{m}(t)}{m(t)} = \delta\left[\ln\left(\frac{M_t}{P_t}\right)^* - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right)\right], \tag{12}$$

If the government needs (G) to be financed by seigniorage exceed the maximum steady-state seigniorage, Romer (1996, pp.425-26) proves that $\frac{\dot{m}}{m}<0$.[7]

In this case, as real money balances are falling,

$$\left[\ln\left(\frac{M_t}{P_t}\right)^* - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right)\right]<0 \tag{13}$$

Expressing the inflation rate as $\pi = \frac{\dot{M}}{M} - \frac{\dot{m}}{m}$ (14) and substituting (12) into (14) gives us:

$$\pi = \frac{\dot{M}}{M} - \left[\ln\left(\frac{M_t}{P_t}\right)^* - \ln\left(\frac{M_{t-1}}{P_{t-1}}\right)\right] \tag{15}$$

Condition (13) means that the rate of inflation exceeds the rate of money growth.

The above argument implies that when the adjustment in real cash balances is gradual, government can obtain seigniorage greater than the steady-state maximum value, but only at the expense of accelerating inflation.

2. Methodology and data

Estimating the optimal seigniorage under steady–state conditions requires the estimation of demand for real money balances. The simplest model links real balances to output and to interest rates, and around that basic idea models have proliferated.[8]

Because interests rates are not market determined and are subject to regulation by the monetary authorities in some transition economies, they are not a good proxy for the opportunity costs of holding money. This is especially typical of countries with high inflation rates and negative interest rates (e.g. Belarus). In such cases can be used to measure the opportunity cost for holding money. Moreover, use of inflationary expectations to represent the opportunity cost of holding precautionary cash balances is needed to explain the relationship between inflation and real cash balances within the adapted framework for estimating optimal seigniorage. Recalling Cagan's study

[7] Romer's (1996) calculations are also based on Cagan's money demand function.
[8] For the systemic literature survey of money demand theories see Sriram (1999).

of hyperinflation, in a period of high inflation, changes in demand for real balances largely result from extreme fluctuations in prices. Finally, the expected rate of inflation as a proxy for opportunity costs has been used in many studies of money demand in the countries with high inflation (see for example, Choudhry 1995 and Yartseva 1999).

As far as the real income variable is concerned, Cagan (1956) does not include it in his model of real cash balances, arguing that it remained relatively stable during the period of hyperinflation. Moreover, Kiguel and Neumeyer (1995), while investigating the relationship between seigniorage and inflation in Argentina in the periods 1979-80, 1982-84, and 1986-1987, found that the coefficient on the transactions variable, represented by GDP, was not significantly different from zero. Other economists include income in the demand function, imposing a unitary income elasticity restriction. Some empirical studies show that this restriction does not hold (see for example Filosa 1995). In the present study I included real income as an explanatory variable, proxying it by monthly GDP.

The problems of empirical modeling of the money demand function in transition economies include the phenomenon of currency substitution for foreign currency and for quasi-money. The latter can be ignored for the time being since in the present study nominal money balances are proxied by high-powered money. As far as the problem of dollarisation is concerned, this can be captured by including the expected rate of devaluation of the national currency as an opportunity cost of holding money. However, using both the expected rate of inflation and the expected rate of currency devaluation in our model can result in problems of multicollinearity.

Thus, the present model of money demand will include real income, proxied by monthly GDP, and the expected rate inflation (see figure 2). The data are represented on a monthly basis ranging from May 1995 and December 2002. The sample is chosen to reflect the periods of high inflation in Belarus and on the basis of data availability. There are 92 observations.

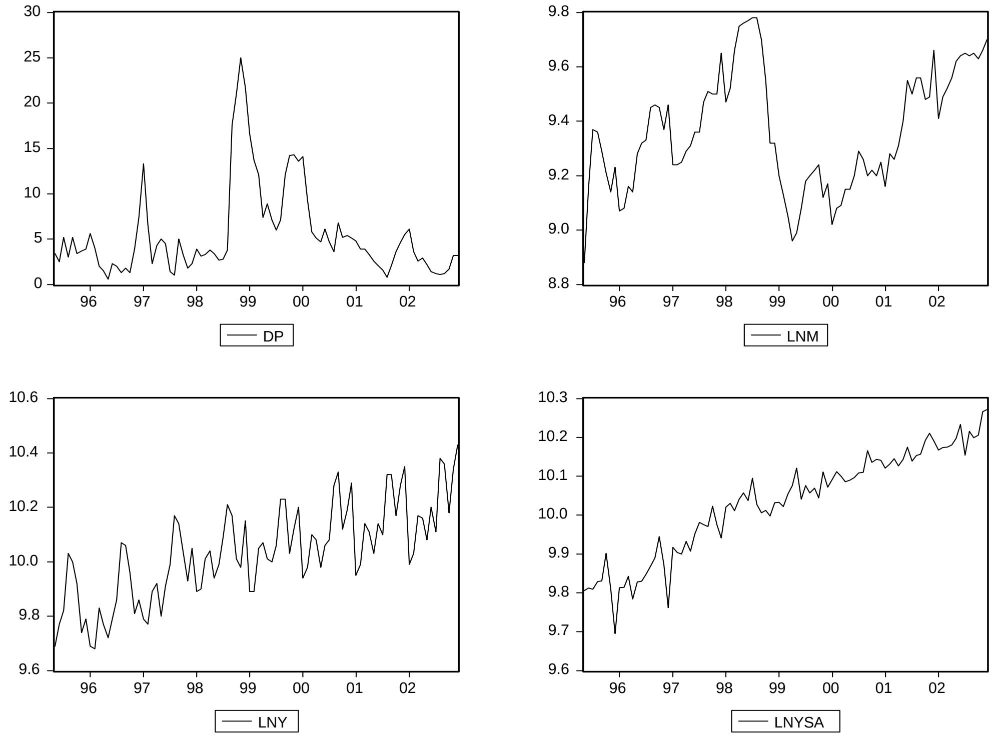

Figure 2: Inflation series (DP), the natural log of real cash balances (LNM), the natural log of real GDP (LNY) and the natural logarithm of real GDP seasonally adjusted[9]

The monetary base (MB) is the sum of currency in circulation and reserve accounts of commercial banks at the National Bank. The nominal monetary base is deflated by the Consumer Price Index (CPI) to create the real money balances, and the inflation rate is the monthly rate of change of the CPI. The nominal GDP is deflated by the GDP deflator to create real GDP, which was seasonally adjusted using X12arima test performed in EViews Version 3.1.[10]

Data on the nominal monetary base was obtained from the National Bank of Belarus[11], while data on the monthly rate of inflation and monthly GDP were provided by the Research Centre of Institute of Privatisation and Management, Belarus.[12]

---

[9] National Bank of Belarus 2000a (January), 2000b (January), 2001, 2002, 2003.

[10] The results of the test for seasonality in series showed that the log of real GDP (LNY) exhibited a seasonal pattern with the peaks in March and August-September that was closely linked with sowing and harvesting campaigns.

[11] National Bank of Belarus 2000a (January), 2000b (January), 2001, 2002, 2003.

[12] Institute of Privatisation and Management [online]. Available from: http://ipm.by/index.pl?topicid=inside [Accessed September 2003].

Sources of dynamic behaviour

Cagan (1956) argues that there is a need to account for lags to explain the impact of the rate of change in prices on the demand for real money balances. First, there is a lag between the expected and the actual change in prices. Second, adjustment of desired real money balances is not instantaneous.

Cagan finds that the lag in inflation expectations appears to be unusually long. At the same time he assumes that a lag in their impact on real cash balances is negligible. However, their separate impact could not be distinguished, implying that the greater length of the lag in expectations can be explained by the effect of the lag in real balance adjustment. He also finds that both an equation accounting for the lag in inflation expectations and an equation capturing the dynamics in real cash balances are identical, and thus imply the same relation between prices and money. Cagan also incorporated both lags together in the model, arguing that an equation with both lags would probably fit the data better. However, he did not estimate this equation, finding it difficult because the inclusion of the lagged dependent variable m_{t-1} - p_{t-1} in the regression could make the estimates inconsistent due to serial correlation. So, in his money demand function, relating actual real money balances to an exponentially weighted average of past rates of price change, he assumes that actual and desired real money balances are equal, and that variations in the expected rate of change in prices account for variations in real cash balances.

In the present work, to capture both dynamic processes, we estimate the following equation with application to PAM:

$$\ln\left(\frac{M}{P}\right)_t = \lambda\beta_1 + \lambda\beta_2 t + \lambda\beta_3\pi_t^e + \lambda\beta_4 \ln y_t + (1-\lambda)\ln\left(\frac{M}{P}\right)_{t-1} + \lambda u_t \qquad (16)$$

$$\pi_t^e = \gamma\pi_t + \gamma(1-\gamma)\pi_{t-1} + \gamma(1-\gamma)^2\pi_{t-2} + \ldots, \qquad (17)$$

where

M- nominal monetary base (MB)

P - price level measured by CPI

$\ln\left(\frac{M}{P}\right)_t$ - natural logarithm of real money balances at time t

π^e - is the expected inflation at time t.

Coefficient $\alpha\beta_i$ shows the short-run relationship effect of the explanatory variables on the dependant one, while the coefficients β_i interpret long-run relationships. Theoretically, the coefficients will take the following signs: β_2>0, β_3<0, β_4>0.

Equation (17) is an adaptive expectations model of inflation[13].

Deriving the revenue-maximising money growth rate and maximum seigniorage with application to our money demand model

Assuming steady-state conditions, converting this money demand function from logs and substituting into the formula for seigniorage yields:

$$S = g_t \frac{M_t}{P_t} = g_t \exp\left[\lambda\beta_1 + \lambda\beta_2 t + \lambda\beta_3\pi_t^e + \lambda\beta_4 \ln y + (1-\lambda)\ln\left(\frac{M}{P}\right)_{t-1} + \lambda u_t\right] \qquad (18)$$

The procedure for obtaining the maximum seigniorage is the same as described in Section 1.

Assuming the steady-state conditions in the long run, the full adjustment of real money balances to its equilibrium level will occur, that is:

$$\ln\left(\frac{M}{P}\right)_t = \ln\left(\frac{M}{P}\right)_{t-1} \qquad (19)$$

and the money demand function will be:

$$\ln\left(\frac{M}{P}\right)_t = \beta_1 + \beta_2 t + \beta_3\pi_t + \beta_4 \ln y_t + u_t \qquad (20)$$

[13] To derive the adaptive expectations model see for example Dougherty (2002).

Under steady-state conditions the expected inflation rate is equal to the actual inflation rate, and equal to the rate of money growth. That is: $\pi^e = \pi_t = g_t$.

To calculate the revenue-maximising money growth rate we have:

$$\frac{\partial S}{\partial g_t} = \frac{\partial}{\partial g_t}\left[g_t \exp\left(\frac{M}{P}\right)_t \right] = \exp\left(\frac{M}{P}\right)_t + g_t \exp\left(\frac{M}{P}\right)_t \frac{\partial\left(\frac{M}{P}\right)_t}{\partial g_t} =$$

$$= \exp\left(\frac{M}{P}\right)_t + g_t \exp\left(\frac{M}{P}\right)_t (\beta_3) = \exp\left(\frac{M}{P}\right)_t (1 + \mathrm{g}_t\ \beta_3) = 0 \tag{21}$$

$$\mathrm{g} = -\frac{1}{\beta_3} \tag{22}$$

The derived revenue-maximising rate of growth is consistent with Cagan's. The next section presents the empirical results for Belarus.

3. Empirical Results

Testing for a unit root in series

The results of the Augmented Dickey-Fuller (ADF) test show that for the natural logarithm of GDP seasonally adjusted (LNYSA) and for the rate of inflation (DP) it is possible to reject the null hypothesis of a unit root at the 1 % and 5 % levels of significance respectively. It suggests that these variables are stationary in levels or in other words they are integrated of order I(0). The natural logarithm of money balances series (LNM) turns out to be stationary in first differences and therefore is integrated of order I(1).

Diagnostic tests performed to see whether the residuals are white noise, are satisfactory, except for the test for normality in the inflation series. A serious problem of normality in the series suggests a structural change in the data. Therefore, the above conclusion of the absence of a unit root can be biased. In this case a test for a unit root in the presence of a structural change should be applied to the series. Moreover, although the results of the test for normality of LNM series with estimation of the ADF regression both in levels and in first differences show that the residuals are normally distributed, a graphic examination of the data points to a structural break around August 1998. According to the results of the ADF test of LNM series in first differences, one should note that the ADF regression exhibits a random walk. However, a graphic examination of the data shows that LNM is trended. Thus, the earlier conclusion that LNM is I(1), might be premature. This offers an impetus along with DP series to also test the LNM series for a unit root allowing for a structural change.

Examining the inflation rate series graphically, we can observe two sharp changes in their level, occurring in December 1996 and September 1998. A sharp surge in inflation in September 1998 can be explained by the impact of the financial crisis in Russia in August 1998. The earlier inflationary surge is more difficult to explain, but is likely linked to accelerated monetary emission, and to a relatively significant devaluation of the Belarusian rouble (evaluated at market exchange rates) at the end of 1996 and the beginning of 1997.

While allowing for structural breaks in series Zivot and Andrews'(1992) methodology[14] with unknown timing of the break is employed here.[15]

The results of the Zivot-Andrews test suggest a clear break in intercept/or intercept and trend occurring in September 1998. The minimum t statistics are equal to –4.91 (break in intercept) and –6.69 (break in both intercept and trend) that allow rejecting the null hypothesis of a unit root in the inflation rate series at the 5 and 1 % levels respectively. Thus, one can conclude that the inflation series is I(0) stationary with at least one clear break in the inflation series, occurring around the date of the financial crisis in Russia (August-September 1998).

The results of the Zivot-Andrews test performed for the real cash balances series suggest it to be I(0) if we allow for a structural change in the data in intercept and in both intercept and trend in the aftermath of the financial crisis in Russia

[14] Zivot-Andrews' test was performed utilising WinRATS-32 version 5.04. The Zivot-Andrews procedure of testing for a unit root in the presence of a structural change allows estimating the breakpoint rather than treating it as fixed. It involves estimating the same three regressions, namely, allowing for a change in the level of the series, in the trend and in both the level and trend. For more descriptions of the test and for critical values see Zivot and Andrews (1992, pp. 251-286).

[15] Perron's (1989) procedure of testing for unit root allowing for a structural break in series can also be applied here. However, the results of Perron's test can be potentially biased because of the assumption of the date of break to be known a priori. As far as the Belarusian data are concerned the break might have occurred not in August 1998 but in September or October 1998, if there was a lag in response to the crisis in Russia. In this case there is need to use a more sophisticated test for the presence of a unit root allowing for a structural break of unknown timing, or in other words assuming that the date of the break is unknown a priori.

(October 1998).[16] This implies that the money demand series is trend-stationary with a shift in mean. Thus, further analysis will be undertaken accounting for this break.

Estimating the final regression: PAM under hypothesis of adaptive expectations formation

To capture both dynamic processes: the lag in inflation expectations and a gradual adjustment of the actual to desired real money balances we use a Partial Adjustment Model (23) with an adaptive expectations model of inflation (24) nested into it.

$$\ln\left(\frac{M}{P}\right)_t = \lambda\beta_1 + \lambda\beta_2\pi_t^e + \lambda\beta_3 \ln y_t + (1-\lambda)\ln\left(\frac{M}{P}\right)_{t-1} + \lambda\beta_4 DU + \lambda u_t \qquad (23)$$

$$\pi_t^e = \gamma\pi_t + \gamma(1-\gamma)\pi_{t-1} + \gamma(1-\gamma)^2\pi_{t-2} + \ldots, \qquad (24)$$

where DU is an impulse dummy variable capturing the impact of the Russian financial crisis. DU =1 for August 1998 – October 1998 and 0 otherwise.

The iterative linearisation method is used here to estimate equation (23). Basically, it involves linearisation of a non-linear equation around some initial set of parameters. Then, OLS is performed on this linear equation, and a new set of parameters is generated. Non-linear equations are linearised around this new set of parameters. The process is repeated until convergence is achieved. Table 2 presents the summary of the most parsimonious results.

α_1	α_2	α_3	α_4	α_5	AIC	SBC	Adj. R sq.
-0.0089 (.0026) P-value [0.001]	.90620 (0.407) P-value [.029]	..0003 (.038) P-value [.998]	0.077 (.065) P-value [.243]	.88575 (.05) P-value [.000]	103.10	95.64	.88750

Table 2: Summary of the results of estimating non-linear regression (23) by the iterative linearisation method[17]

[16] The minimum t-statistics estimated at –5.56 (allowing for a break in intercept) and –5.16 (allowing for a break in both intercept and trend) allow rejecting the H0 of a unit root at the 1 and 10 % levels respectively.

The specified model does not pass the conventional test for serial correlation. To overcome this problem requires using the Newey-West procedure to adjust estimates for serial correlation. Table 3 presents the results of non-linear estimation based on Newey-West adjusted S.E.'s Bartlett weights.

α_1	α_2	α_4	α_5
-.0087 (.972E-3) ___________ P-value [.000]	.96244 (.23381) ___________ P-value [.000]	.10277 (.035617) ___________ P-value [.005]	.89543 (.03825) ___________ P-value [.000]

Table 3: Summary of the results of estimating model (23) with the estimates adjusted for autocorrelation using Newey-West adjusted S.E.'s Bartlett weights

All the coefficients have the expected signs and are statistically significant. One can notice that the coefficient of inflation expectations is close to one. In this regard it is also reasonable to test a hypothesis of rational expectations formation for the robustness of the results.

Estimating the final regression: PAM under hypothesis of rational expectations formation

When hypothesising rational expectations, we assume that on average the rational expected rate of inflation is equal to the actual rate. The interpretation of the conditional expected function, is that the forecast error has a zero mean and is uncorrelated with all the components of the information set (see Patterson 2000, p. 533). Therefore, defining ${}_{t-1}\pi^e{}_t = \mathrm{E}_t\{\pi_t|\Omega_{t-1}\}$ as the expectation of inflation formed at t-1 to prevail at t, where Ω_{t-1} is the information available at the moment of expectation formation, it follows (see Patterson 2000, p.534):

---

[17] Model estimated: $\alpha_0 + \alpha_1(\alpha_2\,\pi_t + \alpha_2(1\text{-}\alpha_2)\,\pi_{t-1} + \alpha_2(1\text{-}\alpha_2)^2\,\pi_{t-2} + \ldots + \alpha_2(1\text{-}\alpha_2)^n\,\pi_{t-n})$ $+\alpha_3$ DU+ α_4 LNY+ α_5 LNM(-1) (25). Initially regression (25) was estimated with the presence of a linear trend. Due it its statistical insignificance, it was omitted from the regression later on. Coefficients α_1, α_4 and α_5 are correspondingly equal to $\lambda\beta_2$, $\lambda\beta_4$, $\lambda\beta_3$ and $(1-\lambda)$ of regression (23). Diagnostics: serial correlation: χ^2 (12)= 26.87[.008]; functional form: χ^2 (1)= .1175[.732]; normality: χ^2 (1)= 3.0240[.22]; heteroscedasticity: χ^2 (1)= .4092[.522].

$\pi_t = \mathrm{E}_t\{\pi_t | \Omega_{t-1}\} + \mathrm{e}_t = {}_{t-1}\pi^e{}_t + \mathrm{e}_t$ and (26)

${}_{t-1}\pi^e{}_t = \pi_t - \mathrm{e}_t$ (27)

By substituting (27) into (23) we obtain equation (28):

$$\ln\left(\frac{M}{P}\right)_t = \lambda\beta_1 + \lambda\beta_2\pi_t + \lambda\beta_3 \ln y + (1-\lambda)\ln\left(\frac{M}{P}\right)_{t-1} + \mu_t\,, \tag{28}$$

where is $\mu_t = \lambda u_t - \lambda\beta_2 e_t$

This equation has potential measurement errors, that could render the inflation estimator inconsistent, because π_t is correlated with a deterministic term and it is determined endogenously. To overcome this problem requires the Generalised Instrumental Variable Method, or in other words the Two-Stage Least Squares Method (TSLS) that requires π_t to be regressed on a set of instruments that are closely correlated with the expected rate of inflation, but uncorrelated with an error term, μ_t. Since it is unrealistic to have all the variables that compose Ω_{t-1}, known a priori, it is reasonable to adopt a 'partly rational expectations' concept. This means that we can use just the lagged values of the inflation rate as the information set. Moreover, since the use of TSLS method requires the number of instruments to be at least equal to the number of regressors, any other right-hand side predetermined (exogenous) variables can be used as instruments as well. Thus, we estimate equation (28) by using TSLS technique, where intercept, dummy variable (DU), real income (LNY), once lagged value of the real cash balances (LNM$_{t-1}$), and twice lagged values of the inflation rate are used as instrumental variables (π_{t-1}, π_{t-2}). The results of the estimated regression are presented in table 4.

α_1	α_2	α_3	α_4	α_5	**GR-Bar-Sq.**	**Sargan's χ^2 (1) statistic**
.65709 (.6423) P-value [.309]	-.00887 (.003) P-value [.004]	.0472 (.064) P-value [.462]	-.002 (.043) P-value [.958]	.88514 (.043) P-value [.000]	.8647	.84258 P-value [.359]

Table 4: Summary of the results of estimating PAM (28) under hypothesis of RE formation

All the coefficients have the expected signs, including the dummy variable, although it is still statistically insignificant. Sargan's χ^2 statistic shows that the model is correctly specified and the instrumental variables are valid instruments. There is still a problem of the presence of serial correlation in the residuals that bias the results. The Newey-West procedure should be used to adjust estimates for serial correlation (see table 5 for the adjusted results).

α_1	α_2	α_3	α_5
.66275 (.41102) ________ P-value [.111]	-.0090727 (.0011237) ________ P-value [.000]	.047771 (.046002) ________ P-value [.302]	.88404 (.040710) ________ P-value [.000]

Table 5: Summary of the results of estimating model (28) with a dummy variable omitted from the regression and with the estimates adjusted for autocorrelation using Newey-West adjusted S.E.'s Bartlett weights

Re-estimation of equation (28) without a dummy variable, after adjusting for autocorrelation, improves the estimates, but the real income variable still appears to be statistically insignificant. This suggests that in Belarus in 1995-2002 money demand was still mainly determined by the expected inflation rate. Indeed, because of the policy of excessive money emission over most of the analysed period, this fact is not surprising. Moreover it is necessary to note that the adjustment in real cash balances is not instantaneous. The coefficient of adjustment is equal to 0.11596 (1-0.88404) suggesting that nearly 12 per cent of the discrepancy between actual and real cash balances is eliminated within one month, and the full adjustment is achieved within less than 9 months. The long-run semi-elasticity coefficient of money demand with respect to the inflation rate is equal to -0.0782 meaning that on the average real cash balances decreased by 7.8 per cent a month when the inflation rate increased by one per cent.

Calculation of the revenue-maximising money growth rate will proceed on the basis of the estimates obtained from the PAM under the hypothesis of rational expectations.

Deriving the revenue-maximising money growth rate on the basis of the obtained estimates from PAM under the hypothesis of rational expectations

The revenue-maximising rate of money growth for Belarus from May 1995 – December 2002, derived from (22), was on average equal to 12.79 per cent per month, or 43.5 per cent per quarter, or 323.88 per cent per year.[18]

To analyse the productivity of seigniorage over 1995-2002, we calculate the maximum revenue that can be obtained if the steady-state conditions hold, and compare this with actual revenue. (see table 6).

From table 6, first of all the maximum seigniorage rate averaged between 7-10 per cent during 1995-2002. That is in line with the results obtained by Cagan (1956) and by Romer (1996). Their findings also suggest that the revenue-maximising money growth rate varies about 300 per cent per annum. This also supports our findings. Table 6 shows that throughout the period the actual rate of seigniorage does not exceed the steady-state one, although it is high enough to cover the budget deficit (averaged 1.6 per cent of GDP in 1995-2001), and even partly cover quasi-fiscal operations accounting for 5-6 per cent of GDP in 1999-2000.

Second, in 1995 the actual rate of money growth exceeded the revenue-maximising rate and a higher level of seigniorage was achieved at the expense of accelerating inflation (calculated as a period average). In this period the actual rate of inflation exceeded the revenue-maximising rate (it is equal to the revenue-maximising money growth rate under the steady-state conditions) by 75 per cent. Despite the fact that in 1998, 1999 and 2000 the actual inflation rate exceeded the nominal money growth rate, both of these indicators remained lower than the revenue-maximising money growth rate. This can be explained by the fact that the estimated revenue-maximising money growth rate is itself high. It, however, should not be referred to as a yardstick for achieving maximum seigniorage because the costs of that will be high in the form of accelerating inflation. Given a mechanism of administrative price controls in Belarus we assume that the difference between the true and official rates of inflation is significant. A measure of a true rate of inflation should have raised a coefficient of the inflation rate, and therefore have reduced the value of revenue-maximizing money

[18] Taking into account that the monthly growth rate is equal to 12.79 per cent and the steady-state conditions held, the quarterly and the yearly revenue-maximising growth rate are calculated correspondingly as ((1.1279)^3 – 1)*100 and ((1.1279)^12 – 1)*100.

growth rate and respectively the values of seigniorage and IT. The fact that in 1995, the year of partial price liberalisation, the rate of actual money growth was in excess of the revenue-maximising one, and period-average inflation exceeded the period-average rate of money growth provides some evidence supporting this argument.

Years	Maximizing money growth rate, % change	Actual money growth rate, period average (end of period), % change	Actual inflation, period average, (end of period), % change	Actual real money growth rate, period average (end of period), % change	Maximum revenue from S, period average as a % of GDP	Actual revenue from S, period average (end of period), as a % of GDP	Actual revenue from IT, period average (end of period), as a % of GDP
1995	323.88	473* (457.43)	566.57 (244.18)	-93.57 (213.25)	9.92	** (3.61)	** (2.47)
1996	323.88	126.01 (75.42)	52.66 (39.13)	73.35 (36.29)	9.92	2.9 (2.44)	1.21 (1.26)
1997	323.88	88.79 (96.41)	63.88 (63.42)	24.91 (32.99)	9.92	2.53 (3.00)	1.82 (1.97)
1998	323.88	100.21 (102.14)	73.2 (181.74)	27.01 (-79.6)	9.92	2.87 (2.04)	2.1 (3.63)
1999	323.88	172.59 (204.05)	293.8 (251.3)	-121.21 (-47.25)	9.92	2.43 (2.27)	4.13 (2.8)
2000	323.88	142.7 (125.23)	168.9 (107.97)	-26.2 (17.3)	9.92	1.92 (1.93)	2.27 (1.66)
2001	323.88	130.1 (120.02)	61.38 (46.35)	68.72 (73.67)	9.92	2.54 (2.73)	1.2 (1.06)
2002	323.88	59.01 (40.1)	42.76 (34.87)	16.25 (5.3)	9.92	1.77 (1.42)	1.28 (1.24)

Table 6: Maximum annual revenue from seigniorage and inflation tax and actual revenue from seigniorage and inflation tax compared[19]

In summary, the policy of money-led stimulation of the economy triggered an inflationary spiral consequently leading to demonetisation and unofficial dollarisation of the economy. According to our results a one per cent increase in the monthly inflation rate in Belarus during 1995-2002 on average led to a 7.8 per cent decrease in

[19] Authors' calculations on the data provided by the National Bank of the Republic of Belarus (National Bank of Belarus 2000a (January), 2000b (January), 2001, 2002, 2003); the Institute of Privatisation and Management [online]. Available from: http://ipm.by/index.pl?topicid=inside [Accessed September 2003]. * Since the data on the total monetary base (inclusive both currency in circulation and bank reserves) are not available for 1994, here the data on currency in circulation are only taken to evaluate the actual monetary growth rate in 1995. **For 1995 the figures on the actual revenue from seigniorage and from inflation tax (period average) as a per cent of GDP are missing because of the lack of the data needed to compute them.

real money balances per month. Thus on average in 1996-2002 only 70 per cent of the economy was monetised.

This policy of monetary emission pursued by the Belarusian government during 1995-2002 aimed to support state-owned enterprises and in doing so, to avoid a sharp output contraction that occurred in many transition economies after the introduction of stabilisation packages. This was undertaken at the expense of the private sector and those households who were not the recipients of subsidies. In this sense such a policy could not be regarded as equitable or efficient. The fact that by 2002 a decrease in money supply could be observed due to restrictions on the policy of monetary emission, with a consequent fall in the inflation rate, and the stabilisation of the Belarusian Rouble, can serve as evidence of the Belarusian authorities finally admitting the costs of excessive money issue.

References

Cagan, P., 1956. Monetary dynamics in hyperinflation. *In:* M. Friedman, ed. *Studies in the quantity theory of money.* Chicago: University of Chicago, pp. 25-117.

Choudhry, E., 1995. High inflation rates and the long-run money demand function: evidence from cointegration tests. *Journal of Macroeconomics,* 17 (Winter)**,** pp. 71-91.

Dougherty, C., 2002. *Introduction to econometrics.* 2nd edition. Oxford: Oxford University Press.

Easterly, W. R., Mauro, P. and Schmidt-Hebbel, K., 1995. Money demand and seigniorage maximising inflation. *Journal of Money, Credit, and Banking,* 27 (2, May)**,** pp. 583-603.

Filosa, R., 1995. Money demand stability and currency substitution in six European countries (1980-1992). *BIS Working Paper,* No. 30 (November). Basle: Bank for International Settlements.

Giovannini, A. and De Melo, M., 1993. Government revenue from financial repression. *The American Economic Review,* 83 (4, September)**,** pp. 953-963.

Kiguel, M. A. and Neumeyer, P. A., 1995. Seigniorage and inflation: the case of Argentina. *Journal of Money, Credit, and Banking,* 27 (3, August)**,** pp. 672-682.

McKinnon, R., 1973. *Money and capital in economic development.* Washington D.C.: Brookings Institution.

National Bank of the Republic of Belarus, 2000a (January). *Dinamika denezhno-kreditnykh pokazatelei za 1995-1999 gody.* Minsk: NBB.

National Bank of the Republic of Belarus, 2000b (January). *Dinamika denezhno-kreditnykh pokazatelei za 1995-1999 gody.* Minsk: NBB.

National Bank of the Republic of Belarus, 2001. *Bulleten' bankovskoi statistiki.* Minsk: NBB.

National Bank of the Republic of Belarus, 2002. *Bulleten' bankovskoi statistiki.* Minsk: NBB.

National Bank of the Republic of Belarus, 2003. *Bulleten' bankovskoi statistiki.* Minsk: NBB.

Patterson, K., 2000. *An introduction to Applied Econometrics: a time series approach.* Basingstoke, London: Macmillan Press.

Perron, P., 1989. The great crash, the oil price shock, and the unit root hypothesis. *Econometrica*, 57 (6, November)**,** pp. 1361-1401.

Romer, D., 1996. *Advanced macroeconomics.* Boston, New York, London: McGrawHill.

Sriram, S. S., 1999. Survey of literature on demand for money: theoretical and empirical work with special reference to Error-Correction Model. *IMF Working Paper*, WP/99/64. Washington D.C.: International Monetary Fund.

Yartseva, A. V., 1999. Stabil'nost' funktsii sprosa na den'gi v Respublike Belarus' i vybor optimal'nykh instrumentov natsional'nym bankom. *Ekovest,* 1 (3)**,** pp. 56-74.

Zivot, E. and Andrews, D. W. K., 1992. Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of Business and Economic Statistics*, 10 (3, July)**,** pp.251-270.