Lags from Money to Inflation in a Monetary Integrated Economy:
Evidence from the Extreme Case of Puerto Rico

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Abstract

This paper studies the time length of the long and short run effects of money growth over inflation in an economy with a high degree of monetary integration: the case of Puerto Rico. The significant influences of policy interventions and its own past and which have greater influence over the inflation will be also analyzed. Money growth is measured as the rate of growth of total banking deposits and inflation with the rate of growth of the Consumer Price Index. According to the results, a dynamic expansion of money is reflected on prices immediately, but the unitary effect occurs approximately in ten quarters. Also, local inflation is significantly influenced by policy interventions and its own past history, but policy interventions have a greater influence.

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I. Introduction

According to monetarist thought, inflation is, in essence, a monetary phenomenon in the sense that a dynamic increase in the general level of prices must be due to the rate expansion of the monetary supply which exceeds the growth in amount of money demanded by economic units.

In the seventies and in the beginning of the eighties authors like Shapiro, (1973), Selden (1975), Rogalsky and Vinso (1977), Alogokoufis and Pissarides (1983) and Barth and Bennett (1975), indicated that this bond between inflation and changes in the money supply is not instantaneous. At that time, monetary aggregates (M1 o M2) were considered the best monetary policy indicators in the United States. In that case, monetary authorities focused on long run inflationary dynamics according to the following objective function:

$$\min \int_{0}^{T} \dot{p}\big[t, m(t), \dot{m}(t)\big]dt \tag{1}$$

Subject to:
$$m(0) = m_0 \quad and \quad m(T) = m_T \tag{2}$$

Where: $\dot{p}$ is the inflation rate, t is the time, $m(t)$ is the money supply, $\dot{m}(t)$ is the money growth and $m(0) = m_0$, $m(T) = m_T$ are the endpoints conditions.

Since the 1982, the Federal Reserve System of the United States use the fed funds interest rate as a monetary policy intermediate object, to control inflation, growth and unemployment. In this case, the monetary policy process turns out to be endogenous. However, in his first report to the Congress the new Chairman of the Federal Reserve, Ben Bernanke, points out the following:

> *"With the economy expanding at a solid pace, resource utilization rising, cost pressures increasing, and short-term interest rates still relatively low, the Federal Open Market Committee (FOMC) over the course of 2005 continued the process of removing monetary policy accommodation, raising the federal funds rate 2 percentage points in eight increments of 25 basis points each. At its meeting on January 31 of this year, the FOMC raised the federal funds rate another 1/4 percentage point, bringing its level to 4-1/2 percent."…*
> *… "Although the outlook contains significant uncertainties, it is clear that substantial progress has been made in removing monetary policy accommodation. As a consequence, in coming quarters the FOMC will have to make ongoing, provisional judgments about the risks to both inflation and growth, and monetary policy actions will be increasingly dependent on incoming data." (Semiannual Monetary Policy Report to the Congress, Before the Committee on Financial Services, U.S. House of Representatives, February 15, 2006).*

These raises in the interest rate, due to a more exogenous policy, will have direct effects in firms that are sensible to this variable. In this case, economies with a greater number of firms that depend on banking loans to finance their investments will be more sensitive to the monetary policy. On the other hand, if the unitary effects of money growth over the inflation are not

instantaneous, their effects over the economy will last for some periods. For example, the nominal interest rate, that is the real interest rate plus the inflation, will have a sustainable growth due to the prices increases.

This paper seeks to contribute to this topic, retaking the approach of money growth's inflationary effects in economies with a high degree of monetary integration. This work will particularly address the following issues:

1. the time length of the unitary effect of money growth on inflation;
2. the short run effect of monetary growth on inflation;
3. if policy intervention or past inflation exert significant influences on the inflationary process;
4. if intervention influences the evolution of the inflation more than inflation's own past.

In this paper, the economy of Puerto Rico will be studied as an extreme case because:

1. it is a commonwealth territory of the United States;
2. the dollar is the official currency;
3. it is subject to the U.S. banking regulations;
4. there is free trade between both economies;
5. there is a high concentration of U.S. firms particularly in the manufacture and commerce sectors.

To develop this work, the second part presents the theoretical foundation and some econometrics consideration that will be very useful in assessing the empirical evidence. The last part presents the general conclusions.

II. Theoretical and econometric considerations

This section presents a general scheme of the standard theoretical exposition that suggests the relation of the variables used in the empirical analysis. This scheme arises from the analysis of the quantity equation of money, starting from the following definition of excess demand in the money market: (Z_m):

$$Z_m = \left(M^d - M^s\right) \tag{3}$$

Where M^d and M^s represents the money demand and supply, respectively. To analyze inflation dynamics, equation (1) should be expressed in its quantity form:

$$Z_m = \left(kPY - M^s\right) \tag{4}$$

In which k is the money velocity reciprocal (which is assumed constant), P is the price level, Y is the real production level and PY is the nominal production level.[i]

In equilibrium:

$$\left(kPY - M^s\right) = 0 \tag{5}$$

This is to say:

$$kPY = M^s. \tag{6}$$

Differentiating this equation it is obtained:

$$M^s \, dV + V \, dM^s = Y \, dP + P \, dY \, .$$
(7)

Where the money velocity is V. Combining (7) with the quantity equation of money yields:

$$\frac{M^s \, dV}{M^s V} + \frac{V \, dM^s}{M^s V} = \frac{Y \, dP}{PY} + \frac{P \, dY}{PY} \, .$$
(8)

By the constant velocity assumption: $\frac{dV}{V} = 0$, and by the money neutrality postulate $\frac{dY}{Y} = 0$[ii], equation (8) may be written as:

$$\frac{dM^s}{M^s} = \frac{dP}{P}$$
(9)

When studying this relation in a monetary system integrated into another, it must be borne in mind that the capacity of local authorities to generate a local monetary policy and monetize debts with its own currency is practically null. In this case, this system cannot use monetary policy to stabilize its economy. This implies that the local money supply depends on the monetary conditions of the monetary system to which it is integrated. In addition, because of the common currency, the local monetary supply is a proportion of that of the country to which the local system is integrated. The equality expressed in (9) can be adapted to the following stochastic functional form, which fits the data best:

$$\dot{P}_t = \left(\iota \dot{M}^s \right)_t^{\beta} e^{\mu_t}$$
(10)

Where ι is the money supply proportion that corresponds to the integrated country; $\dot{P}_t = \frac{dP}{P}$ and $\dot{M}_t^s = \frac{dM^s}{M^s}$ for period t, "β" represents the inflation elasticity respect to the money supply and u_t is the error term, with zero mean and constant variance. In logarithms:

$$\dot{p}_t = \beta \left(\iota \dot{m}_t^s \right) + \mu_t$$
(11)

In which the small case letters represent the logarithms of the variables.

Since the proportional change of inflation in response to the money supply in this type of economy takes several periods, equation (11) can be presented as a general form of a distributed lags model:

$$\dot{p}_t = \sum_{i=0}^{\infty} \beta_i \left(\iota \dot{m}^s \right)_{t-i} + \mu_t$$
(12)

Assuming that money grows more or less at the same rate, the $E[\dot{p}_t]$ equilibrium value will be:

$$\tilde{\dot{p}} = \sum_{i=0}^{\infty} \beta_i \left(\iota \tilde{\dot{m}}^s \right)$$

$$\tilde{\dot{p}}_t = \left(\iota \tilde{\dot{m}}^s \right) \sum_{i=0}^{\infty} \beta_i$$
(13)

Where the permanent values of local inflation and money growth in the integrated country are $\tilde{\dot{p}}_t$ and $\tilde{\dot{m}}^o$. Therefore, for (13) to be finite it must fulfill:

$$\left| \sum_{i=0}^{\infty} \beta_i \right| < \infty \tag{14}$$

According to the unitary effect:

$$\lim_{i \to \infty} \left| \sum_{i=0}^{\infty} \beta_i \right| = 1. \tag{15}$$

The short run effect will be approximately: $\partial \dot{p}_t \big/ \partial \left(\iota \dot{m}_0^s \right) = \beta_0$ and the long run effect will be:

$\beta = \sum_{i=0}^{\infty} \beta_i$, which it is known as the equilibrium multiplier.

Equation (12) may be written in terms of distributive lags as:

$$\dot{p}_t = \sum_{i=0}^{\infty} \beta_i \, L^i \left(\iota \dot{m}^s \right)_t + \mu_t \tag{16}$$

$$\dot{p}_t = B(L) \left(\iota \dot{m}^s \right)_t + \mu_t$$

Where L^i represents the lag operator and B(L) is the polynomial in L $\left(B(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + ... \right)$. This model can be rewritten (16), as:

$$\dot{p}_t = \sum_{i=0}^{\infty} \beta_i \left(\lambda L \right)^i \left(\iota \dot{m}^s \right)_t + \mu_t \tag{17}$$

Where λ is known as the moving average form or the distributive lags.[iii] This equation can be rewritten as:

$$\dot{p}_t = \frac{\beta_0 \left(\iota \dot{m}^s \right)_t}{(1 - \lambda L)} + \mu_t \tag{18}$$

Multiplying by (1- λL) and grouping:

$$\dot{p}_t = \beta_0 \left(\iota \dot{m}^s \right)_t + \lambda \dot{p}_{t-1} + v_t \tag{19}$$

Where, $v_t = \mu_t - \lambda \mu_{t-1}$. In this case, the smaller λ the greater will be the relative effect of monetary policy interventions from the country to which the local system is integrated.

In this type of model, besides analyzing the long run multiplier, the median lag $\left(-\dfrac{\log 2}{\log \lambda} \right)$ and mean lags $\left(\dfrac{\lambda}{1 - \lambda} \right)$ will be used as a summary measure of the speed with which inflation responds to money growth. Also one may analyze the proportion of the long run effect in period i:

$$\beta_i^* = \frac{\beta_i}{\sum \beta_i} \tag{20}$$

Since, in this type of model, the unitary value is distributed through time with weights declining down to zero. In the long run, the net effect of the dynamic increase in the general level of prices must be proportional to money supply growth and his rate of expansion will be:

$$\int_0^T \dot{p}[t, \iota\, m(t), \iota\, \dot{m}(t)] dt = 1 \tag{21}$$

The short run response of local inflation will depend as much on monetary policy interventions as on its own past. According to (19), $\beta_0 > \lambda$ if the local inflation depends less on its past than on money growth. On the contrary if $\beta_0 < \lambda$ the past of the variable will have more influence. Thus, the value of this parameter determines whether a feedback rule used by the Federal Reserve or local supply and demand factors will be more effective in restraining the local inflationary process. Under this regime, high rates of inflation in the past could cause a policy to increase interest rates to control the inflationary phenomenon. If the policy were effective then the inflation rate in the future would be reduced, thereby affecting this variable in integrated systems similar to Puerto Rico is. On the other hand, smaller short run elasticity and smaller λ coefficient means that it takes more time to fulfill the unitary effect in prices, and vice versa.

III. Empirical Evidence

A. Data considerations

One of the more important aspects in this paper is the type of variable to use. Although monetarist theory exposes clearly the variables to include, the conformation of the monetary sector and the statistical system in Puerto Rico suggests the selection of *proxys*.

First of all, the implicit deflator in Puerto Rico is calculated annually. However, the data reflect a high correlation between this variable and the consumer price index (CPI), which is calculated quarterly. For this reason, the CPI will be used as a *proxy*.[iv]

Graph 1: Scatter Plot between the Gross Product Deflator[v] and Consumer Price Index (CPI)
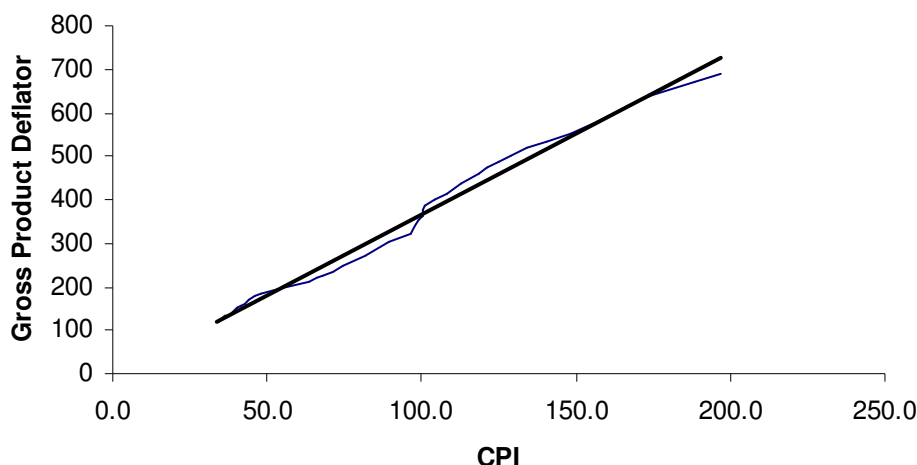
On the other hand, the only mode of money creation in Puerto Rico is through banking deposits. In addition, banks in Puerto Rico are tied to the Federal Reserve System of the United States and the dollar, as is the local currency. In this case, U.S. policy actions will have direct effects in the Puerto Rican system (Toledo, 2002; Rodriguez and Toledo, 2006).

This work assumes that total banking deposits are a good approach of money supply M1 (Toledo, 1996; Rodriguez, 2005). That means that $\left(\iota \, \dot{m}_t^s \right)$ will be represented by the growth of

total banking deposits. The use of this variable does not eliminate U.S. policy effects on the economy of Puerto Rico (Toledo, 1996).

B. Lags Between Money Growth and Inflation

From the estimation of (19), the results are:

Table 1
Money - Inflation Equation

Linear Regression - Estimation by Instrumental Variables
Dependent Variable GLP
Quarterly Data From 1996:01 To 2005:04
Usable Observations   40   Degrees of Freedom   38
Centered R**2   0.575779   R Bar **2   0.617246
Uncentered R**2   0.356012   T x R**2   14.240
Mean of Dependent Variable   0.3674451091
Std Error of Dependent Variable 0.3093639054
Standard Error of Estimate   0.3934211774
Sum of Squared Residuals   5.8816484679
Durbin-Watson Statistic   2.402057
Durbin-h   0.52197

Variable	Coeff.	T-Stat	Signif.
β_0	0.668456	2.25538	0.02995
λ	0.411753	2.63308	0.01217

Table 2
Short and Long Run Impact Multipliers

Variable	Coefficient
β_0	0.66846
λ	0.41175
$\beta_1 = \beta_0\,\lambda$	0.27524
$\beta_2 = \beta_0\,\lambda^2$	0.11333
$\beta_3 = \beta_0\,\lambda^3$	0.04666
$\beta_4 = \beta_0\,\lambda^4$	0.01921
$\beta_5 = \beta_0\,\lambda^5$	0.00791
$\beta_6 = \beta_0\,\lambda^6$	0.00325
$\beta_7 = \beta_0\,\lambda^7$	0.00134
$\beta_8 = \beta_0\,\lambda^8$	0.00055

$\beta_9 = \beta_0\,\lambda^9$	0.00022
$\beta_{10} = \beta_0\,\lambda^{10}$	0.00009
$\sum \beta_i$	1.136193
Lag median	0.78116
Lag mean	0.69999

The parameters are significant at a 5 percent significance level and the model does not present autocorrelation problems, according to the Durbin-h test. According to Table 2, the maximum effect occurs in a period of ten quarters, with the long run elasticity being equal to 1.136193.

The greater effect occurs in the short run with: $\partial \dot{p}_t \big/ \partial(\iota\,\dot{m}_t) = 0.66846$. This means that, in the short run, a one percent increase in inside money generates an increase of approximately 0.67 percent in inflation.

According to the results of the median lag and the mean lags, inflation responds rapidly to money growth changes. Nevertheless, 10 quarters are required for the unitary effect on inflation.

IV. Conclusions

This work investigates the temporary length of the unitary change between inflation and money growth in a monetary integrated economy. The case of Puerto Rico was studied through the distributed lags analysis based on the quantity equation.

According to the empirical evidence a dynamic expansion of money in this type of economy is reflected on prices immediately, but the long run effect occurs approximately in ten quarters. Local inflation receives significant influences of the policy interventions and its own past. However, policy interventions have a greater influence because $\beta_0 > \lambda$.

For the case of Puerto Rico, this means that the investment projects that are sensible to banking loans will also be sensitive to the United States monetary actions. The mayor effect will last two quarters. An exogenous monetary policy in the United States will have a rapid increase over the inflation of Puerto Rico and will have a greater effect in the short run local investment. That means that the prices of the local commodities that are sensitive to these actions will be affected immediately. However, the final result will depend on the type of policy conducted by the FED.

V. References

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[i] Since, if P is the Gross Domestic Product Deflator the expression PY is: $\dfrac{Y_N}{Y} * Y$, where Y_N is the Nominal Gross Domestic Product.

[ii] The postulate that $\dfrac{dY}{Y} = 0$ rests on the notion that changes in real production depends on productivity, technological progress and knowledge, and not on monetary variables.

[iii] This arises according to the following lags operator polynomial (Enders, 2004; Patterson, 2000):

$A(L) = 1 + \lambda L + (\lambda L)^2 + \ldots = \sum_{i=0}^{\infty} (\lambda L)^i$. If, $|\lambda| < 1$, this polynomial is: $A(L) = \dfrac{1}{1 - \lambda L}$.

[iv] However, it should be noted that Puerto Rico's basket of goods and services dates back to 1984. Therefore, recent fluctuations in the prices of important goods are not considered.

[v] Unlike many countries, in Puerto Rico the Gross National Product is used instead of the Gross Domestic Product (GDP) because the production related to external investment is significantly high. In this case, the Gross National Product is a better measure of internal activity.