ON THE CAUSES OF INFLATION: A BRIEF INTRODUCTION TO THE STRATEGIC THEORY*

Alexander Galetović**

ABSTRACT

This note is a brief introduction to the strategic theory of inflation initiated by Barro and Gordon (1983a). The discussion is organized around the question of which are the causes of inflation according to the strategic theory. I show that the answer depends on whether the Central Bank can precommit itself in the very short run to choose an arbitrary rate of growth of money. If the Central Bank cannot precommit itself, it can deliberately create unexpected inflation. Then, the potential *short-run* gains of unexpected inflation affect the *long-run* inflation rate -i.e. these potential short-run gains are a fundamental cause of inflation not necessarily related with the long-run fiscal deficit. Moreover, the assertion that money causes inflation is not warranted; and both politics and institutions affect the long-run inflation rate directly, not only through the fiscal deficit.

SÍNTESIS

Esta nota es una breve introducción a la teoría estratégica de la inflación iniciada por Barro y Gordon (1983a). La discusión se centra en torno a la cuestión de cuáles son las causas fundamentales de la inflación de acuerdo con la teoría estratégica. Muestro que cuando en el muy corto plazo el Banco Central no puede comprometerse creiblemente a fijar tasas arbitrarias de crecimiento del dinero, las sorpresas inflacionarias pueden ser utilizadas como una herramienta de política. En tal caso, las ganancias potenciales de *corto plazo* que se derivan de las sorpresas inflacionarias afectan la tasa de inflación de *largo plazo*, y por lo tanto, constituyen una causa fundamental de la inflación no necesariamente relacionada con el déficit fiscal de largo plazo. Más aún, no es del todo apropiado decir que el dinero causa a la inflación; y tanto las pugnas políticas como las instituciones afectan la tasa de inflación de largo plazo directamente, no sólo a través del déficit fiscal.

* A preliminary version of this paper was presented at the XI Latin American meeting of the Econometric Society held in Mexico City in September of 1992. I am very grateful to Marco Annunziata, Alfredo Cuevas, an anonymous referee, and the participants of the Macro Lunch at Princeton for their comments and suggestions. I am also very grateful to the Centro de Estudios Públicos for its financial support.

** Department of Economics, Princeton University, and Centro de Economía Aplicada, Universidad de Chile.

ON THE CAUSES OF INFLATION: A BRIEF INTRODUCTION TO THE STRATEGIC THEORY*

Alexander Galetović

1. INTRODUCTION

Few regularities of economic life are more universal than the close long-run correlation between money and inflation. This fact makes the conclusion that in the long run "inflation is always and everywhere a monetary phenomenon" almost inescapable.[1] Yet, in spite of this simple characterization, it is hardly disputable that inflation remains one of the most difficult problems faced by policy makers, and, if the recent Latin-American stabilization experience offers any guide, its solution seems to be far-off.

Beginning with Barro and Gordon (1983a) (who built on an example by Kydland and Prescott, 1977) the last ten years have witnessed the development of a radically new approach to the study of inflation that relies on game-theoretic concepts.[2] As in any rational expectations model, in the realms of the strategic theory of inflation private agents respond optimally to the actions of the Central Bank.[3] But in addition, the Central Bank is no longer viewed as a passive entity that can be programmed to follow any arbitrary policy, but rather as a strategic agent that, subject to explicit credibility and commitment constraints, seeks to attain well-specified goals.

This note is a brief introduction to the strategic theory of inflation. I will organize the discussion around the following question: Which are the causes of inflation according to the strategic theory? We will see that the answer to this question depends on whether the Central Bank can precommit itself to choose an arbitrary rate of growth of money in the very short run. In section 2 I study the case where short-run precommitment is possible. In that case the fundamental cause of inflation is most likely the long-run fiscal deficit, and inflation is a

* *Estudios de Economía*, publicación del Departamento de Economía de la Facultad de Ciencias Económicas y Administrativas de la Universidad de Chile, vol. 20, n°2, diciembre 1993.

[1] Friedman (1963, p.17).

[2] For surveys see Blackburn and Christensen (1989), Persson and Tabellini (1990), and Rogoff (1989).

[3] No distinction will be made between the Central Bank and the Government.

purely monetary phenomenon -a periodic re-scaling of all nominal quantities that occurs in response to periodic increases in the stock of money. In the rest of the paper I follow most of the recent literature and assume that the Central Bank cannot precommit itself in the short run. This assumption implies that the Central Bank can deliberately create unexpected inflation, and consequently, that unexpected inflation is a short-run policy tool. This has important implications: the potential short-run gains of unexpected inflation affect the long-run inflation rate -i.e., these potential short-run gains are a fundamental cause of inflation; moreover, the assertion that inflation is a purely monetary phenomenon is not warranted; and both politics and institutions affect directly the long-run inflation rate, not only through the fiscal deficit.

Before proceeding, a caveat is in place. Except for a footnote, I will not discuss any issues related to reputation, uncertainty or imperfect information, in part to keep this introduction brief, but mainly because neither the point that I want to stress --when the Central Bank cannot precommit itself the potential short-run gains of unexpected inflation are a fundamental cause of inflation-- nor its implications change qualitatively in more complicated settings.

2. FIRST MODEL: INFLATION WITH SHORT-RUN PRECOMMITMENT

We want to study what determines the long-run inflation rate taking into account that money is neutral in the long run. So let's consider a deterministic neoclassical model with a standard aggregate supply curve

$$y_t^s = y^T + \alpha(\pi_t - \pi_t^e), \qquad (2.1)$$

where y^T is the log of full employment output (which we assume always constant), and $\pi_t - \pi_t^e$ is unexpected inflation. Aggregate demand is given by the quantity equation

$$y_t^d = m_t^d - p_t ,$$

where $m_t^d - p_t$ is the log of the real demand for money. Last, we assume that the Central Bank chooses the current growth rate of money, δ_t. Thus, the log of nominal money evolves according to

$$m_t^s = m_{t-1}^s + \delta_t .$$

The economy is populated by a continuum of identical private agents uniformly distributed on the interval [0,1]. To put it in a simple way that

unexpected inflation has private costs, we follow Rogoff (1989), and assume that the loss function of each agent is

$$(\pi_t - \pi_t^{ei})^2. \tag{2.2}$$

Each agent chooses his personal expectation, π_t^{ei}, to minimize (2.2).

In most of the literature π_t^{ei} is interpreted merely as a personal expectation of the actual inflation rate. The shortcoming of this interpretation is that one is easily led to think that, as an expectation, π_t^{ei} can be costlessly changed as soon as new information becomes available. Here we want to think of π_t^{ei} as the summary of those economic short-run *decisions* that an agent makes when he expects a given inflation rate. For example, if the *ith* agent is a wholesale firm, π_t^{ei} might summarize decisions as which prices to quote in the next edition of the firm's catalogue, which nominal price to pay to a supplier, or which nominal wage to set for the next three months. The important point is that generally speaking, in the short run (a few weeks or perhaps even months) some of these decisions will not be changed, even if new information becomes available. For this reason, we will consider π_t^{ei} a "decision" rather than an "expectation".

Now in this context, which is the optimal decision rule of an individual agent? If agents make their decisions *after* the Central Bank has chosen the growth rate of money, the rational expectations hypothesis assumes that each agent will take the equilibrium values of δ_t and π_t^e as given, and obtain his optimal decision by solving the structural model of the economy. Therefore, under rational expectations we cannot deduce the optimal decision rule of an agent before characterizing the equilibrium. Assuming that markets clear, the current price level is

$$p_t = m_{t-1} + \delta_t - y^T - \alpha(\pi_t - \pi_t^e). \tag{2.3}$$

We can approximate the actual inflation rate by $p_t - p_{t-1}$. From equation (2.3) we see that the inflation rate is a function

$$\pi_t \equiv p_t - p_{t-1} = \delta_t - \alpha(\pi_t - \pi_t^e) + \alpha(\pi_{t-1} - \pi_{t-1}^e).$$

The rational expectations hypothesis implies that in period t-1 $\pi_{t-1}^e = \pi_{t-1}$. It follows that the actual inflation rate in period t is

$$\pi_t = (1 + \alpha)^{-1} \{\delta_t + \alpha\pi_t^e\}. \tag{2.4}$$

(I will henceforth drop time subscripts.) Equation (2.4) is a relation between the actual inflation rate on the one hand, and the rate of growth of money and aggregate expected inflation, on the other. To minimize (2.2), a rational agent must choose $\pi^{ei} = (1 + \alpha)^{-1} \{\delta_t + \alpha\pi^e\}$. But in addition, each agent knows that all other agents make their decisions using (2.4); by aggregating, each agent will conclude that

$$\pi^e \equiv \int_0^1 \pi^{ei} di = (1 + \alpha)^{-1} \{\delta + \alpha\pi^e\}. \tag{2.5}$$

It follows from (2.5) that $\pi^e = \delta$ is the only solution consistent with rational expectations. From equation (2.4) each agent will conclude that in equilibrium the actual inflation rate equals δ.

It is now easy to obtain the optimal decision rule of each agent: since they observe δ and minimize $(\delta - \pi^{ei})^2$, each agent's decision rule is

$$\pi^{ei*} \equiv \delta. \tag{2.6}$$

When the Central Bank can precommit itself, decisions are quite simple indeed: every period agents observe δ and then re-scale nominal quantities at the same rate as money grows. Aggregation across agents yields the aggregate response function

$$\pi^{e*} \equiv \int_0^1 \pi^{ei*} di = \delta. \tag{2.7}$$

Note that the aggregate response function has a Walrasian flavor: for each possible equilibrium level of an endogenous variable (δ), it shows the aggregate decision. In this sense, it is similar to a Walrasian demand function, which shows the aggregate quantity demanded of good x for each possible equilibrium price p_x. Two implications follow: first, without knowing the objectives of the Central Bank, we conclude that in equilibrium systematic monetary policy is neutral, and that the inflation rate equals the rate of growth of money. Therefore, given rational expectations, these are not only properties of the equilibrium, but also of the economy. Moreover, since δ is an exogenous variable relative to the model that consists of equation (2.4) and the aggregate response function (2.7), the one-to-one correlation between money and inflation reflects a causal relation.[4] Consequently, as the aggregate response function (2.7) shows, inflation is just a periodic and coordinated re-scaling of all nominal quantities that occurs *in response* to periodic increases of the stock of money. It is precisely because these

[4] This is Simon's (1953) definition of causality: δ causes π if and only if δ is exogenous and π is endogenous. δ is exogenous relative to a model if and only if it is determined outside that model.

re-scalings occur in response to increases of the quantity of money that we say that inflation is a purely monetary phenomenon.

A second characteristic of the equilibrium is that we can deduce both the decision rule of each agent, and the aggregate response function without knowing the objective of the Central Bank. Therefore, we can separate the problem of inflation in two distinct and formally independent questions: (i) Which is the relation between money growth and inflation? (ii) Why do Central Banks choose a particular rate of growth of money?[5] For this particular model, the first question has already been answered: It is easily seen by substituting (2.7) into (2.4) that regardless of the objective of the Central Bank, the inflation rate will always equal δ. Nevertheless, before answering the second question we must know the objectives of the Central Bank. Let us suppose that it chooses δ to minimize.

$$B(\pi,y) \equiv \frac{a}{2}(y - ky^T)^2 + \frac{b}{2}\pi^2 - c\pi, \quad k > 1, \tag{2.8}$$

where a, b, are positive constants that summarize, respectively, the costs of the output gap and of inflation; and the positive constant c is the marginal benefit of the inflation tax. When actually choosing δ, however, the Central Bank takes the aggregate response function (2.7) as given, i.e. the equality between expected and actual inflation constrains the choices of the Central Bank. Therefore, when the Central Bank chooses δ before agents make their decisions, it actually minimizes.

$$B_c(\delta) \equiv \frac{a}{2}[(1 - k)y^T] + \frac{b}{2}\delta^2 - c\delta, \tag{2.9}$$

from where it follows that in equilibrium $\delta = c/b$. From equation (2.9) we see that when the Central Bank can precommit itself, it values inflation only through the direct revenue effect on its payoff. Thus, the Central Bank generates inflation because it benefits from the inflation tax ($c > 0$) and, therefore, it is reasonable to think that the ultimate cause of inflation is the long-run fiscal deficit.

3. SECOND MODEL: INFLATION WITHOUT SHORT-RUN PRECOMMITMENT

As we mentioned before, many decisions made with a given expected inflation in mind can be changed only after a lag of weeks or even months. It is a fact that it takes only hours (or at the most a few days) to change the rate of growth of money, so that the "short run" of monetary policy is much shorter than the "short

[5] See Brunner (1975).

run" of most agents in the economy. Partly because of this, the assumption that the Central Bank moves before each agent makes his decision is inadequate. On the contrary, one would think that, even in the short run, the Central Bank cannot commit itself credibly to choose an arbitrary rate of growth of money.

Let us suppose an economy identical to the one in the previous section, but where, as in Barro and Gordon (1983a), the Central Bank moves *after* each agent has made his private decision. In this case the Central Bank observes π^e before choosing δ, and minimizes.

$$B_s(\delta; \pi^e) \equiv \frac{a}{2}\left[(1-k)\,y^T + \alpha(1+\alpha)^{-1}(\delta - \pi^e)\right]^2 + \frac{b}{2}\left[(1+\alpha)^{-1}(\delta + \alpha\pi^e)\right]^2, \tag{3.1}$$

where I have substituted equation (2.4) into the loss function of the Central Bank (2.8) and made $c = 0$. Note that when the Central Bank chooses δ after each agent has made his decision, it can use unexpected inflation as a policy tool. In this particular example, the Central Bank can use unexpected inflation to reduce the output gap, and consequently, it has an incentive to create inflation even though it does not value the revenue generated by the inflation tax (since $c = 0$).

Now since the Central Bank moves after agents have made their decisions, we cannot find π^e without knowing the Central Bank's actual decision rule. This decision rule can be obtained from the first order condition that results from minimizing (3.1). Once this first order condition is solved for δ, we obtain that the Central Bank's decision rule is a function of π^e, to wit

$$\delta = A + B\pi^e, \tag{3.2}$$

with $A \equiv \alpha(1+\alpha)(k-1)ay^T / (\alpha^2 a + b)$ and $B \equiv \alpha(\alpha a - b) / (\alpha^2 a + b)$.

Which is the aggregate response function in this case? To answer this question we note again that under rational expectations each agent solves the model of the economy taking π^e as given, but this time considers that the Central Bank will choose δ according to its decision rule (3.2) after observing π^e. Thus, to make his decision each agent will substitute the Central Bank's decision rule into equation (2.4), to obtain

$$\pi^{ei} = (1+\alpha)^{-1}\{A + (B+\alpha)\pi^e\}.$$

But again, since all agents have rational expectations, by aggregating each will conclude that $\pi^e = \pi$, so that

$$\pi = \frac{\alpha(k - 1)\, ay^T}{b} \equiv \Phi\ (\alpha, a, k, b) > 0$$

Therefore, each agent's decision rule is

$$\pi^{ei*} \equiv \Phi\ (\alpha, a, k, b). \tag{3.3}$$

(3.3) is quite different from equation (2.6), its counterpart in the first model. It is a function of structural parameters, not of the equilibrium level of an endogenous variable; and it involves predicting the behavior of the Central Bank, not just observing its actual decision. Thus, whenever the Central Bank cannot precommit itself, optimal decisions are not just mechanical re-scalings of nominal quantities that occur in response to increases in the quantity of money, because to make a decision each agent must anticipate what the Central Bank will do.

From (3.3) it follows that the aggregate response function is

$$\pi^{ei} \equiv \int_0^1 \pi^{ei*} di = \Phi\ (\alpha, a, k, b). \tag{3.4}$$

Substituting (3.4) into the Central Bank's decision rule (3.2) and simplifying, we can see that in equilibrium $\pi = \delta$. Therefore, no surprises occur, and there is a one-to-one correlation between money and inflation.

Because in equilibrium a one-to-one correlation between money and inflation still holds, at first glance it may seem that the strategic theory adds little to the story we told in the previous section. But the similarities are only apparent. First, the one-to-one correlation is a property of the equilibrium, but not of the economy. To see this, note that given the aggregate response function (3.4), the relation between the rate of growth of money and inflation is

$$\pi = (1 + \alpha)^{-1}\ \{\delta + \alpha\phi(\alpha, a, k, b)\}. \tag{3.5}$$

It can be seen from equation (3.5) that in this case $\pi = \delta$ is a choice of the Central Bank, not a constraint it must obey.

Second, in equilibrium there is inflation, even though the Central Bank gains nothing from it. This was one of the striking findings of Kydland and Prescott (1977): Under rational expectations the incentive to use unexpected inflation as a policy tool leads to excessive inflation without reducing the output gap. In fact, since in this example the Central Bank does not value the revenue generated by inflation, it would choose price stability were it able to precommit itself.[6]

[6] It should be noted that the objective function (3.1) assumes that the Central Bank cares only about the short run. Barro and Gordon (1983b) pointed out that in most circumstances the Central Bank cares also about the future, and will consider that today's monetary policy will affect what agents expect about monetary policy in the future. As Barro and Gordon (1983b) show, the Central Bank can then establish a reputation that allows it to choose credibly inflation rates that are lower than those suggested by our short-run analysis.

Third, the one-to-one correlation between money and inflation does not reflect a causal relation, i.e. money does not cause inflation. To see this, note that δ is obtained from the Central Bank's decision rule (3.2). But since the Central Bank's decision rule is a function of π^e, the rate of growth of money is an endogenous variable relative to the system that comprises equations (2.4), the Central Bank's decision rule (3.2), and the aggregate response function (3.4).[7] An interesting consequence follows: while, of course, it is still the case that ultimately inflation is caused by the incentives that the Central Bank has to increase periodically the money supply, it is no longer true that these re-scalings of nominal quantities occur in response to the increase in the money supply, but rather according to what agents *anticipate* the Central Bank will do. To anticipate the actions of the Central Bank, however, agents have to consider the particular characteristics of the economy, the decision rules of other agents, and the preferences of the Central Bank; this stands in sharp contrast to the model presented in the previous section, where all agents had to do was to observe the rate of growth of money. Because of this , we can say that when the Central Bank cannot precommit itself in the short-run, inflation is no longer a purely monetary phenomenon, but a real phenomenon as well.

4. DISCUSSION

As we have seen, when the Central Bank cannot precommit itself, money does not cause inflation, though of course it is the case that money correlates closely with inflation. Broadly speaking, then, which are the causes of inflation according to the strategic theory?

The second model points out that when the Central Bank cannot precommit itself, it may use unexpected inflation to reduce the output gap. But we can think of many other motives that may induce the Central Bank to generate unexpected inflation. For example, the Central Bank can use unexpected inflation to redistribute wealth, to accommodate supply shocks, or to bail out banks in trouble. Regardless of the particular motive, however, the important point is that while the incentives to cause unexpected inflation are related to short-run gains, they are present period by period nonetheless. As long as people more or less know the magnitude of these short-run incentives, they will anticipate them correctly on average, and nominal decisions will be such that the Central Bank will have no incentive to generate unexpected inflation. Thus, the *short-run* incentives to generate unexpected inflation affect the *long-run* inflation rate. It follows that, in a precise sense, these short-run incentives are a fundamental cause of inflation. What determines these short-run incentives?

[7] Note that we cannot make comparative-static exercises asking which is the effect of changes in the rate of growth of money on inflation, *ceteris paribus*, because the endogeneity of δ renders them ill-defined.

The loss function (3.1) shows that they are determined by three factors. First, by the preferences of the Central Bank, which summarize the benefits and costs of inflation as perceived by the Central Bank (here these are given by the parameters a, k, and b). Second, by structural parameters that determine what can be done with unexpected inflation (here this is given by the slope of the aggregate supply curve, α). And third, by the aggregate response function (here given by the function Φ), determined in turn by aggregating individual decision rules.

Once we accept that the short-run incentives faced by the Central Bank are a fundamental cause of inflation —and this only requires us to accept the premise that the short run of monetary policy is shorter than the short run of most agents in the economy— three implications follow about the nature of inflation. First, since institutions and politics determine the relative importance of the alternative policy goals that can be pursued with unexpected inflation, and the costs of attaining these goals by generating inflation, institutions and politics affect directly the long-run inflation rate, not only through the fiscal deficit. Second, structural features of the economy like the length of contracts, contract laws and practices, indexing laws and practices, etc. affect the long-run inflation rate, not only its short-run dynamics. And third, as already said, since the long run inflation rate depends on how agents make short-run decisions, and these decisions are not just periodic and coordinated re-scalings of all nominal quantities that occur in response to periodic increases of the stock of money, but depend on what agents anticipate the Central Bank will do, inflation is not only a monetary phenomenon, but a real phenomenon as well.

Striking as these conlusions may be, the strategic theory is vague about the exact institutional and political constraints faced by the Central Bank, and about how parameters and individual decision rules are determined, and in that sense it is quite *ad hoc*. In some ways this is a shortcoming, because the theory cannot offer clear-cut policy advice (with the exception, perhaps, of the issue regarding central-bank independence). But on the other hand, the vagueness of the theory is a roundabout way of warning us that we cannot expect a simple and unique answer to the question of which are the causes of inflation, and that it is a good bet that at least to some extent inflation has different causes in different countries. Casual observation suggests that institutions and politics vary considerably across countries, and consequently, so do the relative costs and benefits of alternative policy goals that can be pursued with unexpected inflation. For example, to solve an over-indebtedness problem by generating inflation might be politically acceptable in a Latin-American country with pervasive distributive struggles, but unacceptable in a Western-European democracy. Furthermore, decision rules and structural parameters depend on the inflationary history of the economy, which varies from country to country as well. For example, indexation is widespread in many Latin American countries with a long inflationary history, but not in the United States or in Great Britain.

The final observations about the strategic theory concern its implications for the relation between fiscal deficits and inflation. While strategic models do not imply that fiscal deficits are irrelevant, they certainly do imply that fiscal deficits are not the only factor that matters. Consider the case when the Central Bank cannot precommit itself, but this time suppose that the Central Bank values inflation only as a means of generating revenue (i.e. $a = 0$ and $c > 0$). It is easily seen that in equilibrium $\pi = c/b$, and that changes in fiscal policy (reflected by changes in the parameter c) affect the equilibrium inflation rate. Now consider again the model that we studied in section 3, where $a > 0$ and $c = 0$. As we have seen, the inflation rate is positive in equilibrium, even though the Central Bank derives no direct benefit from printing money (and actually, given that expectations are rational, no benefit at all). Nevertheless, it is still the case that the inflation tax generates revenue. Now this revenue can be used to finance any government expenditure, and of course, it can be used eventually to finance a fiscal deficit. But clearly, in that case one cannot say that the fiscal deficit is the cause of inflation; on the contrary, it is the revenue generated by the inflation tax what causes the government to run a deficit. In such circumstances a fiscal reform that closes the deficit would not eliminate inflation, because inflation is caused by the short-run incentives faced by the Central Bank.

REFERENCES

BARRO, R. and D. GORDON (1983a): "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, Vol. 91, 589-610.

_____ (1983b): "Rules, Discretion, and Reputation in a Model of Monetary Policy," *Journal of Monetary Economics*, Vol. 12, 101-121.

BLACKBURN, K. and M. CHRISTENSEN (1989): "Monetary Policy and Policy Credibility," *Journal of Economic Literature*, Vol. 27, 1-45.

BRUNNER, K. (1975): "Comment", *Journal of Law and Economics*, Vol. 18, 807-836.

FRIEDMAN, M. (1963): *Inflation: Causes and Consequences.* New York: Asia Publishing House.

KYDLAND, F. and E. PRESCOTT (1977): "Rules Rather than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, Vol. 85, 473-491.

PERSSON, T. and G. TABELLINI (1990): *Macroeconomic Policy, Credibility and Politics*. Chur: Harwood Academic Publishers.

ROGOFF, K. (1989): "Reputation, Coordination and Monetary Policy." In R. Barro (ed.) *Modern Business Cycle Theory*. Cambridge: Harvard University Press.

SIMON, H. (1953): "Causal Ordering and Identifiability." In W. Hood and T. Koopmans (eds.) *Studies in Econometric Method.* New York: John Wiley and Sons.