8. Why is long-run inflation positive (II): time-inconsistency

As we have already discussed, the observation that the long run rate of inflation is positive and significant (its average in OECD countries over the past 20 years is about 6%) calls for an explanation. With money being roughly neutral in the long run, it is difficult to understand why policymakers should print money at a rate which results in positive inflation.

From a normative point of view, Friedman (1969) suggested that in a first best world the optimal rate of inflation should actually be negative and equal to minus the real interest rate (Friedman's rule).

We have already seen one theory that can explain positive long-run inflation. Inflation may be the result of the need to finance part of government expenditure through seignorage. From a normative point of view, in a world with only distortionary taxes, the socially optimal amount of seignorage may actually be positive under certain conditions (Phelps 1973).

We will now discuss another theory which aims at explaining the same stylized fact. According to this theory inflation is positive in the long run only because agents *expect* positive inflation. This theory relies on the notion of **time inconsistency**.

1 Time inconsistency

Time inconsistency means that in a dynamic situation agents *ex ante* and *ex post* incentives may differ.

An example may help. Taxation of capital goods reduces the incentive to invest. So, the government has an incentive to promise that capital will be exempted from tax. Yet, once private agents have invested, the government has an incentive to renege on its earlier pledge, since the investment decision has already taken place and the tax does not distort investment choices any more. If private agents are rational (i.e. understand the government future incentives) they will not believe the government promise and underinvest.

This example highlights two aspects that are crucial for this theory: (a) the rationality of expectations about the future and (b) credibility.

If the objectives of the government and private agents differ, there is a situation of *ex post* moral hazard. In a sense, credibility is related to incentive compatibility. Rational agents will believe the government to take only those actions which are optimal from its point of view *ex post.*

Up to now we have assumed that monetary policy was either exogenous or passively determined by the solvency constraint. We now relax this assumption. Monetary policy is chosen optimally by the policymaker to maximize its own objective function. Agents are so rational that they not only know the correct model of the economy, but also the policymaker's objective function.

The economy is described by the following (log-) linear short run aggregate supply (SRAS)

$$y_t = \bar{y} + \alpha(p_t - p_t^e), \tag{1}$$

where p_t^e denotes the expectation of the price level p_t at the beginning of period t. This SRAS is consistent with the sticky-wage, sticky-price and workers' misperception models we have seen. Note that if $p_t = p_t^e$ the economy is at its full employment level of output $\bar{y}$. So, the long run aggregate supply is vertical.

We can add and subtract p_{t-1} from the parenthesis in equation (1) and obtain

$$y_t = \bar{y} + \alpha(\pi_t - \pi_t^e), \tag{2}$$

where the rate of inflation $\pi_t = p_t - p_{t-1}$ and its expectation at the beginning of time t is $\pi_t^e = p_t^e - p_{t-1}$.

This is an equation in three endogenous variables y_t, π_t and π_t^e. So we need two more equations to solve for equilibrium. For given expectations, the rate of inflation will be determined by monetary policy. The policymaker chooses monetary policy to maximize its objective function.

Let us assume that if expectations are correct the classical dichotomy holds and full-employment output $\bar{y}$ is determined on the labour market. Assuming that full-employment output is constant, implies that the rate of inflation coincides with the rate of money growth. We can then think of the policymaker (the government) as choosing the rate of inflation rather than the rate of money growth. The policymaker objective (utility) function is given by

$$W_t = y_t - \gamma \pi_t^2. \tag{3}$$

The policymaker dislikes both positive and negative deviations of inflation from zero and would like output to be as large as possible. This is the source of the moral hazard: while private agents' utility maximization requires output to be at its full employment level, the government targets a higher level of output.

(Important) Structure of the game:

1. Agents form their expectations rationally at the beginning of time t (e.g. prices or nominal wages are set for one period in advance). They know both the correct model of the economy (2) and the policymaker objective function (3).

2. During time t, after people have formed their expectations, the policymaker chooses monetary policy to maximize its welfare function (3) subject to the constraint (2) *and* taking agents expectations as given. For given expectations, the choice of monetary policy determines the inflation rate and output level that prevail at time t.

If agents' expectations are rational the appropriate equilibrium concept is that of 'equilibrium with perfect foresight[1]'. Equilibrium is a vector $[y_t, \pi_t, \pi_t^e]$ such that the SRAS (2) is satisfied, the government maximizes (3) subject to (2) taking expectations as given and expecta-

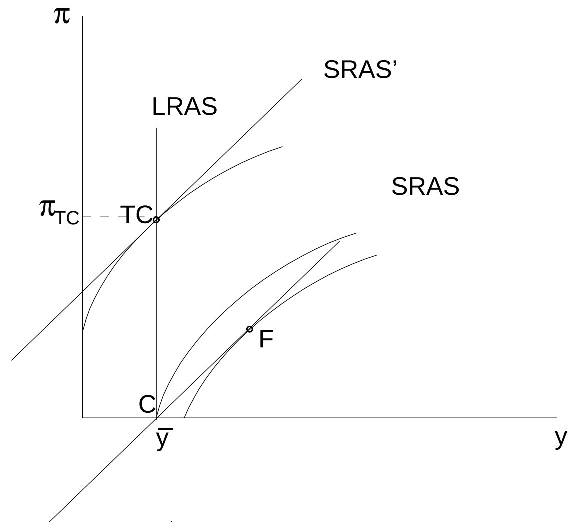
[1]Remember that in the absence of unexpected shocks perfect foresight is equivalent to rational (model-consistent) expectations.

tions are correct ex post; i.e.

$$\pi_t^e = E_{t-1}(\pi_t) = \pi_t. \tag{4}$$

To understand the time-inconsistency problem suppose that the government announces, before people form their expectations, that it will create zero inflation at time t. We want to show that there does not exist an equilibrium in which rational agents believe the government announcement. Suppose the contrary (i.e. that $\pi_t^e = 0$). Notice that π_t^e determines the position of the SRAS. If $\pi_t^e = 0$, the SRAS passes through point C in the figure above.

Let us proceed backward. At time t the policymaker chooses π_t optimally taking π_t^e as given. After people have formed their expectations, the government has an incentive to create unexpected inflation. At point C (i.e. if $\pi_t = \pi_t^e = 0$) the policymaker's marginal rate of substitution between inflation and output is higher than the slope of the SRAS: the government can reach a lower indifference curve by creating positive unexpected inflation (point F). Since agents know the government objective function, at the beginning of time t they understand that if they believe the policymaker's pledge, the government will create positive inflation *ex post.* So, they do not believe the announcement in the first place and $\pi_t^e = 0$ is not an equilibrium.



Why is this not an equilibrium according to our definition? Our 'perfect-foresight equilibrium' concept requires agents' expectations to be correct *ex post.* This can only be the case at a level of expected inflation such that the policymaker's MRS between inflation and output equals the slope of the SRAS (point TC). Only, if inflation is high enough the government's marginal cost and benefit from creating unexpected inflation are equal, the policymaker has no incentive to create unexpected inflation and expectations turn out to be correct.

Let us now solve formally for the equilibrium. The rate of inflation at time t is determined by the government optimization problem. Replacing for y_t in equation (3) using (2) this becomes

$$\max_{\pi_t} W_t = \bar{y} + \alpha(\pi_t - \pi_t^e) - \gamma\pi_t^2. \tag{5}$$

The corresponding FOC is

$$\alpha - 2\gamma\pi_t = 0 \tag{6}$$

or

$$\pi_t = \alpha/2\gamma. \tag{7}$$

The third equation comes from the perfect-foresight assumption

$$\pi_t^e = \pi_t = \alpha/2\gamma. \tag{8}$$

Agents know the government welfare function and will expect the rate of inflation which *ex post* maximizes government welfare. Equation (7) gives the time-consistent rate of inflation. It is the rate of inflation which the government has no incentive to deviate from, *ex post.* It is an increasing function of α (the flatter the SRAS, the bigger the output gain from creating unexpected inflation) and decreasing in γ (the bigger γ the less the government is willing to trade off higher inflation for higher output).

Notice that as $\pi_t^e = \pi_t$, the equilibrium level of output is the full employment level $\bar{y}$. Replacing the equilibrium values of output and inflation in equation (3), government welfare in the time-consistent equilibrium is

$$W_{TC} = \bar{y} - \frac{\alpha^2}{4\gamma}. \tag{9}$$

If, instead, the government were able to *credibly* commit to zero inflation, its welfare would be

$$W_C = \bar{y} > W_{TC}. \quad (10)$$

In terms of the above figure, at point TC (the time consistent equilibrium) the economy is at the natural rate, but has a higher rate of inflation than at C. Hence, government welfare is lower. This is effectively a prisoner dilemma: the economy ends up in the inefficient time-consistent equilibrium TC despite the fact that everybody would be better off at C.

It is the government incentive to trade-off higher inflation against higher output at when expected inflation is zero which results in the economy ending up with positive long run inflation. Unless the government is able to tie its hands the economy ends up at the inefficient equilibrium.

How can a better equilibrium be achieved (i.e. how can the government tie its hands)?

1. Constitutional (irreversible and credible) rule which prescribes zero inflation. In our simple model this would ensure that the economy ends up at C. Problems: in a more realistic set up in which the economy is subject to unexpected shocks such a rule would be too rigid as it would rule out short run stabilization altogether (this is a general problem of any fixed rule).

2. Independent central bank. The government delegates monetary policy to an independent central bank. One possible difference between the government and the central bank is that the central bank dislikes inflation more (has a higher γ). It allows for flexibility, but the time-consistent rate of inflation is still positive, though lower.

3. Optimal contract for central bankers. The efficient equilibrium at C could be achieved if the government wrote an optimal contract that gave the central banker the right incentives (e.g. his/her salary is a decreasing function of the rate of inflation).

McCallum's (1995) put forth an important criticism of these last two strands of the literature: why should the government choose a central bank with different tastes from the government itself?

4. Reputation. In reality the strategic interaction between the government and private agents is repeated over time. A forward-looking government maximizes its welfare over its whole planning horizon. We can think that it maximizes the present value of its instantaneous utility in equation 3; i.e.

$$IW = \sum_{i=0}^{\infty} \frac{W_t}{(1+\rho)^i}, \tag{11}$$

where ρ is the government discount rate.

Suppose that at the beginning of period 1 the government announces that inflation will be zero and people believe it. If then the government creates unexpected inflation (point F in the picture) it can increase its welfare in period 1 from W_C (the utility associated with the indifference curve through point C) to W_F (the utility associated with the indifference curve through point F). But in all the following periods agents will now expect the time consistent rate of inflation given by equation (6) and government welfare will be W_{TC} (the level associated with the indifference curve through point TC). So the PDV of government welfare would be

$$IW_F = W_F + \sum_{i=1}^{\infty} \frac{W_{TC}}{(1+\rho)^i}. \tag{12}$$

Viceversa if the government stuck to its pledge of zero inflation, its utility would be W_C (where $W_F > W_C > W_{TC}$) in all present and future periods. In this case the PDV of government welfare would be

$$IW_C = W_C + \sum_{i=1}^{\infty} \frac{W_C}{(1+\rho)^i}. \tag{13}$$

The government will renege on its promise if $IW_F -$

$IW_C > 0$. We have

$$IW_F - IW_C = (W_F - W_C) + \sum_{i=1}^{\infty} \frac{(W_{TC} - W_C)}{(1+\rho)^i}. \tag{14}$$

The first addendum on the RHS of the above equation is positive: the government makes a one-period gain by fooling people. But $W_{TC} - W_C < 0$. In all future periods, the government is worse off since the economy ends up at point TC in the figure rather than at point C. If the PDV of the future losses exceed the present gain (i.e. if $IW_F - IW_C \leq 0$) the government will find it optimal to preserve its *reputation* and stick to its promise and the efficient equilibrium at C can be supported without any other commitment device.

Yet, for agents to be able to check whether the policymaker is keeping its pledges or not, the government needs to phrase its policies in a transparent and verifiable way.