Macro 3 EUI 2009, Lecture 2

Inflation: monetary vs. fiscal distortions

- Monetary distortions and welfare: measuring the cost of inflation

- Benefits from inflation: seigniorage revenue. Is there a trade-off between monetary and fiscal distortions? Optimality of the Friedman rule in an economy with distortionary taxation.

- Seigniorage: empirical evidence.

During past 25 years, average inflation:

- has fallen from 9 percent in the first half of the 1980s down to 2 percent after 2000 in industrial countries .

- has fallen from 31 percent in the first half of 1980s down to single digit after 2000, in developing countries. Fall is dramatic in Latin America. For instance in the 'Western Hemisphere' inflation falls from an average of 162 percent in 1988-97 down to an average of 7.4 in 1998-2007.

Global disinflation views: greater central bank independence, improved macroeconomic policies, increasing competition and 'globalization'.

What are the gains from reducing inflation? The classical view

- Monetary assets provides services to society by 'facilitating exchanges.' Because of these services, people hold money even if it pays no interests, or a lower interests than other assets.

- **By raising the nominal interest rate**, (expected) inflation raises the return differential between holding money and assets. This differential creates costs for society.

- Shoe-leather costs (cash management), shopping time: real resources are wasted in an effort to avoid the costs of holding non-interest bearing money balances. The higher the inflation (nominal interest) rate, the larger these costs.

A quotation and a useful example

- Friedman: "*A retailer can economize on his average cash balances by hiring an errand boy to go to the bank on the corner to get change for large bills tendered by costumers. When it costs ten cents per dollar per year to hold an extra dollar of cash, there will be a greater incentive to hire the errand boy, that is, to substitute other productive resources for cash*".

- In the 'shopping cost' model, let

$$H\left(c_t, \frac{m_{t+1}}{p_t}\right) = \frac{c_t}{m_{t+1}/p_t}\varepsilon$$

where c_t denotes consumption, m_{t+1} denotes the amount of money balances held between t and $t+1$, p_t is the price level.

- If an agent spends at the constant rate c_t per unit of time, $\frac{c_t}{m_{t+1}/p_t}$ can be interpreted as the number of trips the 'errand boy' makes to the bank, ε the cost of each trip to the consumer. See Baumol (1952) and Tobin (1956).

- To reduce this cost to zero, the government could pursue policies which make it cost-less to hold a very large amount of money balances, i.e. they government should set the interest differential between money and bond equal to zero. In the example above: $m/p \to \infty$.

- Friedman prescription: '*satiate the system with real balances, insofar this is possible*'.

How to measure the costs of inflation?

- Martin Bailey (1956) Lucas (2001): use public finance principles
  - From a social point of view, real balances (think of bills) are produced at approximately zero marginal costs. From an individual point of view, the cost of holding money is the interest forgone by not holding interest-bearing asset. Households are willing to pay this cost, if the services provided by money are at least as valuable.
  - By lowering the interest rate to zero, there are no costs of holding money balances. Private and social costs of money are equated.

- **Bailey**: Define the welfare cost of inflation as the area under the money demand curve {real money balances as a function of the interest rate} — this is the consumer surplus which is lost because the interest rate is strictly above zero (see Walsh textbook page 61, Lucas 2000, pp. 250-2).

- **Lucas**' estimate: the costs of a 10 percent interest rates for the US is about 1 percent of GDP (see Walsh page 62).

- Many open issues, including:

  - How does money demand behave at very low interest rates?

    - ∗ crucial question: what is the costs of going from, say, 3 percent to 0?

Other views on the (efficiency) costs of inflation emphasized by different models

- CIA models: inflation is a tax on consumption. Since the consumption of leisure does not require the use of money, inflation affects the marginal rate of substitution between consumption and leisure.
  - More in general, similar distortions characterize models which exogenously split goods into ‘credit goods’ and ‘cash goods.’
- (Search model)

II. *Friedman vs. Phelps*

A zero-interest-rate policy eliminates monetary distortions (shoe-leather costs). However, it also eliminates possible benefits from inflation. An important example is seigniorage revenues for the government, which could be used to reduce distortionary taxation, a point stressed by Phelps. Is there a trade-off between inflation and tax distortions? Below we draw on the LS textbook (chapter 24) to address this issue.

- Consider a simple economy with production and distortionary taxes (next lecture we will study equilibrium in depth)

- *the government budget*

$$g_t = \tau_t y_t + \frac{B_{t+1}}{R_t} - B_t + \frac{M_{t+1} - M_t}{p_t}$$

- Taxes are not lump sum: which level of seigniorage revenue would be optimal against the tax-induced distortions in production?

- *Resource constraint*

Define y_t as output and n_t as employment. With a linear technology

$$y_t = n_t = c_t + g_t$$

Let ℓ_t denote leisure, s_t time devoted to shopping, b_t households' holding of one period discount government bond maturing at the beginning of t (as opposed to the stock of bonds outstanding, so that in equilibrium $B_t = \int^1 b_t = b_t$).

Households problem

$$\sum \beta^t U(c_t, \ell_t)$$

subject to:

$$\begin{aligned} 1 &= \ell_t + s_t + n_t \\ c_t + \frac{b_{t+1}}{R_t} + \frac{m_{t+1}}{p_t} &= y_t (1 - \tau_t) + b_t + \frac{m_t}{p_t} \end{aligned}$$

where shopping time is assumed (a) to be homogeneous of degree ν in consumption and real balances, and (b) to have a satiation point at ψc_t

$$\begin{aligned} s_t &= c^{\nu} H\left(1, \frac{m_{t+1}}{p_t c_t}\right); \\ H_{m/p}(.) &= H(.) = 0 \text{ for } \frac{m_{t+1}}{p_t} \geq \psi c_t \end{aligned}$$

To solve this problem, let's derive the present-value budget constraint. As in lecture 1, combine budgets at two different dates:

$$\begin{aligned} & c_t + \frac{c_{t+1}}{R_t} + \left(1 - \frac{p_t}{p_{t+1}} \frac{1}{R_t}\right) \frac{m_{t+1}}{p_t} + \frac{b_{t+2}}{R_t R_{t+1}} + \frac{m_{t+2}}{p_t R_t} \\ = \; & y_t \left(1 - \tau_t\right) + \frac{y_{t+1}\left(1 - \tau_{t+1}\right)}{R_t} + b_t + \frac{m_t}{p_t} \end{aligned}$$

(recall that a bounded budget set requires $i \geq 0$) and iterate this expression forward, imposing the two transversality conditions

$$\lim_{T\to\infty} q_T^0 \frac{b_{T+1}}{R_T} = 0; \qquad \lim_{T\to\infty} q_T^0 \frac{m_{T+1}}{p_T R_T} = 0$$

where $q_t^0 = \Pi_{i=0}^{t-1} R_i^{-1}$ denote Arrow Debreu (AD) Price, with numeraire $q_0^0 = 1$. These conditions state that (a) non-satiated households will never find it optimal to accumulate bonds at a rate higher than the equilibrium return on AD bonds; (b) the same must be true for real money holdings, because (i) money as an asset is dominated by bonds, and (ii) shopping costs have a satiation point at ψc_t.

The present-value budget constraint is

$$\sum_{t=0}^{\infty} q_t^0 \left(c_t + \frac{i_t}{1+i_t} \frac{m_{t+1}}{p_t} \right) = \sum_{t=0}^{\infty} q_t^0 (1-\tau_t) \left(\overbrace{1-\ell_t-s_t}^{y_t=n_t} \right) + \left(b_0 + \frac{m_0}{p_0} \right)$$

Let λ be the multiplier associated with this constraint. The first order conditions of the households problem are

$$c_t \quad : \qquad \beta^t \left[U_c(t) \right] - \lambda q_t^0 \left[1 + (1-\tau_t) H_C(t) \right] = 0$$

$$\ell_t \quad : \qquad \beta^t U_\ell(t) - \lambda q_t^0 (1-\tau_t) = 0$$

$$\left(\frac{m_{t+1}}{p_t} \right) \quad : \qquad -\lambda q_t^0 \left[(1-\tau_t) H_{m/p}(t) + \frac{i_t}{1+i_t} \right] = 0$$

A close look at tax distortions

The f.o.c.s derive above clearly shows that tax rates distort the labor-leisure choice, the state prices (unless τ is constant), as well as money holding:

(a): $$U_\ell = (1-\tau)\left(U_C - U_\ell H_C\right);$$ (b): $$q_0^t = \beta^t \frac{U_\ell(t)}{U_\ell(0)} \frac{1-\tau_0}{1-\tau_t}$$

(c): $$\frac{i_t}{1+i_t} = -\left(1-\tau\right) H_{m/p}(t)$$

According to (a), households equates the marginal utility of an extra hour of leisure, to the marginal utility of consumption that can be obtained from the extra income from working, net of taxes and shopping costs. Interpret (c).

Would a planner choose positive seigniorage, deviating from Friedman's prescription, for the sake of reducing tax distortions?

Ramsey problem

To address this issue, set up a Ramsey problem. Two alternatives:

- **Dual approach:** define the policymakers instruments, say {tax rates, interest rates}. Pick a sequence of instrument that delivers maximum expected utility at 0, given the first order conditions of the household problems, the transversality conditions, market clearing, the resource constraint, initial conditions and arbitrage pricing conditions. Intuitive, but usually (analytically) hard problem to solve.

Primal approach: pick *directly* the allocation from the set of private sector equilibrium allocations which deliver the highest welfare. To this end, use FOCs and any arbitrage pricing conditions to substitute out *policy instruments and prices* from the PV budget constraint (which uses transversality); the result will be the *implementability constraint*.

- Maximize expected utility subject to
  - implementability,
  - technology/ resource constraint,
  - initial conditions.

To derive the implementability constraint, start with the present value budget constraint. Setting the initial conditions $b_0 = m_0 = 0$ to save on notation, you have:

$$\sum_{t=0}^{\infty} q_t^0 \left(c_t + \frac{i_t}{1+i_t} \frac{m_{t+1}}{p_t} \right) = \sum_{t=0}^{\infty} q_t^0 \left(1-\tau_t\right)\left(1-\ell_t-s_t\right)$$

Define $\widehat{m}_{t+1} \equiv \frac{m_{t+1}}{p_t}$ to stress that this is a real quantity. Using the f.o.c. for ℓ and $\widehat{m}_{t+1}$ you can write

$$\sum_{t=0}^{\infty} \beta^t \frac{U_\ell(t)}{U_\ell(0)} \frac{1-\tau_0}{1-\tau_t} \left(c_t - \left(1-\tau\right) H_{m/p}(t) \widehat{m}_{t+1} \right)$$

$$= \sum_{t=0}^{\infty} \beta^t \frac{U_\ell(t)}{U_\ell(0)} \left(1-\tau_0\right)\left(1-\ell_t-s_t\right)$$

Note that $(1-\tau_0)/U_\ell(0)$ drop from the above equation. Then use the f.o.c. for c write:

$$
\begin{aligned}
& \sum_{t=0}^{\infty} \beta^t \left[(U_C - U_\ell H_C) c_t - U_\ell H_{m/p} \widehat{m}_{t+1} \right] = \\
& \sum_{t=0}^{\infty} \beta^t \left[U_C c_t - U_\ell \left(H_C c_t + H_{m/p} \widehat{m}_{t+1} \right) \right] \\
= \;& \sum_{t=0}^{\infty} \beta^t U_\ell (1 - \ell_t - s_t)
\end{aligned}
$$

Using Euler theorem: $vH = H_C c_t + H_{m/p} \frac{m_{t+1}}{p_t}$ and of course $s = H$, finally we have

$$
\Sigma_{t=0}^{\infty} [U_c(t) c_t - U_\ell(t)] \left[1 - \ell_t - (1-\nu) H \left(c_t, \frac{m_{t+1}}{p_t} \right) \right] = 0
$$

The Ramsey allocation problem (including generic initial conditions) is

$$Max_{c,\ell,m/p} \sum \beta^t U(c_t, \ell_t) \tag{1}$$

$$\Sigma_{t=0}^{\infty} \left[U_c(t)c_t - U_\ell\left(t\right)\right] \left[1 - \ell_t - \left(1-\nu\right) H\left(c_t, \frac{m_{t+1}}{p_t}\right)\right] +$$

$$+\frac{1-\tau_0}{U_\ell(0)}\left[b_0 + \frac{m_0}{p_0}\right] = 0 \qquad (multiplier: \ \Phi)$$

$$1 - \ell_t - H_t\left(.\right) - c_t - g_t = 0 \qquad (multipliers \ : \theta_t)$$

- The first order conditions for c and ℓ

$$u_c(t) + \ \Phi \left\{ U_{cc}(t) c_t + U_c(t) - U_{\ell c}(t) \left[1 - \ell_t - (1-\nu) H(t) \right] + U_\ell(t) (1-\nu) H_c(t) \right\} - \theta_t \left[H_c(t) + 1 \right] = 0$$

$$U_\ell(t) + \ \Phi \left\{ U_{c\ell}(t) c_t + U_\ell(t) - U_{\ell\ell}(t) \left[1 - \ell_t - (1-\nu) H(t) \right] \right\} - \theta_t = 0$$

- The first order condition for money balance is

$$H_{m/p}(t) \left[\Phi (1-\nu) U_\ell(t) - \theta_t \right] = 0$$

- To prove the *optimality of the Friedman rule:* need to show that he above is satisfied **only for** $H_{m/p}(t) = 0$, that is, satiating the economy with money balances, according to Friedman's prescription.

To prove the *optimality of the Friedman rule*, we need to show (after Correia and Teles) that

$$\theta_t = \Phi\,(1-\nu)\,U_\ell(t)$$

cannot be a solution. See LS p.887.

- For $\nu > 1$: the above is true if either $\theta_t = \Phi = 0$ or the two multipliers have opposite signs. But this is not the case since $\Phi \geq 0$, and with non-satiation $\theta_t > 0$.

- For $\nu = 1$, $\theta_t > 0$ means that the above cannot hold.

- For $\nu < 1$, rewrite the f.o.c. for ℓ incorporating the above

  $$U_\ell\,(t) + \ \Phi\left\{U_{c\ell}(t)c_t + U_\ell(t) - U_{\ell\ell}(t)\left[1-\ell_t-(1-\nu)\,H(t)\right]\right\} - \Phi\,(1-\nu)\,U_\ell(t) =$$
  $$U_\ell\,(t) + \ \Phi\left\{U_{c\ell}(t)c_t + \nu U_\ell(t) - U_{\ell\ell}(t)\left[1-\ell_t-(1-\nu)\,H(t)\right]\right\} = 0$$

  leads to a contradiction, since the LHS is strictly positive under assumptions.

An illustration

Consider an economy with

$$g_t = g(constant) \quad and \quad b_0 = m_0 = 0.$$

Conjecture that the Ramsey plan can be implemented with a constant allocation $(\widehat{c}, \widehat{n})$ and a constant rate $\widehat{\tau}$ supporting a balanced government budget. We know that real money balances are at the satiation point. With a constant allocation, the return on money is equal to the constant real interest rate R. Hence money also grows at R:

$$\left\{ \frac{M_{t+1}}{p_t} = \psi \widehat{c}; \ \frac{p_t}{p_{t+1}} = R_m = R \right\} \implies \frac{M_t}{M_{t+1}} = R$$

How to implement such allocation?

- In period 0, the government sell M_1 to the private sector, in exchange for $p_1 B_1 / R$ bonds. So in the first period seigniorage revenue is positive at the rate

$$(M_1 - 0)/p_0 (= \psi \hat{c}) \qquad\qquad at\ t = 0$$

The government becomes a *net creditor.*

- In each subsequent period, the government uses the return from asset holdings (a positive entry in the public budget) to retire currency from circulation (so that seigniorage revenue is actually negative) at the rate

$$\frac{M_{t+1} - M_t}{p_t} = (R - 1)\psi \hat{c} < 0; \qquad for\ t > 0$$

Notes on the allocation

- Seigniorage does not contribute at all to finance spending. Hence there is no reduction in the tax-related distortions: $\widehat{\tau} = g$.

- After the first period, money holding shrinks over time in nominal terms, not in real terms.

- Note: the government is assumed to be an asset manager as good as the private agents.

A digression

- Observe that the beginning of an 'economy with negative inflation' coincides with a large increase in money aggregates $(M_1 - 0)/p_1 (= \psi \widehat{c})$.

- The increase in M accompanies the rise in demand for real balances in a stable environment, and should not be confused with a (inflationary) 'monetary expansion' which is 'inflationary'.

- This is reminiscent of the increase in money aggregates often observed during the implementation of 'successful stabilization' that bring down inflation substantially (see Latin America experiences). These rise in money stock are an equilibrium implication of low inflation, not shocks causing inflation.

The importance of initial conditions: posit that government nominal liabilities are not zero.

What if $M_0 > 0$? Combining the two equations characterizing the stationary equilibrium we derived in lecture 1:

$$\begin{aligned} g - \tau + B\frac{R-1}{R} &= f(R_m)\,(1 - R_m) \\ \frac{M_0}{p_0} &= f\,(R_m) - (g_0 + B_0 - \tau_0) + B/R \qquad\qquad => \\ \frac{M_0}{p_0} &= \frac{R - R_m}{1 - R_m}\frac{B}{R} + (g - \tau) - (g + B_0 - \tau) \end{aligned}$$

In the optimal allocation $\widehat{\tau} = g$ in all periods, and $R = R_m$. With $B_0 = 0$ we have

$$\frac{M_0}{p_0} = \frac{R - R_m}{1 - R_m}\frac{B}{R} = 0$$

P_0 must jump high enough to wipe out the value of initial outstanding money (see 24.3.8 LS).

Interpretation: 'Inflation' and optimal taxation of initial wealth

- LS interprets M_0 as money (but provides no liquidity services), and the jump in p_0 as 'period 0 hyperinflation'. Just after the 'period 0 hyperinflation', expectations of credible disinflation raises money demand up to $p_1 \psi \widehat{c}$.

- A useful way of looking at M_0 is that of a given stock of public nominal liabilities towards the private sector. If their value is not wiped out initially, there will be a positive amount of public debt to service over time. This would require an increase in distortionary taxation relative to Ramsey. (What if $B_0 > 0$?)

Notes on the literature (Friedman vs Phelps)

- Friedman rule does not necessarily hold with money in utility function, depending on whether money and consumption are substitute or complements (Mulligan and Sala-i-Martin 1997), or CIA models.

- However, Friedman turns out to be right under a number of alternative plausible restrictions. Moreover, quantifications of gains from taxing money are usually small.

Empirical evidence: seigniorage in practice is quite low

Data show that seigniorage is actually quite low in general, and even in situations where budget crises or high costs of tax collection would suggests some merit in raising revenue by taxing money holdings.

In the US, which collects seigniorage on large dollar holdings by non-residents, seigniorage is around 1.5 of government budget, or 0.3 of GDP.

In Europe in the 1985 and 1995, largest seigniorage collection was by Greece (around 2,5 percent of GDP), Portugal (2-3) Italy (1.5-1). The other countries were systematically below 1 percent.

So far we have seen that (a) macro-efficiency arguments in favor of seigniorage are weak; (b) seigniorage is low in practice. But positive inflation has implications for the government budget that are independent of seigniorage.

Examples of fiscal implications of (sustained) inflation

- Inflation raises the real tax burden if tax rates are progressive and tax brackets are not indexed (**creeping brackets, fiscal drag etc**.). This is an implications of imperfect indexation of the tax code.

- However, with high inflation, the lag between tax declaration and tax payments reduces the real value of government revenues (**Tanzi effects**).

- the revenue implications of *imperfect indexation of nominal liabilities.* This is a topic which has received increasing attention.

In lecture 1, you have seen a 'fiscal theory of inflation'

- The government sets g, τ at all dates, M_0 and B_0 are inherited from the past.

- The government sets B (deficit), first equation determines R_m. In other words, the government commits to a overall deficit (including interest payments). Then the market determines the inflation rate.

- Any initial increase in the deficit B_1 (say, due to an open market operation which reduces money supply), causes an increase in inflation rate R_m.

The unpleasant monetarist arithmetic once again

- Note that inflation increases (permanently) even if initially there is a monetary contraction. This is unpleasant monetarist arithmetic.
  - the increase in debt does is not matched by any adjustment in primary surpluses. Hence what needs to adjust is the operational surplus (i.e. seigniorage).

- Fiscal root of inflation: deterioration of primary surpluses are inflationary. But remember that $f(R_m)(1 - R_m)$ is bounded (Laffer curve)

An observation on the initial conditions

- However, given B and R_m (from the first equation), the second equation determines p_0:

$$\frac{M_0}{p_0} = \downarrow f(R_m) - (g_0 + B_0 - \tau_0) + \uparrow B/R$$

  The effect of an increase in the deficit B_1 on p_0 can go either way, depending on the interest elasticity of money.

- In many contributions, this effect on p_0 is disregarded: it is undone by assuming that the government adjusts τ_0 appropriately. Movements in p_0 are instead central to recent literature, reviewed below.

Fiscal Theory of the Price Level (an introduction)

- Woodford and Sims (in LS terms) stress that in modern economies, the government sets g and τ, the central bank chooses the interest rate (in a stationary equilibrium, this is tantamount to choosing the inflation rate), hence presets seigniorage. Then the first equation determines B (which is endogenous), the second equation p_0.

- So, the public sector (government plus central bank) commits to a path of the primary surplus cum seigniorage (called 'operational surplus'). Deficit dynamics (B) is endogenous, and the initial price level is determined by:

$$\frac{M_0}{p_0} = \sum_{t=0}^{\infty} R^{-t} \left[(\tau_t - g_t) + f(R_m)(1 - R_m) \right]$$

An asset-pricing interpretation

- Think of $\frac{1}{p_0}$ as the price of the nominal asset M_0 in terms of real good. The value M_0/p_0 is the value of a claim on the current and future operational surpluses of the government. The higher this surpluses, the higher the price of this claim: given M_0, the lower the initial price level.

- The 'price level' is both the relative price of money in terms of goods, and the relative price of government (imperfectly indexed) nominal liabilities in terms of present and future goods.

The fiscal foundations of price stability

- Even if the central bank sets the interest rate (and long-run inflation), the current price level cannot be determined independent of fiscal conditions. 'Price stability' requires more than Central Bank independence: fiscal policy must be consistent with it!

but:

- To some authors, the FTPL is just a 'device for selecting equilibria from the continuum which can exists in monetary models'.

Controversy on solvency

- Note the differential treatment of the private and the public sector:
  - Households' present value budget constraint must hold for any path of prices (not only the equilibrium one).
  - The government can instead set g,τ and B which satisfy its PV constraint only at the equilibrium price p_0.

Debate on the government solvency constraint.

Implications for modelling

When the government follows policies such that its present value budget constraint holds for any price path (not only the equilibrium one), these policies are defined by some authors (namely, Woodford) 'Ricardian'.

- An example of rules insuring that fiscal policy is Ricardian is provided by a feedback rule from the stock of debt to taxes: taxes increases with debt (Eric Leeper).

Policies which instead satisfy solvency only for a particular equilibrium path for prices are called 'Non-Ricardian.'

Concluding observations

Independently of the academic success of the FTPL, it remains true that, if government spending commitments and liabilities are not perfectly indexed, moderate or even low inflation can generate high public saving. See work by Persson, Persson and Svensson (1998), and Bernstein, Eichenbaum and Rebelo.

Christiano L. and T. Fitzgerald, 'Understanding the Fiscal Theory of the Price Level,' Federal Reserve Bank of Cleveland Economic Review, Quarter 2, vol. 36, no. 2