

# A Central Bank Theory of Price Level Determination

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- A widely accepted view is that central bank's mandate should be explicit in terms of price (or inflation) stability.
  - Can the central bank really control the price level? And how?
  - Literature on the **fiscal theory of price level** has concluded that "fiscal policy can be a determinant, or even the sole determinant, of the price level" (Sims, 2013):
    - **Deflationary spirals** and liquidity traps can be ruled out by the threat of a fiscal stimulus;
    - **Inflationary spirals** can be trimmed through the use of a fiscal anchor.
- ⇒ Architecture of European Monetary Union is built on precarious foundations lacking a fiscal authority behind the ECB and with too many fiscal authorities constrained by budget rules.

This work challenges the above results and proposes an alternative view showing that the central bank can control the price level by relying only on its means.

The central bank should:

- receive an appropriate capitalization (in real terms) at its inception;
- borrow issuing money or reserves;
- set interest rate on reserves through an 'active' interest rate rule;
- invest in risk-less securities;
- be financially independent from the Treasury;
- be ready to issue shares of its capital and pay an appropriate stream of real dividends.

By undertaking **risky** open-market operations, central bank may give up its financial independence and leave the economy exposed to self-fulfilling inflationary spirals or chronic liquidity traps.

# The Problem of Price Level Determination

Consider a simple endowment monetary economy in a perfect foresight equilibrium.

- Euler equation implies:

$$1 + i_t = \frac{1}{\beta} \frac{P_{t+1}}{P_t}.$$

- Interest rate rule:

$$1 + i_t = \max \left\{ \frac{1}{\beta} \left( \frac{P_t}{P^*} \right)^\phi, 1 \right\}$$

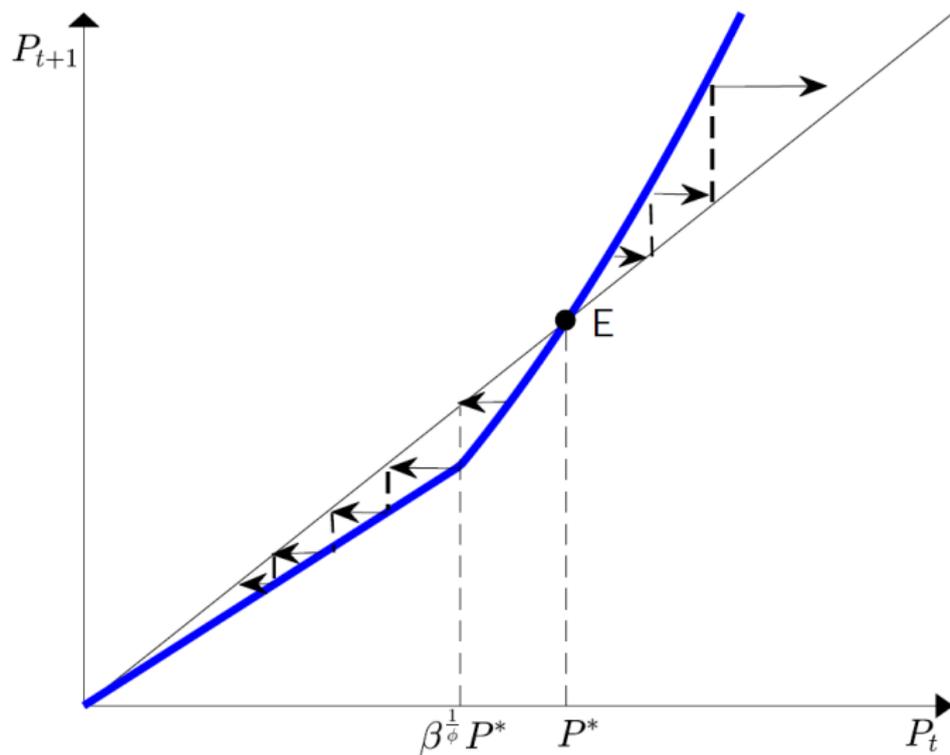
with  $\phi \geq 0$ .

- Combine them:

$$\frac{P_{t+1}}{P_t} = \max \left\{ \left( \frac{P_t}{P^*} \right)^\phi, \beta \right\}$$

⇒ Non-linear difference equation with multiple solutions.

# Multiple solutions



## Kaldor-Woodford theory of money that “rules the roost”

- Monetary economy characterized by a currency, let's say dollars, that serves as a “unit of account” and “store of value.”
- A “unit of account” is
  - 1 the *numeraire*, unit of measure to value goods and securities;
  - 2 **the liability** of an agent (and only of one agent) in the economy (central bank).

Implications:

- Price of one unit of central bank's liability is just one dollar, because that liability exactly defines what a dollar is.
- A dollar claim at the central bank is **risk-free regardless** of the resources that the central bank has in its balance sheet.
- Central bank can set independently quantity of reserves and the interest rate paid. Interest rate on reserves (by an arbitrage argument) determines any other short-term risk-less rate in the economy.
- Any other agent in the economy can issue claims **denominated** in the “unit of account”, but do not define the “unit of account” $\Rightarrow$  their debt is **risk-free provided** they are solvent.

Key point: to get determinacy should consider other equilibrium conditions.

- Exhaustion of intertemporal budget constraint of the consumer

$$\sum_{t=t_0}^{\infty} \beta^{t-t_0} c_t = \sum_{t=t_0}^{\infty} \beta^{t-t_0} (y - \tau_t),$$

- or transversality condition

$$\lim_{t \rightarrow \infty} \left\{ \beta^{t-t_0} \frac{B_t}{P_t(1+i_t)} \right\} = 0,$$

- or

$$\sum_{t=t_0}^{\infty} \beta^{t-t_0} \tau_t = 0.$$

Prices sequences that solve the non-linear difference equation can be ruled out as equilibria if they imply violations of one of the above conditions  $\Rightarrow$  it depends on the specification of  $\{\tau_t\}_{t=t_0}^{\infty}$ .

Set the following tax policy:

- 1 a real deficit at time  $t_0$ :  $\tau_{t_0} = \tau_{t_0}^* < 0$  and
- 2 a path of future real primary surpluses  $\{\tau_t\}_{t=t_0+1}^{\infty}$  with  $\tau_t = \tau_t^*$  and

$$\sum_{t=t_0+1}^{\infty} \beta^{t-t_0-1} \tau_t^* = \frac{B_{t_0}^G}{P^*}.$$

Consider that the intertemporal budget constraint at time  $t_0 + 1$  requires

$$\sum_{t=t_0+1}^{\infty} \beta^{t-t_0-1} \tau_t = \frac{B_{t_0}^G}{P_{t_0+1}}$$

It follows that:

$$\left( \frac{B_{t_0}^G}{P^*} - \frac{B_{t_0}^G}{P_{t_0+1}} \right) = 0,$$

$\Rightarrow P_t = P^*$  forever.

- **Uniqueness** of equilibrium depends on the beliefs of the consumer on the path followed by fiscal policy even off equilibrium.
- On a deflationary path ( $P_{t_0+1} < P^*$ ):

$$\sum_{t=t_0+1}^{\infty} \beta^{t-t_0-1} \tau_t^* = \frac{B_{t_0}^G}{P^*} < \frac{B_{t_0}^G}{P_{t_0+1}}.$$

- Path of primary surplus is lower than what required to pay back the outstanding obligations.
- Wealth effect on consumers creates excess demand of goods which pushes up prices.
- Need a fiscal stimulus to reflate the economy!

- How is it possible to rule out equilibria by committing to have less resources than needed?
- Consider European Monetary Union and assume  $B_t$  denotes outstanding debt of a group of countries.
- Three things can happen on a deflationary path:
  - ① Primary surpluses are adjusted, debt remains risk free  $\implies$  commitment is not credible  $\implies$  deflation is an equilibrium;
  - ② Primary surpluses are not adjusted, debt is defaulted  $\implies$  deflation is an equilibrium;
  - ③ Primary surpluses are not adjusted, debt is bought by the central bank that issues “units of accounts” at the rate:

$$\lim_{T \rightarrow \infty} \left\{ \beta^T \frac{B_T}{P_T(1 + i_T)} \right\} > 0$$

$\implies$  deflation is ruled out as an equilibrium.

- **Prescription:** to trim deflationary solutions should use the threat of a fiscal stimulus coupled with an expansion of the real liabilities of central bank.

- On an inflationary path ( $P_{t_0+1} > P^*$ ):

$$\sum_{t=t_0+1}^{\infty} \beta^{t-t_0-1} \tau_t^* = \frac{B_{t_0}^G}{P^*} > \frac{B_{t_0}^G}{P_{t_0+1}},$$

- Path of primary surpluses should exceed the amount of outstanding real obligations. Is it credible?
  - 1 Treasury may have incentive to cut primary surpluses  $\implies$  inflationary path develops;
  - 2 Treasury could backstop inflation at a price  $P_{t_0+1} > P^* \implies$  needs coordination with monetary authority if the latter follows an active interest rate rule;
  - 3 Treasury may really fulfill its commitment  $\implies$  inflationary path is ruled out.
- **Prescription:** to rule out inflationary spirals have a fiscal anchor that ties the price level at the target.

- Central bank can control the price level by relying only on its means.
- There is no need to have a fiscal stimulus nor a fiscal anchor, nor any coordination with Treasury.
- How is it possible?
  - ① Use power of central bank's liabilities that can be increased at will and be risk free in the unit of account;
  - ② Even if solvency is not an issue for central-bank liabilities, solvency, balance sheet, remittances policy matter to determine the value of the liabilities in terms of goods—the price level.
- Role of Treasury: not different from any other debtor in the economy that should be solvent or, otherwise, default on debt. Assume that Treasury's debt is always zero in what follows.

Consider central bank's flow budget constraint

$$\frac{B_t^C - X_t^C}{1 + i_t} = B_{t-1}^C - X_{t-1}^C - T_t^C,$$

with  $B_{t_0-1}^C = X_{t_0-1}^C = 0$ .

- 1 Central bank issues interest-bearing reserves,  $X_t^C$ , to invest in riskless securities,  $B_t^C$ ;
- 2 ...receives initial injection of real capital  $n_{t_0}^C$

$$-\frac{T_{t_0}^C}{P_{t_0}} = \tau_{t_0} = n_{t_0}^C;$$

- 3 ...remits nominal profits to the treasury after period  $t_0$

$$T_t^C = \Psi_t^C = \frac{i_{t-1}}{1 + i_{t-1}} (B_{t-1}^C - X_{t-1}^C);$$

- 4 ...should be free from any third-party interference asking for higher remittances or attempting to deplete central bank's resources.

Implications of above conditions:

- 1 Central bank's nominal net worth is constant over time and positive

$$N_t = N_{t-1} + \Psi_t^C - T_t^C = N_{t-1} = \dots = P_{t_0} n_{t_0}^C > 0.$$

- 2 Central bank's profits are non-negative and therefore central bank is **financially independent** from treasury

$$\Psi_t^C = \frac{i_{t-1}}{1 + i_{t-1}} (B_{t-1}^C - X_{t-1}^C) = i_{t-1} N_{t-1} = i_{t-1} P_{t_0} n_{t_0}^C \geq 0,$$

with taxes on households given by

$$\tau_t = -\frac{T_t^C}{P_t} = -i_{t-1} P_{t_0} n_{t_0}^C,$$

for each  $t > t_0$ .

## Ruling out deflationary spirals

- Assume  $P_{t_0} \leq \beta^{\frac{1}{\phi}} P^*$  and therefore economy is in a liquidity trap: i.e.  $i_t = 0$  for each  $t \geq t_0$ , then following path of taxes is implied by remittances' rule:

$$\tau_{t_0} = -\frac{T_{t_0}^C}{P_{t_0}} = n_{t_0}^C,$$

$$\tau_t = -\frac{T_t^C}{P_t} = 0,$$

for each  $t > t_0$ .

- Consider demand of goods at time  $t_0$

$$c_{t_0} = y - (1 - \beta) \sum_{t=t_0}^{\infty} \beta^{t-t_0} \tau_t,$$

$$c_{t_0} = y - (1 - \beta) n_{t_0}^C < y.$$

- Demand of goods is below supply  $\Rightarrow$  prices with  $P_{t_0} \leq \beta^{\frac{1}{\phi}} P^*$  do not clear the market.

## Ruling out deflationary spirals

Alternatively, central bank real net worth is growing unboundedly

$$\lim_{t \rightarrow \infty} \left\{ \beta^{t-t_0} \frac{N_t^C}{P_t} \right\} = n_{t_0}^C > 0$$

⇒ debt of private sector is growing unboundedly:

$$\begin{aligned} \lim_{t \rightarrow \infty} \left\{ \beta^{t-t_0} \frac{N_t^C}{P_t} \right\} &= \lim_{t \rightarrow \infty} \left\{ \beta^{t-t_0} \frac{B_t^C - X_t^C}{P_t(1+i_t)} \right\} \\ &= - \lim_{t \rightarrow \infty} \left\{ \beta^{t-t_0} \frac{B_t + X_t}{P_t(1+i_t)} \right\} > 0 \end{aligned}$$

⇒ violating the No-Ponzi condition at some point in time:

$$\frac{B_t + X_t}{P_{t+1}} \geq - \sum_{T=t}^{\infty} \beta^{T-t} (y - \tau_{t+1}).$$

- Deflationary equilibrium cannot form because the central bank is holding real resources that are needed for goods market to clear, consumption is below output  $\Rightarrow$  Central bank's net worth should be **expropriated**.
- Credibility depends on the **financial independence** of central bank. Central bank should not be subject to raids on its capital or be questioned for its remittances policy.
- Critical role of all assumptions: initial capitalization, investment in risk-less securities.
- **Prescription** to rule out deflations: set up a financially-independent central bank with initial level of real capital and restrict asset holdings to riskless securities.

## Ruling out inflationary spirals

- Maintain all previous assumptions.
- Addition: use remittances  $T_t^C = \Psi_t^C$  for each  $t_0 < t < \tilde{t}$  but then threaten to switch to a real remittances' policy after and including time  $\tilde{t}$

$$\frac{T_t^C}{P_t} = \frac{1 - \beta}{\beta} \frac{P_{t_0}}{P^*} n_{t_0}^C.$$

- Consider value of central bank at time  $\tilde{t} - 1$

$$\frac{N_{\tilde{t}-1}^C}{P_{\tilde{t}-1}} = \sum_{T=\tilde{t}}^{\infty} \beta^{T+1-\tilde{t}} \frac{T_T^C}{P_T}.$$

and substitute the path of real remittances for each  $t \geq \tilde{t}$  to obtain

$$\frac{P_{t_0}}{P_{\tilde{t}-1}} n_{t_0}^C = \frac{P_{t_0}}{P^*} n_{t_0}^C.$$

- The above equation determines  $P_{\tilde{t}-1} = P^*$  if and only if  $n_{t_0}^C \neq 0$  and therefore  $P_t = P^*$  forever.

- Implementation: central bank could sell shares of its nominal capital (each of a dollar unit value) promising a constant stream of real dividends  $(1 - \beta)/(\beta P^*)$  whose market value is  $1/P^*$ .
- If prices at time  $\tilde{t} - 1$  are above  $P^*$ , there can be arbitrage opportunities:
  - Consumers can borrow in the financial markets  $1/P^*$  unit of goods at  $\tilde{t} - 1$  and promise to pay a constant real stream  $(1 - \beta)/(\beta P^*)$ .
  - They can sell the goods for  $P_{\tilde{t}-1}/P^* > 1$  dollars.
  - They can invest one dollar in the central bank to receive a stream of dividends that exactly offset the payment to make.
  - They remain with  $P_{\tilde{t}-1}/P^* - 1$  dollars that can be used to buy goods at time  $\tilde{t} - 1$ .
  - Arbitrage opportunities are closed if and only if  $P_{\tilde{t}-1} = P^*$ .

- The central bank is committed to transferring resources by an amount that exceeds the real value of its net worth:

$$\sum_{T=\tilde{t}}^{\infty} \beta^{T-\tilde{t}+1} \frac{T_T^C}{P_T} = \frac{N_{\tilde{t}-1}^C}{P^*} > \frac{N_{\tilde{t}-1}^C}{P_{\tilde{t}-1}}.$$

- Question 1: Can the central bank at time  $\tilde{t}$  generate these resources?
  - Yes, can issue an increasing amount of reserves growing at a rate equal or higher than  $1/\beta$ .
- Question 2: Suppose that at time  $\tilde{t} - 1$  the price level is  $P_{\tilde{t}-1} > P^*$ , is it really credible to expect that the central bank follows its threat or instead will backstop prices at  $P_{\tilde{t}-1}$ ?
  - If commitment to an active interest rate rule ( $\phi > 0$ ) is credible  $\Rightarrow$  price level at time  $\tilde{t} - 1$  is either  $P^*$  or infinity. But, in the latter case (a barter economy) society will completely waste the initial real resources.  
 $\Rightarrow$  real capitalization, commitment to an active interest rate rule and other elements discussed above can anchor the price level to  $P^*$ .

- An **alternative** to rule out inflationary spirals: central bank can raise real resources in excess than what needs to pay to private sector by imposing reserve requirements on private sector's net debt paid at below market rates,

$$\frac{N_{\tilde{t}-1}^C}{P_{\tilde{t}-1}} + \sum_{T=\tilde{t}}^{\infty} \beta^{T-\tilde{t}+1} \left( \frac{i_T - i_T^r}{1 + i_T} \right) \frac{X_T^r}{P_T} = \sum_{T=\tilde{t}}^{\infty} \beta^{T-\tilde{t}+1} \frac{T_T^C}{P_T}.$$

- Can do it because it is the only institution that can credibly be the lender of last resort in the 'unit of account'.
- By this virtue, it can exert a taxation power on the financial sector.
- Therefore, can promise a stream of real payments to private sector which is less than the current real value of its net worth.

- If central bank undertakes **risky** operations, it can experience income losses.
- Under the remittances rule  $T_t^C = \Psi_t^C$  everything goes through but...
- ...if there are income losses, the treasury is supporting the central bank which then loses **financial independence**
  - ⇒ in a deflation, the treasury may feel authorized to exercise taxation power or raids on central bank.
  - ⇒ Deflations can be equilibria.

- Central bank maintains financial independence (like under the Fed's deferred-asset regime) but:
  - cannot defeat inflationary spirals since its equity may now become negative leaving no possibility to back the price level using internal resources without Treasury support;
  - if there are credit losses, a liquidity trap or deflationary spirals can also be equilibria.

- Propose an alternative theory of price determination with respect to the fiscal theory of the price level.
- Central bank can control the price level without help of the treasury or coordination!
- All ingredients discussed are not far from how modern central bank are conceived.
- Architecture of EMU may not be inconsistent with full control of price level by ECB.