Are Low Interest Rates Deflationary? A Paradox of Perfect-Foresight Analysis

Mariana Garcia Schmidt
Columbia University

Michael Woodford
Columbia University

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Interest Rates and Inflation

- First Japan, and now the US, have gone through prolonged periods of ultra-low interest rates, without this leading to high inflation or even very robust growth

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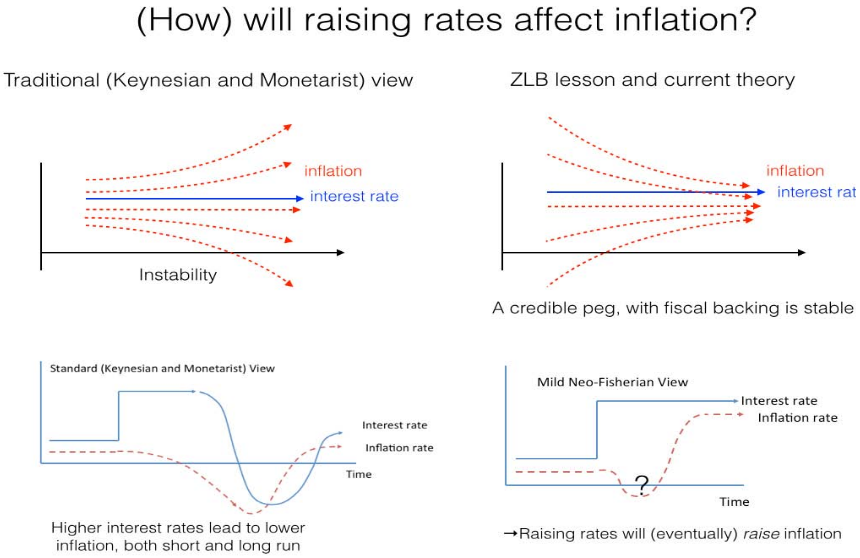
  — some (e.g., Bullard, 2010) even propose that interest rates should be **raised** in order to exit from a deflationary slump

The “Neo-Fisherian” View (Cochrane, 2015b)



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2. Can one maintain the orthodox view — that maintaining a lower nominal rate for longer should cause higher inflation and capacity utilization — while having a view of expectations that implies that central-bank commitments regarding future policy should have any effect?

Our View

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- PFE predictions are relevant only to the extent that

  - the PFE is the **limit** of an iterative process of **belief revision** (as in Evans and Ramey, 1992)
  - and this process **converges fast enough** for the limit to well approximate the outcome from a finite degree of reflection

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  — nonetheless, robust conclusions may be possible about how the outcome should be **changed** by choosing one policy rather than another

  — and these can **differ** from what a study of the **PFE** consistent with each policy would suggest

Temporary-Equilibrium Analysis in an NK Model

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[Details of temporary-equilibrium model: Woodford (2013)]

Optimal Expenditure

- Log-linearization of solution for optimal spending by household i:

$$c_t^i = \sum_{T=t}^{\infty} \beta^{T-t} \hat{E}_t^i \{(1-\beta)Y_T - \beta\sigma(i_T - \pi_{T+1}) - \beta\Delta\bar{c}_{T+1}\}$$

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  - generalizes PIH to allow for non-constant desired path of spending owing to

    (i) real interest-rate variation, or

    (ii) transitory variation in urgency of spending $\bar{c}_t$

Optimal Expenditure

- Can summarize relevant expectations of i by a single variable:

$$c_t^i = \ldots + \beta \hat{E}_t^i v_{t+1}^i$$

where

$$v_t^i = \sum_{T=t}^{\infty} \beta^{T-t} \hat{E}_t^i \{(1-\beta)Y_T - \sigma(\beta i_T - \pi_T) - (1-\beta)\bar{c}_T\}$$

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- Hence aggregate demand depends on a measure of average subjective expectations

$$e_{1t} \equiv \int \hat{E}_t^i v_{t+1}^i di$$

Aggregate Demand ("IS Equation")

- Then defining aggregate demand

$$Y_t = \int_i c_t^i di$$

and output gap $y_t \equiv Y_t - Y_t^n$, individual decision rules aggregate to AD relation

$$y_t = \rho_t - \sigma i_t + e_{1t}$$

where $\rho_t \equiv \bar{c}_t - Y_t^n$ collects exogenous terms

Price Adjustment

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- Calvo-Yun model of staggered price adjustment [fraction α of prices not reconsidered each period, automatic price increases at target rate π^* between adjustments]
- Log-linear approximation [around steady state with inflation π^*] to optimal price-setting:

$$p_t^{*j} = (1-\alpha\beta)\sum_{T=t}^{\infty}(\alpha\beta)^{T-t}\hat{E}_t^j[p_T + \xi y_T - \pi^*(T-t)] - (p_{t-1} + \pi^*)$$

where p_t is (log) price index, p_t^{*j} is j's estimate of optimal (log) price relative to average unadjusted price $p_{t-1} + \pi^*$

Aggregate Supply ("AS Equation")

- Implied AS relation:

$$\pi_t = \kappa y_t + (1-\alpha)\beta\, e_{2t}$$

where π_t is inflation in excess of the target π^*,

$$\kappa \equiv \frac{(1-\alpha)(1-\alpha\beta)\xi}{\alpha} > 0,$$

and

$$e_{2t} \equiv \int \hat{E}_t^j p_{t+1}^{*j} dj$$

measures average expectations of another composite variable

Complete 3-equation TE Model

$$y_t = \rho_t - \sigma i_t + e_{1t}$$

$$\pi_t = \kappa y_t + (1-\alpha)\beta\, e_{2t}$$

and a monetary policy rule, such as

$$i_t = \bar{\imath} + \phi_\pi \pi_t + \phi_y y_t$$

- System to determine TE paths of $\{y_t, \pi_t, i_t\}$ given paths for expectations $\{e_{1t}, e_{2t}\}$ and exogenous disturbances $\{\rho_t\}$

  — regardless of how expectations are determined

Perfect Foresight Analysis

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- Then eq'm relations can equivalently be written

$$y_t = y_{t+1} - \sigma(i_t - \pi_{t+1}) - \Delta\rho_{t+1} \qquad [\text{“NK IS”}]$$

$$\pi_t = \kappa y_t + \beta\pi_{t+1} \qquad [\text{“NKPC”}]$$

Perfect Foresight Analysis

- Case of monetary policy that fixes interest rate $i_t = \bar{\imath}$ indefinitely:
  - one-parameter family of solutions to PFE equations (indexed, for example, by value of π_0) with the property that inflation and output gap remain bounded for all t
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  - **all** of these solutions converge asymptotically to the constant-π steady state with nominal interest rate $\bar{\imath}$
- This long-run inflation rate is **lower** the lower is $\bar{\imath}$
  - thus one can argue that permanently maintained low i must (at least eventually) bring about correspondingly low π

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- But is this a reasonable view of what should follow from intertemporal optimization, and an ability to reason about the implications of the central bank's policy commitments for future economic outcomes?

Bounded Rationality

- Suppose beliefs are revised through an iterative process:
  - given any sequences $\{e_t\}$ describing the evolution of average expectations, and a specification of monetary policy, the TE relations deliver implied sequences $\{\pi_t, y_t, i_t\}$
  - these imply sequences $\{e_t^*\}$ of **correct expectations,** the result of a mapping $e^* = \Psi(e)$

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  - these imply sequences $\{e_t^*\}$ of **correct expectations,** the result of a mapping $e^* = \Psi(e)$
  - define a continuous updating rule for beliefs

$$\dot{e}_t(n) = e_t^*(n) - e_t(n)$$

where the continuous variable n indexes how far along the revision process is; $\dot{e}_t$ is the derivative of e_t with respect to n; for each n, $e^*(n) = \Psi(e(n))$

— starting from some (relatively naive) initial specification $\{e_t(0)\}$ of the evolution of average beliefs

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  - and if the process converges, the particular fixed point to which it converges **also** answers the question about equilibrium selection, left open by the mere conjecture that outcome should be a PFE

  - but if the process **doesn't converge,** the PFE prediction may be quite different from what this model of expectation formation would imply, even if the process of reflection is carried quite far

Bounded Rationality

- Even when the process of belief revision converges, if **convergence is slow,** the PFE prediction may still not be too relevant

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- If slow convergence or non-convergence: the relevant model prediction should be the **set** of possible paths for the economy's evolution corresponding to some not-too-extreme range of possible specifications of $e(0)$, and a range of possible finite values of n

Case of Temporary Fixed Interest Rate

- Suppose that for all $0 \leq t < T$, $\quad i_t = \bar{\imath}$ regardless of inflation or output

  — but reversion to "normal" policy (Taylor rule) for all $t \geq T$

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  - question: to what extent can increasing the **length of commitment** substitute for possibility of deeper immediate interest-rate cut?

Numerical Illustrations

Parameter values used in numerical illustrations:

- Model parameters are those used in Denes, Eggertsson and Gilbukh (2013), which allow a ZLB episode similar to the US Great Recession, in the case of a suitable exogenous shock:

$$\alpha = 0.784, \quad \beta = 0.997, \quad \sigma^{-1} = 1.22, \quad \xi = 0.125$$

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- Temporary policy: $i_t = \bar{\imath}$ for dates $0 \le t < T$ corresponds to nominal rate of zero (in un-transformed variables)

Results: Temporary Fixed Interest Rate

1. TE paths converge to the PFE paths for inflation, output and interest rates, as $n \to \infty$

   — specifically, to the unique PFE paths with property that each of these variables remains **bounded** for $t \to \infty$

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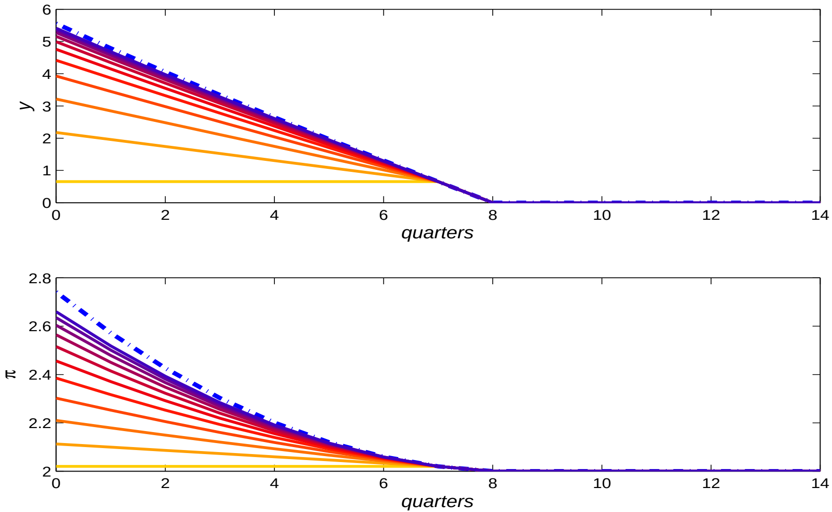

TE paths for $n = 0 - 4$, if at ZLB for 8 quarters

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     - and assuming commitment is not for too long a horizon T
   - analysis does **not** support selection of "backward stable" solution (Cochrane, 2015a) as prediction of the model

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   - In this case, TE analysis implies forward guidance should be **less powerful** than the PFE analysis (with conventional equilibrium selection) would imply

     — though still quite powerful (indeed, implausibly so...)

     — and much more powerful than PFE analysis with Cochrane (2015a) equilibrium selection would imply

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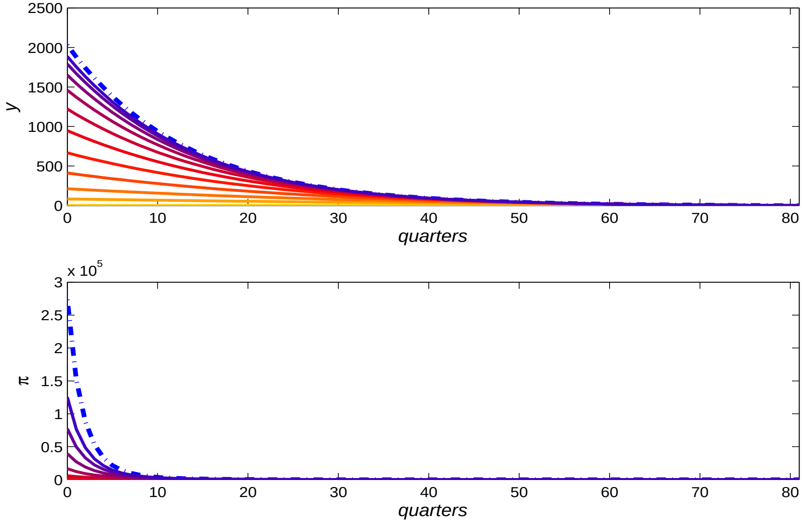

TE paths for $n = 0 - 20$, if at ZLB for 20 years

Results: Temporary Fixed Interest Rate

- Moreover, in the fixed-i case, there is **no finite n** for which TE dynamics and PFE dynamics are similar **for all values of T**
  - for any finite n, the TE responses are **the same** for all large enough T (and so remain **bounded** as $T \to \infty$)
  - instead, the PFE responses (under the conventional eq'm selection) grow explosively as T is made large

Results: Temporary Fixed Interest Rate

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  - instead, TE analysis for finite n avoids the unreasonable prediction

  - but **not** because it's like "backward stable" PFE!

    — the conventional PFE solution is accurate for small T

    — and **no** PFE solution is accurate for large T

Permanently Fixed Interest Rate

- What if interest rate is expected to be fixed **indefinitely?**
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  - and for no n are they similar to **any** of the PFE solutions

Permanently Fixed Interest Rate

- If we let $R^n(T)$ be the vector of responses when commitment is for T periods and belief revision continues to level n, then

$$\lim_{T\to\infty} R^n(T) \;=\; R^n(\text{permanent}) \qquad \text{for any finite } n$$

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- But the limits

$$\lim_{n\to\infty} \lim_{T\to\infty} R^n(T), \qquad \lim_{T\to\infty} \lim_{n\to\infty} R^n(T)$$

both **diverge**

— neither converges to **any** of the PFE solutions under assumption of permanently fixed rate

Permanently Fixed Interest Rate

- Hence consideration of the set of PF equilibria is especially misleading in the (somewhat artificial) thought experiment of a permanent interest-rate peg

  — a case in which none of the PFE paths approximate TE paths for finite n, even for very large n

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- What would we conclude about the consequences of such a commitment if, instead, we use TE analysis for some finite (though possibly high) value of n?

Results: Temporary Fixed Interest Rate

3. Effects of **increasing length of time** at which one expects to remain at ZLB (by some **finite** amount):

   - as in the PFE analysis **with conventional eq'm selection** (not Cochrane's), this should increase output and inflation immediately

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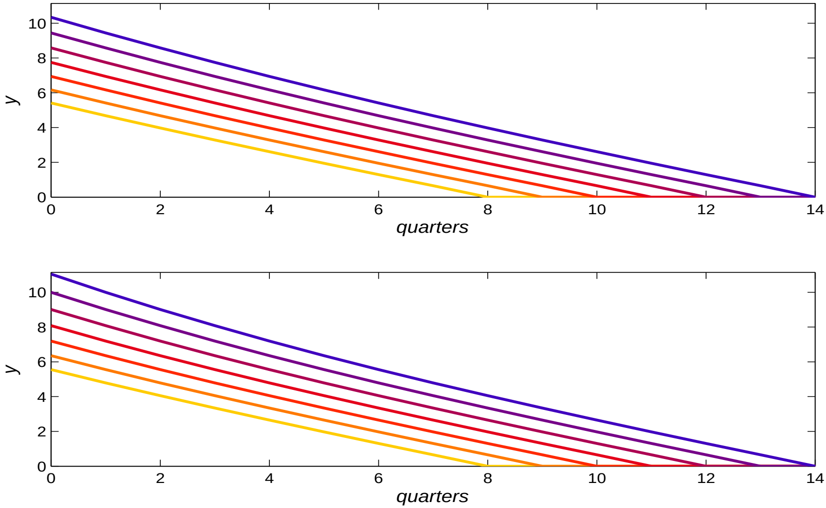
    - as in the PFE analysis **with conventional eq'm selection** (not Cochrane's), this should increase output and inflation immediately
    - for large enough n, predictions of TE analysis are similar to PFE predictions (with this eq'm selection)
    - but even for **smaller** $n > 0$, predictions are **qualitatively** like PFE predictions (with this eq'm selection)

Effects of Increasing Length of Commitment



varying T from 8-14 quarters; top: $n = 4$, bottom: PFE

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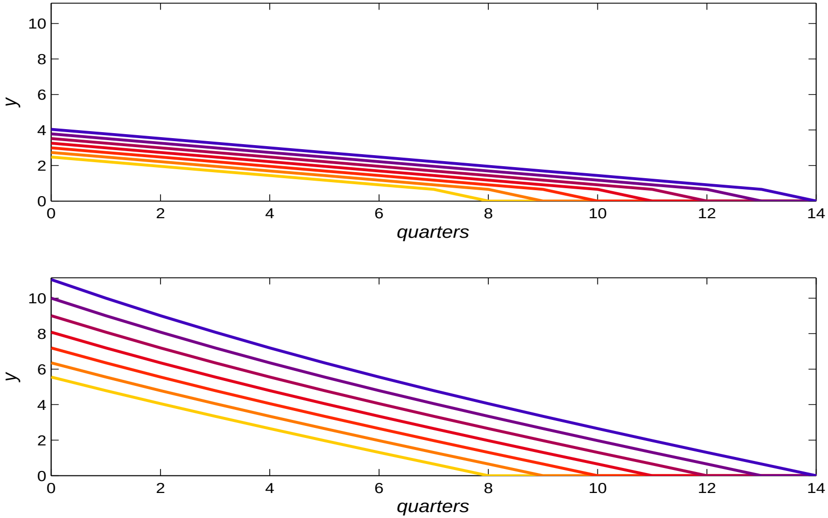

varying T from 8-14 quarters; top: $n = 0.5$, bottom: PFE

Effects of Increasing Length of Commitment

- Where the conventional PFE analysis of effects of forward guidance is less reliable: in its implication that further lengthening of time expected to remain at ZLB should be able to increase output and inflation effects **without bound**

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  - PFE predictions for larger T are progressively less reliable, as the size of n required for them to be approximately correct grows and grows

  - in fact, for any finite n, TE analysis implies **bounded** effects, no matter how large T is made

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  - the finite-T PFE analysis, however, represents an **upper bound** on the size of effect that one can plausibly expect
  - and the larger T is, the more reason to doubt that the effect should be as large as predicted by the PFE analysis
- Especially for larger values of T, the approach recommended here leads only to a **set** of possible predictions for a given policy
  - but this still allows **qualitative** conclusions that remain very useful for practical policy analysis
  - and insisting on PFE analysis simply because it makes more sharply defined predictions may lead to large errors