Stablization Policy when Planning Horizons are Finite

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Rational Expectations and Policy Analysis

- The conventional approach to assessing the projected effects of alternative monetary policies assumes **rational expectations equilibrium:**

  — in the case of any hypothetical policy, one asks what dynamics one's model predicts, on the assumption that everyone **expects exactly the dynamics predicted by the model**

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- But obviously a rather heroic assumption, especially in the case of **novel policies,** with which people would have had little prior experience (as with recent experiments with "forward guidance")

Finite-Horizon Planning

- Here show the possibility and importance of relaxing the strong assumptions of REE analyses of DSGE monetary models in one respect: the assumption that agents formulate **complete infinite-horizon state-contingent plans** that are optimal, under a correct understanding of how the economy will evolve [according to one's model]

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- This is surely not feasible in practice, no matter the extent to which one may assume agents are **motivated** and **experienced**

  — for example, even in artificial environments where set of feasible moves from any position is finite (e.g., chess or go), not even the best professional players (human or AI) can **solve the game by backward induction,** and simply execute the optimal strategy

Finite-Horizon Planning

- What the best programs (DeepMind, AlphaGo) actually do: each time one must move,

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4. **select** the move with highest estimated value

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  — because even with advances in parallel computing [and even in these highly structured environments!], exhaustive tree search is too costly

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- Why do **any** forward planning at all?

  — because it is not feasible to learn and store an **exact** value function [the one that could be calculated, in principle, by backward induction]

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- Design trade-off:
  - *forward planning* allows use of **fine-grained information** about specific situation: because only undertaken for a given situation when it occurs — but **cost** grows explosively with planning horizon
  - *value function* **inexpensive** to apply (once learned), but only practical to learn to value **coarse description** of situation

Finite Planning Horizons in a Macro Model

- Illustration of how this approach can be used in macro modeling: consider the spending/saving decision of households

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- As in basic NK model, a single asset: riskless short-term nominal debt (yield i_t on which will be CB's policy instrument)

- Flow budget constraint of household i:

$$b^i_{t+1} \; = \; (1 + i_t)\left[b^i_t(P_{t-1}/P_t) + y_t + T_t - c^i_t\right]$$

where b^i_t is nominal debt maturing at date t, deflated by **period $t-1$ price level,** so that it is a **predetermined real variable**

— value of b^i_{t+1} is known as a result of choices at date t, though real purchasing power of that future wealth will depend on **expectations** about inflation between t and $t+1$

Household with k-Period Planning Horizon

- Household i problem in period t: choose spending plan $\{c^i_\tau(s_\tau)\}$ for periods $t \leq \tau \leq t+k$ to maximize

$$\hat{\mathrm{E}}^i_t \sum_{\tau=t}^{t+k} \beta^{\tau-t} u(c^i_\tau) + \beta^{k+1} v(b^i_{t+k+1}; s_{t+k})$$

subject to constraints

$$b^i_{\tau+1} = (1+i_\tau)\left[b^i_\tau(P_{\tau-1}/P_\tau) + Y_\tau + T_\tau - c^i_\tau\right]$$

for all $t \leq \tau \leq t+k$,

- Here $v(b^i_{\tau+1}; s_\tau)$ is the **value function** used to evaluate possible situations in a terminal state s_τ

Decisions with a Finite Planning Horizon

- Expectations about periods $t \leq \tau \leq t + k$ used in planning exercise:
  - **deduced from structural equations of model** (including monetary/fiscal policy rules) for periods t through $t + k$
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  - but no consideration of branches **beyond horizon** $t + k$ means aggregate conditions in period $t + j$ assumed to be determined by decisions of people who plan **only** $k - j$ **periods ahead**
- Just as household models **own** behavior in future period $t + j$ as if will only have horizon of length $k - j$ then, models all **other households and firms** as optimizing, but only having horizons of length $k - j$ in period $t + j$

Equilibrium with a Finite Planning Horizon

- Let Y_t^j, Π_t^j, i_t^j be the (counterfactual) output, inflation, and nominal interest rate in the case that all had a planning horizon of $j \geq 0$ periods; then **Euler equation** of representative household requires that for any $j \geq 1$,

$$u'(Y_t^j) \;=\; \beta(1 + i_t^j + \Delta_t)\, \mathrm{E}_t[u'(Y_{t+1}^{j-1})/\Pi_{t+1}^{j-1}]$$

while for $j = 0$,

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- Since can solve equations for behavior of households with **any** planning horizon j, can also derive dynamics of aggregate spending in the case of an arbitrary **distribution of planning horizons** in population: simply define $Y_t \;=\; \sum_j \omega_j Y_t^j$

Equilibrium with a Finite Planning Horizon

- Can similarly analyze finite-horizon version of the problem of a price-setting firm
- Similarly obtain a **recursive system** of FOCs:
  - equation for Π_t^0 depends only on Y_t^0
  - equation for Π_t^1 depends on Y_t^1, and **[model-consistent!]** expectations regarding Π_{t+1}^0, Y_{t+1}^0
  - and so on, for progressively longer planning horizons

Equilibrium with Finite Planning Horizons

- Given evolution of the value functions [to specify below], complete system of structural equations are then:
  - Euler equations above
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  - FOCs for inflation dynamics
  - equations specifying the monetary/fiscal policy regime

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- A **finite** system of equations, with a **recursive** structure, for any assumed planning horizon k — or any distribution of planning horizons — for which we wish to analyze the predicted dynamics

Modeling Value Function Learning

- Similar to proposal of Evans and McGough (2018):
  - each period, DM undertakes a forward-planning exercise using currently **assumed** value function $v_t(\cdot)$
  - in addition to choosing current action, also estimates her discounted objective function, given current situation
  - can also calculate what estimate of objective **would** have been under counter-factual values for individual state variables [e.g., real wealth] $\Rightarrow$ computes an **estimate** of the value function $v_t^{est}(\cdot)$ implied by forward planning

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  - if $v_t^{est}(\cdot)$ differs from assumed $v_t(\cdot)$, DM **adjusts** her assumed value function:

$$v_{t+1} = v_t + \gamma \left[v_t^{est} - v_t \right]$$

for some gain parameter $0 < \gamma \leq 1$

Applications of the Framework

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   — "neo-Ricardian" conclusions from RE models

3. Assessing advantages of **price-level targeting** over inflation targeting

4. Reconsidering role of **fiscal transfer policies** as a tool of stabilization when monetary policy constrained by the ZLB

   — simple RE models imply "Ricardian equivalence"

Application 1: A Source of Inertial Dynamics

- The model predicts effects similar to those of a **"hybrid New Keynesian model":**
  - weaker forward-looking effects than under RE
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  - weaker forward-looking effects than under RE
  - **intrinsic inertia** in both aggregate expenditure and inflation

- But provides clearer choice-theoretic foundations for these (econometrically supported) features of many empirical NK models

  — without any resort to model features such as "habit" preferences, costs of adjusting rate of spending, or automatic indexation of wages or prices to lagged inflation, that lack support from studies of individual behavior

Implications: Effects of a Monetary Policy Shock

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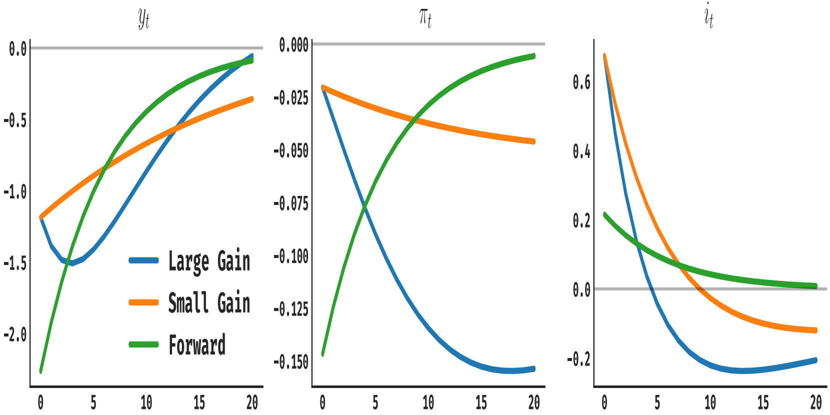
- Example of implications: dynamic effects of a **monetary policy shock** [exogenous transitory shift in intercept of CB reaction function]
  - effects no longer strongest at the time of the shock, as in simple NK model with **rational expectations**
  - simple model often criticized as "excessively forward-looking"

Implications: Effects of a Monetary Policy Shock



rational expectations versus finite horizon (mean $h = 2$ quarters)

alternative gain parameters: $\gamma = 0.05$ versus $\gamma = 0.5$

[from Gust, Herbst, and López-Salido (2019)]

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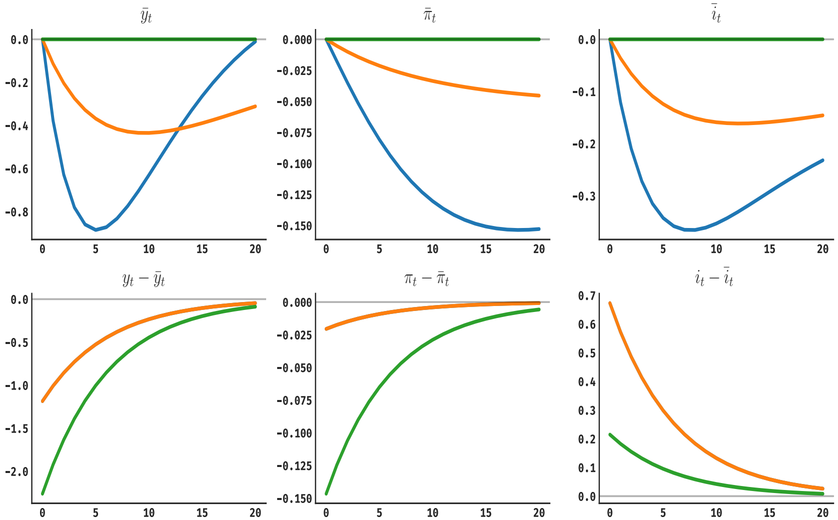

decomposition of responses: top = due to value function adjustment

bottom = due to changing assumptions used in forward planning

Implications: Inertial Dynamics

- Gust *et al.* (2019) fit 3-equation model from Woodford (2019) to US time series for output, inflation, and nominal interest rate over period 1966-2007

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- US monetary policy over entire period fit with a reaction function with constant inflation target, constant coefficients; but distinct responses to "trend" and "cyclical" variations in inflation and output gap
  - response to deviations of inflation from target: **strong** ($\bar{\phi}_\pi > 2$) if "trend", **weak** ($0 < \phi_\pi < 1$) if merely "cyclical"
  - response to output gap: essentially **zero** if "trend", **positive** if merely "cyclical"

Application 2: Effects of Forward Guidance

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- In RE analyses (e.g., Eggertsson and Woodford, 2003), should be a powerful tool for additional stimulus, if announcement is a credible commitment

  — but this conclusion obviously depends on people being able to **calculate** how future dynamics of economy should be different as a result of novel policy commitment

Effects of Forward Guidance

- With finite-horizon planning: commitment should still have stimulative effect [if sufficient number have horizons long enough for policy after ZLB ceases to bind to be relevant]

  — but effect is **smaller** than in RE analysis, especially in the case of a **long-lasting** commitment

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- Predicted effect remains **bounded** as termination date of policy is pushed indefinitely into the future: because no effect of commitments about policy beyond anyone's current planning horizons

  — eliminates the implausible predictions of RE models discussed in the literature on "the forward guidance puzzle" (Del Negro *et al.*, 2013; McKay *et al.*, 2016).

Can Low Interest Rates Be Deflationary?

- Finite-horizon analysis also eliminates one of the most paradoxical conclusions from RE analysis: the “Neo-Fisherian” conclusion that a commitment to maintain low nominal interest rates **forever** would have to **reduce inflation,** rather than increasing it

  — key idea: at least in the long run, should approach a stationary equilibrium consistent with the **Fisher equation,** so that lower nominal interest rate in long run would require inflation to be correspondingly lower

  — used by some to argue that committing to keep nominal interest rates low is exactly the wrong policy to get out of a low-inflation trap

Can Low Interest Rates Be Deflationary?

- With finite-horizon planning: commitment to keep nominal interest rates lower for longer **must** be expansionary/inflationary [to extent that it changes beliefs at all]

  — and effect is similar [only modestly stronger] even in case of a commitment to keep rates low **forever**

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- As time passes under the new regime: continued experience of outcomes systematically different than under old regime should lead to **adjustment of value functions**

  — but these adjustments are in a direction that only makes the new monetary policy **even more expansionary** over time (Woodford, 2019)

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- In the model, if dynamics converge to a long-run steady state, it must satisfy the Fisher equation

  — but under the policy of fixing the nominal interest rate at some level forever, regardless of how inflation and output evolve, dynamics are **unstable**

  — and as a consequence, expectations remain **forever out of line** with the actual dynamics

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  - the change in policy is not expected to **last too long,** relative to the length of most people's planning horizons
- But RE analysis can instead lead to **dramatically different** conclusions in some cases: such as the thought experiment of committing to a fixed nominal interest rate for a very long time (as in the literature on forward guidance paradoxes)

Application 3: Price-Level Targeting

- Since the financial crisis of 2008, increased discussion of possible advantages of **price-level targeting** (PLT) as a framework for monetary policy

  — similar implications as a conventional inflation target, when policy is able to keep inflation close to the target at all times

  — but importantly different when monetary policy is sometimes constrained by **lower bound** on nominal interest rates

Application 3: Price-Level Targeting

- If inflation is allowed to undershoot target during a period when ZLB binds, conventional (forward-looking) IT implies that one simply continues to aim at usual inflation target, once again feasible to hit it

  — PLT would instead require a temporary period of **higher inflation** to "catch up" to the target price-level path

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  — PLT would instead require a temporary period of **higher inflation** to "catch up" to the target price-level path

- In RE analyses (e.g., Eggertsson and Woodford, 2003), anticipation of "catch-up" can have powerful stimulative effects during period while ZLB still binds

  — but how dependent are these conclusions on implausibly forward-looking thinking?

A Simple Case

Consider the effects of alternative monetary policies under the following scenario:

- At $t = 0$, unexpected shock occurs, creating a **wedge** $\Delta > 0$ between the return on **safe assets** [balances held at CB] and other assets [“shock to safe asset demand”]

  — as a result of which nominal return on safe assets required in steady state is now $r^* + \pi^* - \Delta < 0$

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  — as a result of which nominal return on safe assets required in steady state is now $r^* + \pi^* - \Delta < 0$

- Once economy enters this **"crisis state,"** there is a probability $0 < \delta < 0$ each period that crisis state continues in following period

  — otherwise, economy reverts to **"normal state"** in which financial wedge is again zero, and is expected to be zero **forever after** [2-state Markov chain for financial wedge]

Effect of the Shock under Inflation Targeting

- First consider what should happen when the crisis occurs, if there is **no change** in either fiscal or monetary policy

  — monetary policy specified by a **strict inflation target:** inflation rate π^* maintained as long as consistent with the ZLB

  — i_t held at zero as long as inflation undershoots the target

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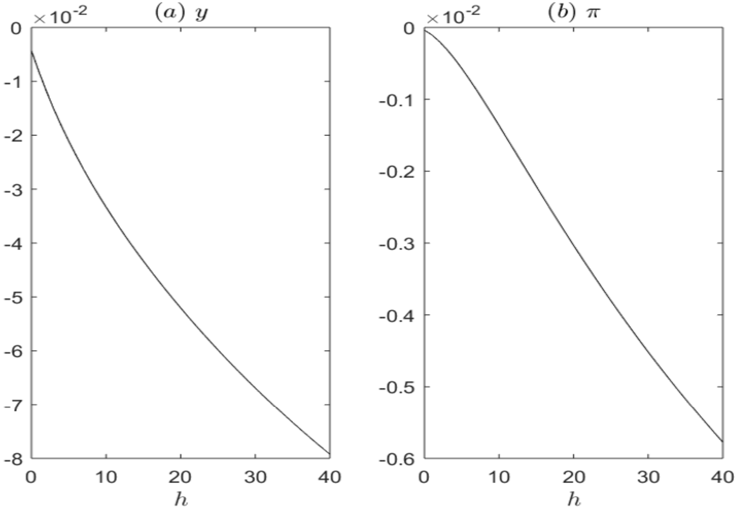
- Regardless of planning horizon h, solution is **Markovian:** constant inflation rate $\underline{\pi} < 0$, output $\underline{y} < 0$, as long as crisis state continues; return to the target inflation rate and associated output level as soon as fundamentals revert to normal state

  — but with finite planning horizons, contraction/deflation **not as severe**

Output, Inflation in Crisis State



constant levels as function of planning horizon h

PLT: Ad Hoc Commitment vs. a Policy Rule

- In considering what PLT can achieve, it's important to distinguish between two cases:

  1. an **ad hoc** commitment (after unexpected crisis arises) to deviate from usual inflation target temporarily, until previously expected price-level path is regained

     — but once the shortfall has been made up, return to usual IT regime [with no commitments about policy during future crises before they arise]

     — Bernanke *et al.* (2019) call this "temporary PLT"

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  2. commitment to a **PLT rule** at all times, even if it only differs significantly from IT during crises that cause ZLB to bind

PLT: Ad Hoc Commitment vs. a Policy Rule

- Under RE analysis, the effects of these two policies on equilibrium during crisis are **the same** [at least to a linear approximation, allowing decomposition of dynamics into separate effects of independent shocks]

- Hence greater appeal of TPLT to policymakers who would prefer not to "tie the hands" of future policymakers

Effect of an Ad Hoc Price-Level Target

- Essentially, a form of **forward guidance**

  — though the time period for which the CB commits to keep interest rate low is **endogenous** (depends on time taken for price level to reach pre-specified target path)

- As with date-based FG policies discussed above, shorter planning horizons $\Rightarrow$ weaker effects of such a commitment on aggregate demand

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- Nonetheless, such policies can provide an effective form of stimulus, even when horizons are finite [if not **too** short]

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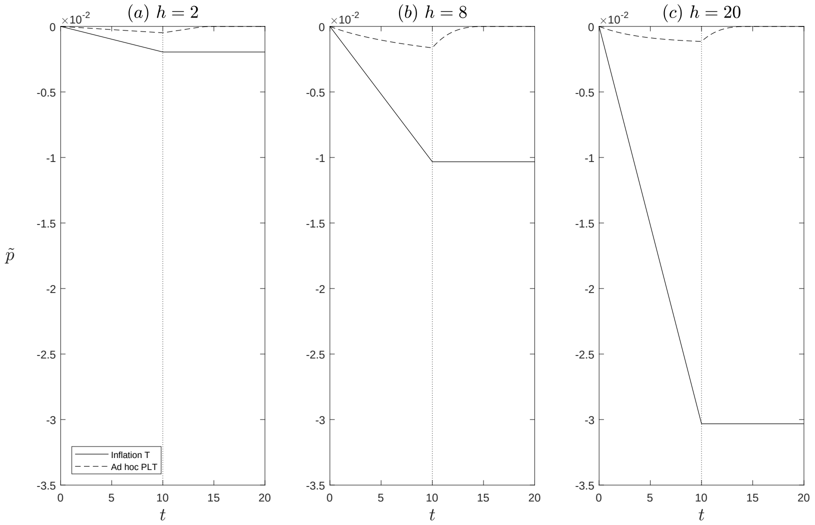

price-gap dynamics with reversion to normal state after 10 quarters

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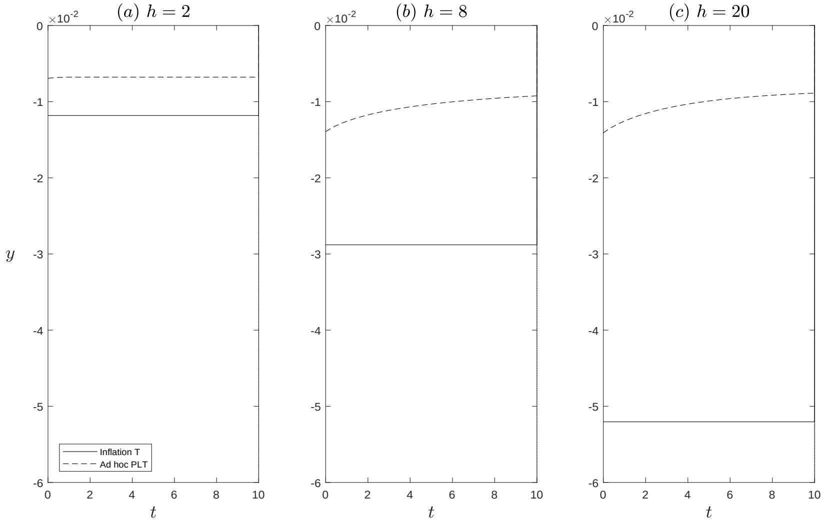

output-gap dynamics under same assumptions

Ad Hoc Commitments vs. Policy Rules

- An important difference between REE analyses of forward guidance and those assuming only a finite planning horizon: under REE analysis, dynamics are **the same** under a commitment that requires interest rates to remain low until price level regains the target path

  — whether this is an ad hoc commitment, made only after the shock is realized, or required by a systematic PLT rule

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- With finite-horizon planning, there is instead an important difference, no matter how credible the ad hoc commitment might be: pursuit of a different policy systematically, outside of crisis periods, can allow **learning of different value functions** by households and firms, that then matter for behavior during a crisis

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- Then, as a result of experience during normal times, households and firms can **learn a value function** appropriate to the PLT regime:

  — one that makes estimated continuation value a function of P_{t+k}/P^*_{t+k}, where P^*_τ is the (deterministic) price-level target path

  — Woodford and Xie (2019) assume that the function learned is the one that is correct under the PLT regime [stationary equilibrium with financial-crisis shocks]

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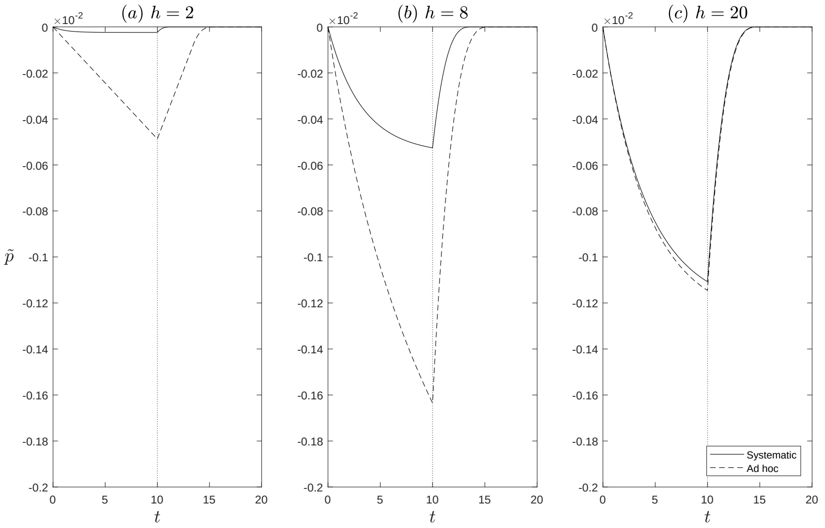

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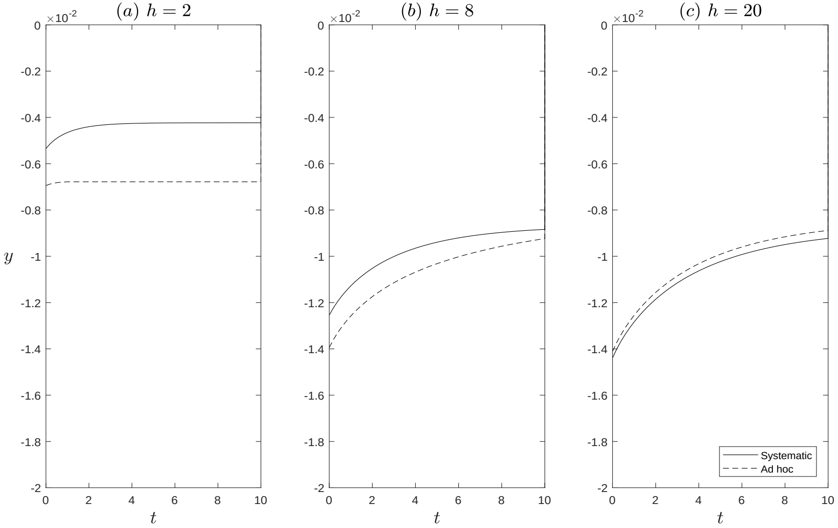

output-gap dynamics under same assumptions

Ad Hoc Commitments vs. Policy Rules

- Some might suppose that recognizing limitations on people's ability to correctly anticipate future consequences of a new policy should **reduce the benefits from policy commitment** — and hence favor a purely **discretionary** approach to policy

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- Instead, in this analysis, recognizing that planning horizons may not be too long reduces the predicted efficacy of **ad hoc commitments** in response to a special situation

  — strengthening the case for seeking to design regimes that apply all the time, but that also have desirable properties when a rare financial shock occurs

Application 4: Countercyclical Fiscal Policy

- The global financial crisis also led to renewed interest in use of "fiscal stimulus" packages as tool of stabilization policy

- The academic literature in response has largely focused on effects of countercyclical **government purchases** — because simple RE NK models imply that lump-sum transfers should have no effect, owing to **Ricardian equivalence**

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- Actual "fiscal stimulus" packages in response to crisis largely **transfers,** so important to assess their potential role

  — and "Ricardian equivalence" depends on correctly understanding the implications of an **ad hoc** policy change, **very far** into the future (since adjustments of tax policy may take decades)

Breaking Ricardian Equivalence

- Simple class of policies to consider: real public debt $\{b_{t+1}\}$ an exogenous (but possibly state-contingent) process

  — allow level of public debt to respond to changes in the size of **financial wedge**

  — government budget adjustments required to achieve this public debt path through variation in **lump-sum transfers**

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- Eq'm conds for household spending are then: for any $j \geq 1$,

$$u'(Y_t^j) \; = \; \beta(1 + i_t^j + \Delta_t)\, \mathrm{E}_t[u'(Y_{t+1}^{j-1})/\Pi_{t+1}^{j-1}]$$

while for $j = 0$,

$$u'(Y_t^0) \; = \; \beta(1 + i_t^0 + \Delta_t)\, v'(b_{t+1}^0)$$

Breaking Ricardian Equivalence

- Why RE fails: here we assume a definite rule for how any increased fiscal transfer now changes future tax collections, and assume that everyone understands it [debatable in practice!]; and we assume that this knowledge **is** used in households' forward planning **over their finite planning horizon**

  — but that households continue to use their usual value function $v(b^i_{t+k+1})$ for personal asset position at truncation: do **not** take into account fact that higher outstanding public debt at truncation should imply more taxation later

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- Thus a policy change that increases predictable real public debt at the end of currently active households' planning horizons increases the extent to which they over-estimate the amount that they can afford to spend $\Rightarrow$ increases aggregate demand

Increased Possibility for Stabilization

- Suppose that monetary policy has i_t track variation in r_t^n, when this is not prevented by the ZLB; and i_t as low as possible, when ZLB binds

  — if $b_t = 0$ at all times, this implies complete inflation and output-gap stabilization, as long as ZLB never binds

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- Let $\tilde{\Delta}_t \equiv \max(\Delta_t - (r^* + \pi^* - \underline{i}),\ 0)$ measure the part of the financial wedge **not offset** by interest-rate reduction

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- Finally, consider the case of an exponential distribution of planning horizons, $\omega_j = (1-\rho)\rho^j$ for all $j \geq 0$ for both households and firms, which facilitates aggregation of the decision rules

Increased Possibility for Stabilization

- Log-linearized equilibrium conditions:

$$
\begin{aligned}
y_t &= -\sigma\left[\tilde{\Delta}_t - \rho \mathrm{E}_t \pi_{t+1}\right] + \rho \mathrm{E}_t y_{t+1} + (1-\rho)(1-\beta) b_{t+1} \\
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- Finite planning horizons have two consequences:

  1. lower weight on forward-looking terms in both equations
  2. positive effect of public debt on aggregate demand

— standard NK model equations recovered in the limiting case $\rho \to 1$

Increased Possibility for Stabilization

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- It is now possible to **completely stabilize** both aggregate inflation and aggregate output (achieve $\pi_t = y_t = 0$ at all times), through appropriate expansion of public debt (through lump-sum transfers) in response to large increases in financial wedges

— fiscal policy needed is

$$b_{t+1} = \frac{\sigma}{(1-\rho)(1-\beta)} \tilde{\Delta}$$

Why Forward Guidance Still Matters

- It might seem from this result that central bank can simply commit to **pursue usual inflation target,** to extent allowed by ZLB, with **fiscal authority** responsible for supplying sufficient aggregate demand to ensure that the required interest rate is always non-negative

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- This would be a mistake: in eq'm with complete aggregate stabilization, monetary policy rule fixes i_t as function of exogenous state, **regardless** of the inflation that this may involve

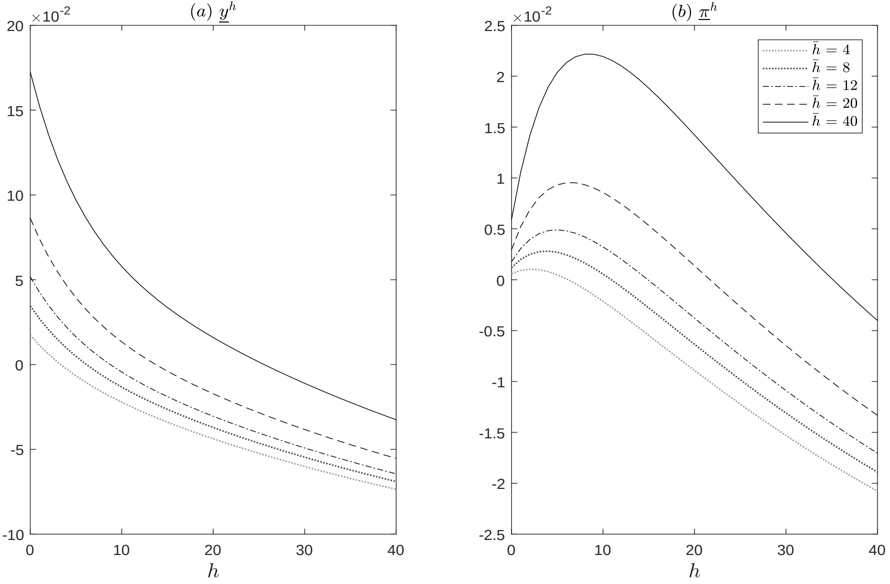
  — and while aggregate inflation is zero in equilibrium, the forward plans of agents generally involve positive probability of **inflation overshooting** the long-run target π^*

Why Forward Guidance Still Matters

- Example: consider again the case in which $\tilde{\Delta}_t$ follows a 2-state Markov process; under proposed policy, equilibrium is again Markovian

— as long as "crisis" persists, households with horizon k spend $\underline{y}_k$ and firms with horizon k increase prices at rate $\underline{\pi}_k$

Heterogeneous Responses



responses as a function of planning horizon h

Why Forward Guidance Still Matters

- Firms with short horizons increase prices at rate above π^* during the crisis, under this policy

  — which means that both households and firms with short horizons **expect inflation** above π^* with positive probability in the next period

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- If instead CB is understood to be committed to **prevent inflation overshooting,** the scope for stabilization through fiscal transfers is limited, no matter how large the transfers (Woodford and Xie, 2019)

Why Forward Guidance Still Matters

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- Moreover, the "complete stabilization" policy above isn't really optimal: with heterogeneous planning horizons, welfare depends on the **dispersion** of spending y_t^k and inflation π_t^k across units with different horizons, not just aggregate y_t and π_t

  — one can do better with a policy that commits to continued (temporary) fiscal and monetary policy expansion **even after** financial wedges return to normal (Woodford and Xie, 2020)

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- Optimal policy requires commitment to future monetary accommodation of fiscal stimulus, even though it would then be possible to achieve complete stabilization with a balanced budget