Is There a Forward Guidance Puzzle?

Francesco Bianchi
Johns Hopkins University,
NBER, and CEPR

Leonardo Melosi
University of Warwick,
Chicago FRB, and CEPR

Giovanni Nicolò
Federal Reserve Board

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Introduction

In standard New Keynesian (NK) models, announcements about the future path of the policy rate can lead to the so-called forward guidance puzzle (Del Negro et al., 2012):

- The effects of forward guidance grow boundlessly the further into the future the announced monetary policy shock is implemented.

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The literature typically attributes the sources of the forward guidance puzzle to:

- Excessive sensitivity of consumption to interest-rate changes
  - Del Negro et al. (2023), McKay et al. (2016), Werning (2015); Gabaix (2020).
- Front-loading associated with NK Phillips Curve
  - Carlstrom et al. (2015), Kiley (2014).

This paper

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- The key to proving these results is a representation theorem
  - ⇒ a method to assess if forward guidance is consistent with equilibrium uniqueness
  - ⇒ a method to model recurrent, time- or state-dependent forward guidance
    - ⇒ enabling alt sims to assess the effects of hawkish or dovish communications

The origin of the puzzle

A simple NK model with FG shocks

Consider the NK model

$$y_t = E_t(y_{t+1}) - \sigma(R_t - E_t(\pi_{t+1}) - r_t), \quad r_t \sim \mathcal{N}(0, \sigma_r^2) \tag{1}$$

$$\pi_t = \beta E_t(\pi_{t+1}) + \kappa y_t, \tag{2}$$

with the central bank following the rule

$$R_t = r_t + \phi E_t(\pi_{t+1}) + \varepsilon_{0,t} + \sum_{k=1}^{K} \varepsilon_{k,t-k}, \tag{3}$$

where $\varepsilon_{j,t-k}$ are anticipated FG shocks:

- Announced at time $t-k$
- Implemented j periods after the announcement

The standard model with FG shocks

Defining $s_t \equiv \{y_t, \pi_t\}'$, we need to solve

$$s_t = BE_t(s_{t+1}) - C\varepsilon_{0,t} - C\left(\sum_{k=1}^{K} \varepsilon_{k,t-k}\right),$$

$$B = \begin{bmatrix} 1 & -\sigma(\phi-1) \\ \kappa & \beta - \kappa\sigma(\phi-1) \end{bmatrix}, \qquad C = \begin{bmatrix} \sigma \\ \kappa\sigma \end{bmatrix}.$$

Intuition: If

$$1 < \phi < 1 + \frac{2(1+\beta)}{\kappa\sigma},$$

- $\Rightarrow$ Both eigenvalues of B lie inside the unit circle $\Rightarrow$ A RE equilibrium exists and is unique
- $\Rightarrow$ $E_t(s_{t+K+1}) = E_t(s_{t+K+2}) = \cdots = 0$

A simple NK model with FG shocks

The resulting solution is

$$s_t = \underbrace{-C\left(\sum_{k=1}^{K} \varepsilon_{k,t-k}\right)}_{\substack{\text{FG shocks announced in the past} \\ \text{and implemented today}}} \underbrace{-\left[\sum_{j=1}^{K-1} B^j C\left(\sum_{k=j+1}^{K} \varepsilon_{k,t-k+j}\right)\right]}_{\substack{\text{FG shocks announced in the past} \\ \text{and implemented in the future}}}$$

$$\underbrace{-C\varepsilon_{0,t}}_{\text{Unanticipated MP shock}} \underbrace{-\left[\sum_{j=1}^{K} B^j C\varepsilon_{j,t}\right]}_{\substack{\text{FG shocks announced today} \\ \text{and implemented in the future}}}.$$

Contemporaneous effects of FG shocks

Theorem (Bounded effects of forward guidance shocks)

If an equilibrium exists and is unique, the contemporaneous response of every endogenous variable to a forward guidance shock of any horizon k, such that $0 < k < K$, is bounded. That is,

$$\frac{\partial s_t}{\partial \varepsilon_{k,t}} = B^k C \; < \infty.$$

Corollary (No asymptotic effects of forward guidance shocks)

If an equilibrium exists and is unique, the response of every endogenous variable goes to zero as the horizon of forward guidance shocks approaches infinity. That is,

$$\frac{\partial s_t}{\partial \varepsilon_{k,t}} = B^k C \underset{k \to \infty}{\longrightarrow} 0.$$

IRFs

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IRFs

Corollary (Cumulative effects)

If an equilibrium exists and is unique, the cumulative response of the endogenous variables to a forward guidance shock announced at time t converges to $-(\mathbf{I}_2 - B)^{-1}C$ as the horizon of the shock approaches infinity.

Forward guidance puzzle

- So far no puzzling, explosive outcomes from monetary policy announcements
- Why? In the literature, forward guidance is made of two bits:
  1. the promise of changing the interest rate in the future
  2. a time-dependent peg until then

$\Rightarrow$ **The peg is the culprit of the forward guidance puzzle**

- By pegging the policy rate, the central bank is not expected to respond to the economic effects of the announced future change in the interest rate

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To show this point, we introduce **two equivalent representations** of the policy function

1. Shocks representation (Laséen and Svensson, 2011)
2. Regimes representation

Shocks representation

- Let us consider a forward guidance policy announcing that the central bank:
  - Keeps the nominal interest rate at $\bar{R}$ for K periods
  - Cuts the interest rate by 1% in period K: $\bar{R}_{t+K} = -1\%$
  - Follows the active MP rule beyond K periods forever
- Implementation:
  1. Find the sequence of FG shocks
  $$\left\{\bar{\varepsilon}_{0,t}, \bar{\varepsilon}_{1,t-1}, ..., \bar{\varepsilon}_{k,t-k}\right\}$$
  such that $R_t = R_{t+1} = ... = \bar{R}$ and $R_{t+K} = \bar{R}_{t+k} = -1\%$
  2. Study contemporaneous effects of these forward guidance shocks ($K = 2$)
  $$s_t = -C\left(\varepsilon^A_{1,t-1} + \varepsilon^A_{2,t-2}\right) - BC\varepsilon^A_{2,t-1} - C\bar{\varepsilon}_{0,t} - \left(BC\bar{\varepsilon}_{1,t} + B^2C\bar{\varepsilon}_{2,t}\right).$$

Shocks representation

Given the Taylor-type rule

$$R_t = r_t + \phi E_t(\pi_{t+1}) + \varepsilon_{0,t} + \varepsilon_{1,t-1} + \varepsilon_{2,t-2},$$

the expectations about the policy rate for the next two periods are

$$\begin{aligned} E_t(R_{t+1}) &= \phi E_t(\pi_{t+2}) + \varepsilon_{1,t} + \varepsilon_{2,t-1}, \\ E_t(R_{t+2}) &= \phi E_t(\pi_{t+3}) + \varepsilon_{2,t} = \varepsilon_{2,t}. \end{aligned}$$

Equivalently,

$$\begin{bmatrix} R_t \\ E_t(R_{t+1}) \\ E_t(R_{t+2}) \end{bmatrix} = \begin{bmatrix} 1 & -\phi\kappa\sigma & -\phi\kappa\sigma(1+\beta-\kappa\sigma(\phi-1)) \\ 0 & 1 & -\phi\kappa\sigma \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{0,t} \\ \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix}.$$

Shocks representation

Inverting the matrix...

$$\begin{bmatrix} \varepsilon_{0t} \\ \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix} = \begin{bmatrix} 1 & \phi\kappa\sigma & \phi\kappa\sigma(1+\beta+\kappa) \\ 0 & 1 & \phi\kappa\sigma \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} R_t \\ E_t(R_{t+1}) \\ E_t(R_{t+2}) \end{bmatrix}. \tag{4}$$

Solving for the shocks as a function of the current and expected future rates $\left\{\bar{R}, \bar{R}, \bar{R}_{t+2}\right\} = \{0, 0, -1\}$, then

$$\begin{bmatrix} \bar{\varepsilon}_{0,t} \\ \bar{\varepsilon}_{1,t} \\ \bar{\varepsilon}_{2,t} \end{bmatrix} = \begin{bmatrix} -\phi\kappa\sigma(1+\beta+\kappa) \\ -\phi\kappa\sigma \\ -1 \end{bmatrix}.$$

Shocks representation

An announced interest rate peg until a one-percent cut in period K requires

$$\begin{bmatrix} \bar{\varepsilon}_{0,t} \\ \vdots \\ \bar{\varepsilon}_{K-1,t} \\ \bar{\varepsilon}_{K,t} \end{bmatrix} = \begin{bmatrix} -d_K(\phi\kappa\sigma) \\ \vdots \\ -d_1(\phi\kappa\sigma) \\ -1 \end{bmatrix},$$

where $g \equiv (1+\beta+\kappa\sigma) > 1$ and for $k = \{1,\ldots,K\}$

$$d_k \quad = \quad g^{(k-1)} + \sum_{l=2}^{\bar{l}} \alpha(l, k+1-2l)(-\beta)^{l-1} g^{(k+1-2l)} > 0.$$

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First shock must be infinitely large to enforce the peg ($\bar{R}$) $\Rightarrow$ forward guidance puzzle

$$\lim_{K\to\infty} \bar{\varepsilon}_{0,t} \to -\infty.$$

$\Rightarrow$ Explosive contemporaneous macro effects as $K \to \infty$.

Regimes representation

Forward guidance is modeled as sequence of peg regimes followed by a cut regime

$$R_t \quad = \quad c_{\omega_t} + \phi_{\omega_t} E_t(\pi_{t+1}),$$

where ω_t is an exogenous Markov-switching process with two types of regimes:

$$c_{\omega_t} = \begin{cases} \bar{R}, & \text{if} \quad \omega_t = \{0, \ldots, K-1\} \qquad \textit{Peg regimes}, \\ \bar{R}_{t+K}, & \text{if} \quad \omega_t = K \qquad \textit{Cut regime}, \\ r_t, & \text{if} \quad \omega_t = K+1 \qquad \textit{Active regime} \end{cases}$$

$$\phi_{\omega_t} = \begin{cases} 0, & \text{if} \qquad \omega_t = \{0, \ldots, K\} \qquad \textit{Peg \& cut regimes}, \\ \phi_A, & \text{if} \qquad \omega_t = K+1 \qquad \textit{Active regime} \end{cases}$$

Regimes representation

The dynamics of these regimes are governed by the $(K+2)\times(K+2)$ transition matrix $\mathbf{Q}$:

$$\mathbf{Q} = \begin{bmatrix} 0 & 0 & 0 & \cdots & 0 & 0 \\ 1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 1 & 0 & \cdots & 0 & 0 \\ \vdots & \ddots & \ddots & \ddots & \vdots & \vdots \\ 0 & \cdots & 0 & 1 & 0 & 0 \\ 0 & \cdots & \cdots & 0 & 1 & 1 \end{bmatrix},$$

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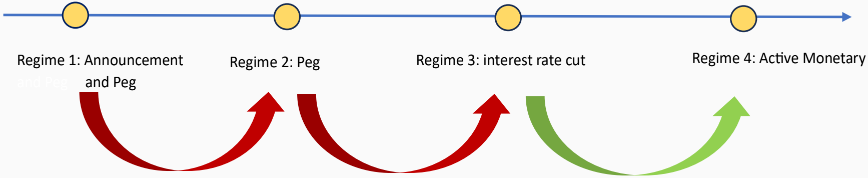

Regimes representation

We need to solve the following model

$$s_t = C_{\omega_t} + B_{\omega_t} E_t s_{t+1},$$

$$C_{\omega_t} = \begin{cases} [\sigma, \kappa\sigma]' c_{\omega_t}, & \text{if} \quad \omega_t = \{0, \ldots, K\} \\ [0, 0]', & \text{if} \quad \omega_t = K+1 \end{cases}$$

Peg regimes,

Active regime.

If $\omega_t \in \{0, \ldots, K\}$ (peg and cut regimes),

$$B_{\omega_t} = B_P = \begin{bmatrix} 1 & \sigma \\ \kappa & \beta + \kappa\sigma \end{bmatrix} \Rightarrow$$ **one explosive root**

if $\omega_t = K + 1$ (active regime)

$$B_{\omega_t} = B_A = \begin{bmatrix} 1 & -\sigma(\phi_A - 1) \\ \kappa & \beta - \kappa\sigma(\phi_A - 1) \end{bmatrix} \Rightarrow$$ **both eigenvalues < 1**

Regimes representation: the effects of forward guidance

Forward guidance at period t:

1. a K-period peg of the interest rate followed by a unitary interest rate cut in period $t+K$
2. the central bank pegs the interest rate at steady-state, $c_{\omega_{t+j}} = 0 \; j \in \{0, \ldots, K-1\}$

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In period $t+K$, the endogenous variables will be given by

$$s_{t+K} = B_P E_{t+K}(s_{t+K+1}) - C_{\omega_{t+K}} = -C_{\omega_{t+K}}, \tag{5}$$

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Going backward from period $K-1$ through period t,

$$s_t = B_P E_t(s_{t+1}) = -B_P^K C_{\omega_{t+K}}, \tag{6}$$

where now the matrix B_P^K reflects the fact that the interest rate is pegged from periods t through period $t+K-1$.

Equivalence theorem

Theorem (Equivalence theorem)

The shocks representation and the regimes representation deliver identical equilibrium dynamics of the endogenous variables in response to the same forward guidance; that is, the same horizon of the peg and the same anticipated change in the nominal interest rate.

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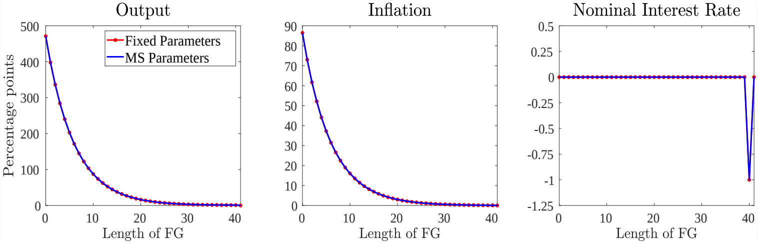


Current responses to peg and 1% drop in the policy rate $k = \{1, \ldots, 40\}$ quarters ahead.

Regimes representation: the forward guidance puzzle

Recall that the solution is

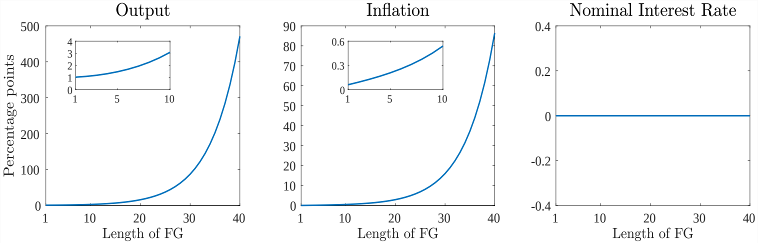
$$s_t = B_P E_t(s_{t+1}) = -B_P^K C_{\omega_{t+K}}.$$

Theorem (The forward guidance puzzle)

The contemporaneous response of the model endogenous variables upon the announcement of a peg grows unboundedly with the duration of the peg. That is,

$$\lim_{K\to\infty} s_t = -B_P^K C_{\omega_{t+K}} \longrightarrow \infty.$$

Regimes representation: the forward guidance puzzle



Forward guidance puzzle: Taking stock

The puzzle stems from announcing a time-dependent peg of the rate

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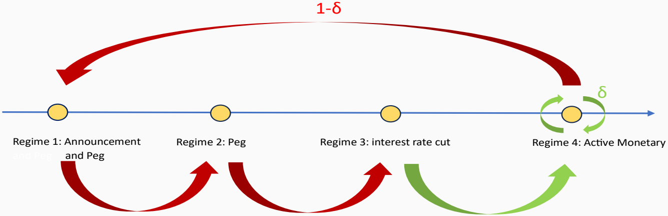
The regimes representation offers several advantages, allowing us

1. to make forward guidance part of the monetary policy strategy
   - going beyond the ubiquitous *one-off assumption*
   - No longer an MIT shock, forward guidance reflected in agents' beliefs
2. to evaluate existence and uniqueness of a RE equilibrium
   - The announced peg implies a prolonged spell of passive monetary policy
   - The Generalized Taylor Principle (Davig and Leeper 2007)
3. to model announcements of state-dependent path of interest rate (e.g. SEP)
   - Run alt sims to assess the effects of hawkish or dovish communications

Equilibrium Uniqueness?

Recurrent forward guidance policy

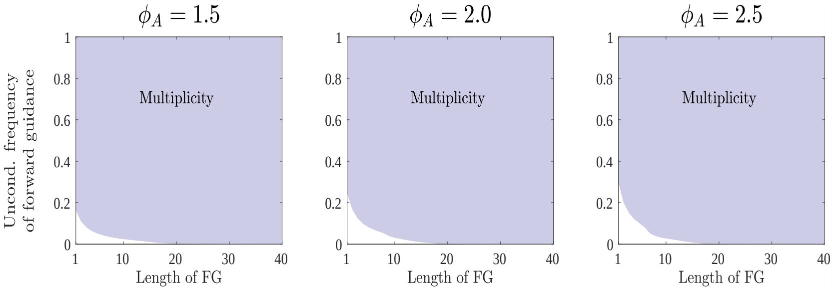
The announced forward guidance may repeat with probability $1-\delta$



Three factors affect the equilibrium properties of the model:

1. Duration of announced policy (K)
2. Probability of recurrence ($1-\delta$)
3. Aggressiveness of the monetary policy in the active regime (ϕ_A)

Equilibrium uniqueness?



⇒ Effects of time-dependent FG are uniquely determined only if they are very rare

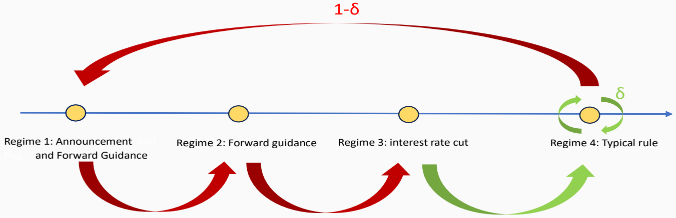
⇒ The claim that "FG has implausibly large contemporaneous effects in DSGE models" loses meaning since these effects are just of the infinitely many outcomes

Announcing a state-dependent path of interest rates

State-dependent forward guidance

The central bank announces

- to set the nominal interest rate over the next K quarters using the rule $R_t = \phi_{FG} E_t(\pi_{t+1})$
- to cut the policy rate by one percent at the end of that period
- to switch to the (typical) rule $R_t = \phi_A E_t(\pi_{t+1})$ thereafter (with $\phi_A = 1.5$).



State-dependent forward guidance

Transition matrix

$$Q = \begin{bmatrix} 0 & 0 & 0 & \cdots & 0 & (1-\delta) \\ 1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 1 & 0 & \cdots & 0 & 0 \\ \vdots & \ddots & \ddots & \ddots & \vdots & \vdots \\ 0 & \cdots & 0 & 1 & 0 & 0 \\ 0 & \cdots & \cdots & 0 & 1 & \delta \end{bmatrix}.$$

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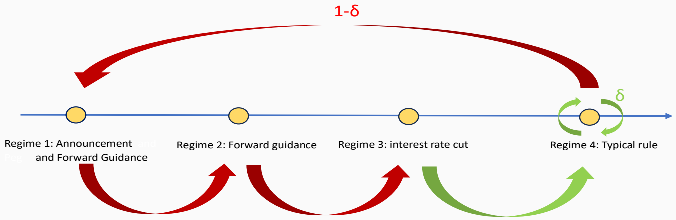
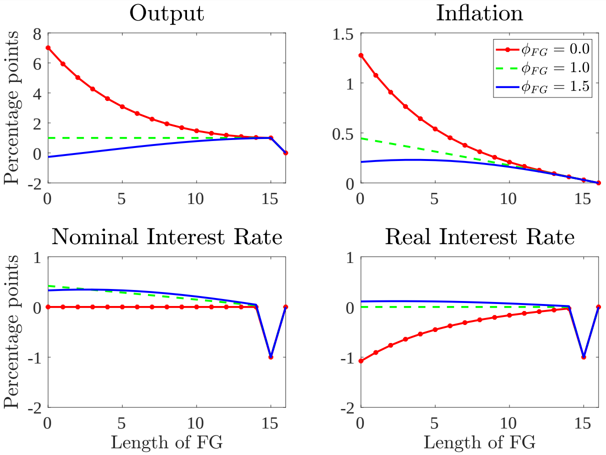
\vdots & \ddots & \ddots & \ddots & \vdots & \vdots \\
0 & \cdots & 0 & 1 & 0 & 0 \\
0 & \cdots & \cdots & 0 & 1 & \delta
\end{bmatrix}.
$$



State-dependence forward guidance policy



⇒ **FG puzzle ceases to exist & equilibrium outcomes are bounded and unique**

Alt sims: communicating reaction functions

- Take an estimated DSGE model with K FG shocks (state-dependent FG)
- Model estimated using the market path of the interest rate
- Obtain forecasts conditional on the market path
- Run alt sim augmenting the model with K FG regimes st $\phi_{FG} \neq \phi_{\text{est}}$; $\phi_A = \phi_{\text{est}}$

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Appendix

Purposes and properties:

1. Assess the effects of communication of a different reaction functions
2. Assess alternative scenarios where markets change its expected path
3. Assess if and why the the alt sim leads to FG puzzle

Conclusions

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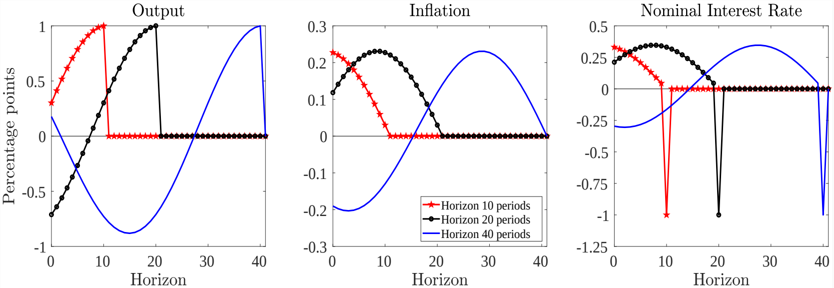
IRFs to FG shocks at selected horizons

Responses of s_{t+j} to 1% drop in the policy rate $K = \{10, 20, 40\}$ quarters into the future.



⇒ Between t and $t + K$, Taylor-type rule prescribes policy rate path.

Back

Setting up the alt sim

Forward guidance is modeled as sequence of peg regimes followed by a cut regime

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where ω_t is an exogenous Markov-switching process with two types of regimes:

$$c_{\omega_t} = \begin{cases} \hat{\varepsilon}_{t,t+\omega}, & \text{if} \quad \omega = \{0, \ldots, K\} \qquad \textit{Alt mkt path regimes}, \\ 0 & \text{if} \quad \omega = K+1 \qquad \textit{Active/estimated regime} \end{cases}$$

$$\phi_{\omega_t} = \begin{cases} \phi_{\text{FG}}, & \text{if} \quad \omega = \{0, \ldots, K\} \qquad \textit{Alt mkt path regimes}, \\ \phi_{\text{est}}, & \text{if} \quad \omega = K+1 \qquad \textit{Active/estimated regime} \end{cases}$$

◂ Back