Monetary Policy and Exchange Rate Fluctuations: A Markov-switching DSGE Approach for Korea

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Motivation

- How monetary policy (MP) has been determined and evolved over time?
  - MP in a large closed economy can be summarized by prototypical Taylor-type rules (Taylor 1993)
  - policy rate is determined in response to inflation and output
- In small open economies (SOEs), exchange rate (ER) volatility is additionally taken into consideration
  - because excessive fluctuations in the ER can have significant impacts on trade
  - conventional Taylor rules may be unsuitable to analyze MP of SOEs with substantial trade openness

Estimation of Monetary Policy in SOEs

- In practice, interest rates are determined in response to ER fluctuations in many SOEs
- Important to estimate how sensitive the SOEs' MP with respect to ER movements
  - time-invariant MP (with fixed coefficients)
    - Lubik and Schorfheide (2007): Australia, Canada, New Zealand and the UK
  - time-varying MP using Markov-switching approaches
    - Alstadheim, Bjornland and Maih (2013): Canada, Norway, Sweden and the UK
    - Liu and Mumtaz (2011) and Chen and MacDonald (2012): the UK
    - Choi and Hur (2015): Korea

What We Do

- Investigate how MP has been implemented and changed in Korea since the 1980s
- Modify the time-varying structure of MP behavior
  - the existing MS-DSGE literature often posits that changes in the MP stance toward its objectives (inflation, output and the ER) are governed by a sole common latent state
  - this paper relaxes the assumption by classifying MP behavior into two orthogonal categories
    - i) MP focusing on the domestic mandates—inflation & output
    - ii) MP pursuing ER stability (the extreme form is an ER peg)

WHAT WE DO

- A Markov-switching SOE DSGE framework is employed in order to identify how the MP regimes evolve over time
  - the model is drawn from Justiniano and Preston (2010)
    - Gali and Monacelli (2005) augmented with incomplete asset market, habit formation and indexation of prices to past inflation, in order to fit the data better
  - 2×2 independent MP regimes: one capturing the time-variation of I) and the other capturing that of II)
- Based on the estimated model, we seek answers to the following questions:
  (1) which MP specification is more suitable for Korea?
  (2) what are the macroeconomic implications of MP responsive to ER fluctuations?

What We Find

- The model with the 2×2 MP regimes outperforms that with the common MP regimes in terms of data fit
  - the time-varying MP stance to ER turns out to be largely independent of the MP behavior toward inflation and output
    - (A) inflation targeting (IT): the second half of the 80s and the post-Asian currency crisis period
    - (B) MP responsive to ER movements: the early 80s, 82–85, 92–95, and during the COVID-19 pandemic period
  - assuming the conventional common MP regimes is likely to miss the evidence in data regarding the presence of (B)
- Macroeconomic implications of MP?
  - adopting the IT system helps reduce inflation variability
  - MP strong reaction to ER fluctuations, in general, tends to increase output and inflation volatilities

The Model and Estimation

Model

- The model follows Justiniano and Preston (2010):
  - a SOE new Keynesian (NK) model
  - an extension of Monacelli (2005) & Gali and Monacelli (2005)
- Key model features:
  - incomplete asset markets
  - habit formation
  - indexation of domestic and foreign prices to past inflation

HOUSEHOLDS

- Preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \varepsilon_{g,t} \left[\frac{(C_t - hC_{t-1})^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right]$$

  - external habit persistence in aggregate consumption C
    - a composite of domestic and foreign produced goods using a Dixit-Stiglitz aggregator
  - N_t: the labor input
  - $\varepsilon_{g,t}$: a general preference shock
  - β: the discount factor
  - $\sigma > 0$ and $\varphi > 0$: the inverses of intertemporal elasticity of substitution and Frisch labor supply elasticity, respectively

Households

- Budget constraint

$$P_tC_t + D_t + e_tB_t = D_{t-1}(1+i_{t-1}) + e_tB_{t-1}(1+i^*_{t-1})\phi_t(A_t) + W_tN_t + \Pi_{H,t} + \Pi_{F,t} + T_t$$

where

$$\phi_t = \exp[-\chi(A_t + \varepsilon_{rp,t})] \quad \text{with} \quad A_t = \frac{e_tB_t}{\bar{Y}P_t}$$

  - Benigno (2001), Kollmann (2002) and Schmitt-Grohé and Uribe (2003)
  - e_t: the nominal exchange rate
  - D_t and B_t: one-period domestic and foreign bonds
  - $\varepsilon_{rp,t}$: a risk-premium shock

Domestic Producers

- The domestic production sector consists of:
  1. monopolistically competitive intermediate goods producing firms who produce a continuum of differentiated inputs
  2. a representative final goods producing firm

- Each $i \in [0,1]$ in the domestic intermediate goods sector produces a differentiated good $y_{H,t}(i)$

$$y_{H,t}(i) = \varepsilon_{a,t} N_t(i)$$

  - $N_t(i)$: firm i's labor input
  - $\varepsilon_{a,t}$: a technology shock

Retail Firms

- Retail firms import foreign differentiated goods
  - assumed to be monopolistically competitive, which leads to a violation of the law of one price in the short run

- The resulting Phillips curve for import price inflation

$$(1+\beta\delta_F)\pi_{F,t} = \delta_F \pi_{F,t-1} + \beta E_t \pi_{F,t+1} + \frac{(1-\theta_F)(1-\theta_F\beta)}{\theta_F}\psi_{F,t} + \varepsilon_{cp,t}$$

  with the law of one price gap defined as

$$\psi_{F,t} \equiv (e_t + p_t^*) - p_{F,t}$$

  - p_t^*: the foreign price
  - $p_{F,t}$: the domestic currency price of imported goods
  - $\varepsilon_{cp,t}$: an import cost-push shock

Monetary Policy

- MP obeys Taylor rule

$$i_t = \rho_i(\xi_t^p) i_{t-1} + (1-\rho_i(\xi_t^p)) \left[\lambda_\pi(\xi_t^p)\pi_t + \lambda_y(\xi_t^p) y_t\right] + \lambda_e(\xi_t^q) e_t + \sigma_i \varepsilon_{i,t}$$

  - $\varepsilon_{i,t} \sim \mathbb{N}(0,1)$
  - λ_π, λ_y, and λ_e measure the policy responses to inflation, output and the nominal ER, respectively
  - ξ_t^p and ξ_t^q are unobservable state variables governing the non-ER MP and ER MP regimes at time t, respectively
    - ξ_t^p and ξ_t^q are independent
  - notice that the MP specification in the existing MS-DSGE literature is given as

$$\hat{i}_t = \rho_i(\xi_t^c)\hat{i}_{t-1} + (1-\rho_i(\xi_t^c)) \left[\lambda_\pi(\xi_t^c)\hat{\pi}_t + \lambda_y(\xi_t^c)\hat{y}_t + \lambda_e(\xi_t^c)\hat{e}_t\right] + \sigma_i \varepsilon_{i,t}$$

SHOCKS

- 8 exogenous shock processes
  - technology shock $\varepsilon_{a,t}$
  - preference shock $\varepsilon_{g,t}$
  - import cost-push shock $\varepsilon_{cp,t}$
  - risk premium shock $\varepsilon_{rp,t}$
  - monetary policy shock $\varepsilon_{i,t}$
  - three foreign shocks on output ($\varepsilon_{y^*,t}$), interest rate ($\varepsilon_{i^*,t}$) and inflation ($\varepsilon_{\pi^*,t}$)
- Beside the MP shock, all shocks are assumed to follow AR(1) processes as

$$\hat{\varepsilon}_{x,t} = \rho_x \hat{\varepsilon}_{x,t-1} + \sigma_x \epsilon_{x,t}, \quad \epsilon_{x,t} \sim \mathbb{N}(0,1)$$

Data

- 8 observable variables
  - five domestic (Korea): GDP, the nominal interest rate, CPI inflation, import goods inflation and the real exchange rate
  - three foreign (US): GDP, the nominal interest rate and CPI inflation
- Sample period: 1980:Q1–2021:Q3
  - Korea had a fixed exchange rate system with its currency pegged to the US dollar prior to the 1980s

Estimation

- Estimation via Bayesian techniques
  - e.g., An and Schorfheide (2007)
  - priors drawn from Justiniano and Preston (2010) and Bianchi (2013)
  - other parameters fixed either at well-established values or at the average of the sample period
    - $\beta = 0.99$ (discount factor)
    - $\chi = 0.01$ (debt elasticity w.r.t. interest rate premium)
    - $\alpha = 0.371$ (share of foreign goods in the domestic consumption bundle, trade openness)

Solution of the MS-DSGE Model

- The state variables, ξ_t^p and ξ_t^q, are assumed to follow a *two-state* first-order Markov chain:
  - two non-ER MP regimes
  - two ER MP regimes
- The sample span of each country includes pre-inflation targeting period
  - standard solutions for rational expectation models (e.g., Sims or Blanchard-Kahn) may be plagued by the indeterminacy issue
- We solve the system using the solution algorithm that is recently developed by Bianchi and Nicolo (2021)
  - it solves the model in case of indeterminacy

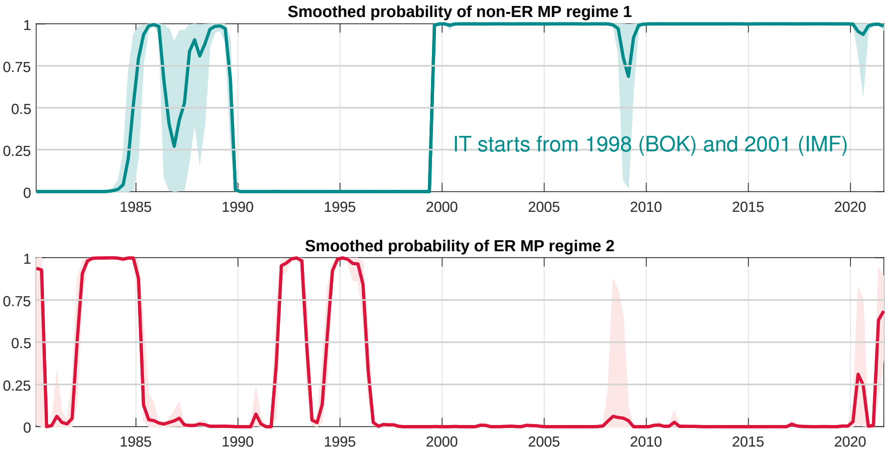
Empirical Results

Parameter Estimates

Parameter	2 × 2 Regime 1	2 × 2 Regime 2	Common MP Regimes Regime 1	Common MP Regimes Regime 2
ρ_i (Taylor rule AR(1))	0.42 [0.29, 0.54]	0.36 [0.27, 0.44]	0.35 [0.21, 0.46]	0.43 [0.35, 0.51]
λ_π (Taylor Rule Inflation)	2.40 [2.11, 2.73]	0.88 [0.79, 0.98]	2.31 [2.03, 2.62]	0.85 [0.76, 0.94]
λ_y (Taylor Rule Output)	0.06 [0.02, 0.10]	0.08 [0.04, 0.13]	0.03 [0.01, 0.07]	0.12 [0.06, 0.19]
λ_e (Taylor Rule Exchange Rate)	0.01 [0.00, 0.01]	0.12 [0.07, 0.15]	0.01 [0.01, 0.02]	0.01 [0.00, 0.02]
P_{11} & P_{22} (Prob. of non-ER MP regimes)	0.96 [0.92, 0.99]	1.00 [0.99, 1.00]		
Q_{11} & Q_{22} (Prob. of ER MP regimes)	0.94 [0.91, 0.97]	0.92 [0.85, 0.97]		
C_{11} & C_{22} (Prob. of common MP regimes)			0.96 [0.92, 0.99]	0.98 [0.94, 1.00]

Posterior mean and [5%, 95%] estimates are reported.

Regime Probability Estimates (2 × 2)



Solid: Mean; Shaded: [5%, 95%] estimates

Regime Probability: Narrative Evidence

- Non-ER MP regime 1
  - the start timing of the IT regime in the late 1990s is consistent with the official documents
  - an IT regime is identified in the second half of the 1980s
    - 85–86: this period is marked with remarkable price stability as the average annualized inflation rate of 83–87 is 2.8%
    - the late 80s: there was a possible shift in the policy stance toward price stability (inflationary pressure caused by rapid surges in wages since the mid-80s due to the democratization of Korean society, KDI (2010, p.165))

Regime Probability: Narrative Evidence

- ER MP regime 2
  - the early 80s: transition from a a fixed ER system to the one pegging the Korean won to a basket of currencies for major trading partners
  - 82−85: the concerns of MP could have shifted toward ER stabilization
    - turmoils in international financial markets created by the second oil crisis of 1979, constant depreciation of KRW
    - domestic inflation may not have been the primary concern of MP as it displayed a clear downward trend
  - the 90s: the adoption of the new ER system in 1990
    - a new ER system referred to as the "market average rate" system replaced the old one
    - the regime estimates can be rationalized as the central bank's concerns shifting away from inflation toward ER stability, following the adoption of the ER rate system

Model Fit

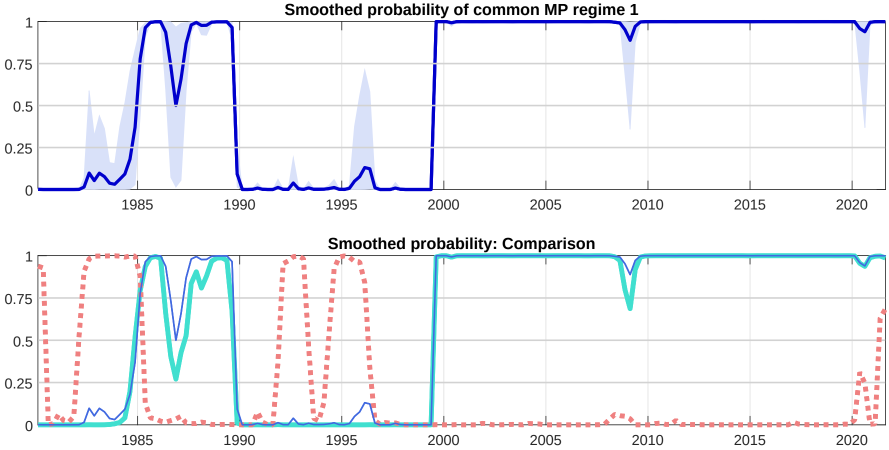
Specification	MHME	DIC	BPIC
Fixed coefficient	−2141.2	4032.8	4052.3
Regime switching: non-ER regime only	−2052.4	3793.1	3813.0
Regime switching: ER regime only	−2074.0	3857.1	3877.3
Regime switching: 2 $\times$ 2 MP regimes (baseline)	−2041.0	3770.1	3792.4
Regime switching: common MP regimes	−2055.6	3781.8	3803.2

A higher MHME, but lower DIC and BPIC indicate a better fit of the data.

Model Fit

- The only difference across the six models is the time variability in their monetary policy rules
  - model fit corresponds to an assessment of the time variability of monetary policy toward its objectives
- By any criterion, the data prefer the Markov-switching model with the 2×2 MP regimes
  - next in the ordering comes either the model with the common MP regimes or Markov-switching in the non-ER regime only, with no clear preference between them
  - the results also show that the Markov-switching structure in the non-ER regime tends to be more important than that in the ER regime in improving the model's fit to data

REGIME PROBABILITY COMPARISON



Regime Probability Comparison

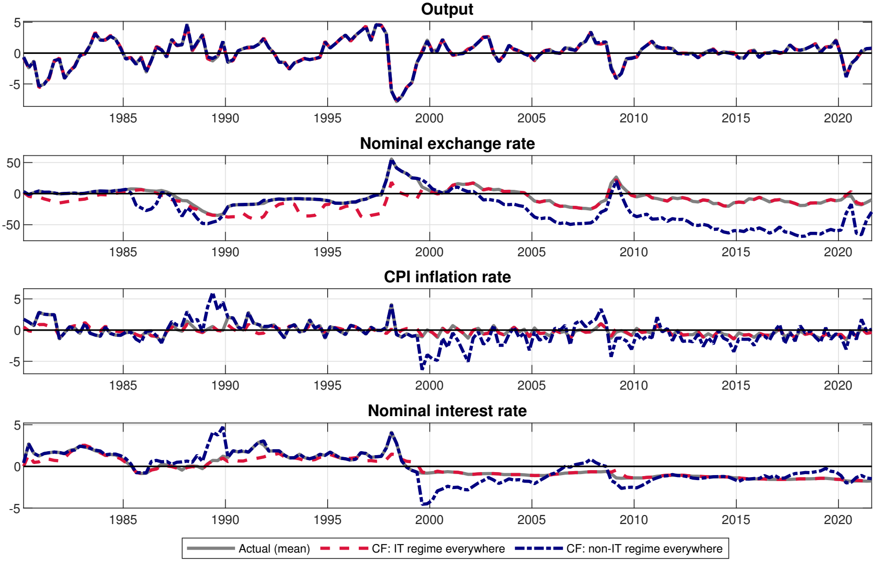
- Finding:
  - the regime estimates of the model with the common MP regimes are similar to those of the baseline specification
- The model fit results suggest as follows:
  - evidence of the time variability in the non-ER regime is more stringent than that in the ER regime

    $\Longrightarrow$ MP regime estimates are likely to be governed heavily by the central bank's inflation-targeting behavior
  - but still, the data seem to be in favor of allowing for the time variability in the ER regime
- Implication:
  - the conventional Markov-switching setup—positing only two MP regimes governed by a common latent state—may be inappropriate for Korea, as it is likely to miss the presence of the MP responses toward ER fluctuations

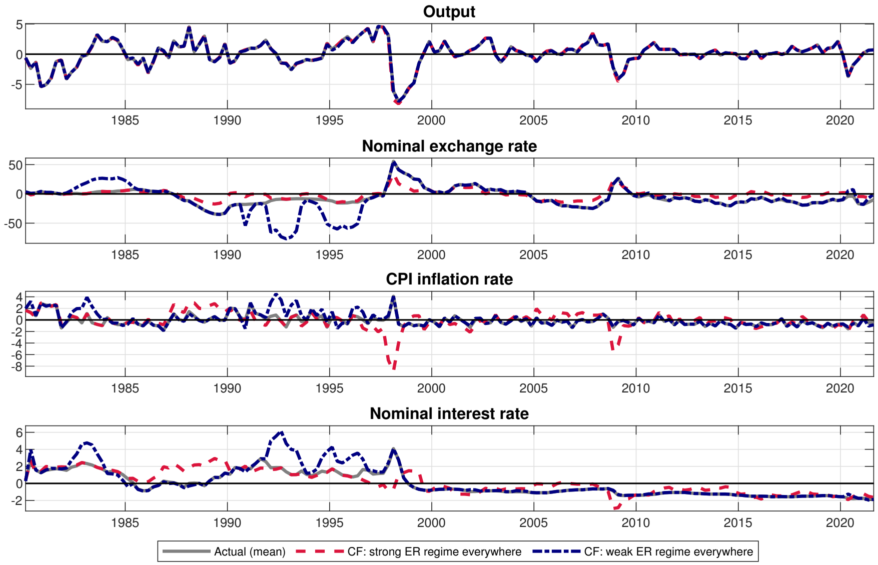
Counterfactual Exercise

- Policy counterfactuals: what if one of the non-ER or ER regimes have prevailed over the entire sample period?
  1. IT vs. non-IT
  2. strong vs. weak responses to ER fluctuations
- These experiments are designed to evaluate the empirical importance of each policy behavior

Counterfactuals: Non-ER MP Regime



COUNTERFACTUALS: ER MP REGIME



Second Moment Implication of MP

	Output	CPI inflation rate	Nominal interest rate
Actual	4.26	0.89	1.84
	[4.02, 4.56]	[0.81, 1.08]	[1.71, 1.96]
CF: IT regime everywhere	4.32	0.36	1.23
	[4.07, 4.63]	[0.32, 0.40]	[1.05, 1.38]
CF: non-IT regime everywhere	4.30	3.38	3.16
	[4.06, 4.61]	[2.64, 4.48]	[2.46, 4.28]
CF: strong ER regime everywhere	4.49	2.43	1.88
	[4.23, 4.84]	[1.78, 2.84]	[1.57, 2.15]
CF: weak ER regime everywhere	4.23	1.69	3.69
	[4.00, 4.53]	[1.31, 2.23]	[2.97, 4.62]

Actual and counterfactual (CF) conditional variance of the model's endogenous variables. Mean and [5%, 95%] estimates are reported.