Diagnostic Expectations in Housing Price Dynamics

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Motivation

- The Great Recession documented that the housing market could initiate booms and busts that affect the real economy's stability and welfare tremendously.
- Rational expectation cannot generate enough volatilities and other patterns in housing price with identified structural shocks; Structural shocks contribute substantially to housing price volatility. empiricalFEVD
- Professional forecasts and consumer forecasts display predictability, identified overreaction and diagnostic expectations.
- **Research Question: how the diagnostic expectations interacting with structural shocks drive the housing price dynamics and aggregate economy?**

This Paper

- Test the predictability of forecast errors in the housing market and find deviation from rational expectation
- Integrate diagnostic expectations into two-agent New Keynesian model with credit constraint and housing market
- Evaluate effect of overreaction on the housing price dynamics, through both aggregate level housing price and housing value distribution

Related Literature

- Housing Price Dynamics Determinants
  - Credit Conditions
    Stein (1995), Kiyotaki et al. (2011), Favilukis et al. (2017), Cox and Ludvigson (2019) (compare credit and belief's role)
  - Investors' Expectations
    Case et al. (2012), Adelino et al. (2016), Albanesi et al. (2017), De Stefani (2020)

- Diagnostic Expectations and its Applications
  Gennaioli and Shleifer (2018), Bordalo et al. (2016, 2018, 2020) (nothing before considered on housing market)

Diagnostic Expectations: Overview

- Expectations are biased due to representative heuristics (Kahneman and Tversky, 1972, 1983)
  Overweight future states that become more likely in light of recent information.

- The diagnostic expectation is formalized pdf with the following form (Bordalo et al., 2018)

$$\omega_t = b\omega_{t-1} + \epsilon_t \tag{1}$$

$$\mathbb{E}_t^\theta(\omega_{t+1}) = \mathbb{E}_t(\omega_{t+1}) + \theta[\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_{t+1})] \tag{2}$$

Roadmap

- Empirical Evidence
  - Predictability of Forecast on Forecast Errors
  - Predictability of Forecast Revisions on Forecast Errors
- The Full Two-Agent New Keynesian Model
- Impact of Diagnostic Expectations
  - Housing price growth rate and housing value distribution
  - Impulse response functions
- Conclusion

Predictability: Deviation from Full Information Rational Expectation

Following Coibion and Gorodnichenko (2015), **Full information rational expectation** indicates $\beta_a = 0$. Results are presented for both the whole sample and different income groups. ICs

$$FE_{t,t+12}(\Delta HP_{t+12}) \equiv \Delta HP_{t+12} - F_{t,t+12} = c_1 + \beta_a F_{t,t+12} + \Phi_t + e_t \quad (3)$$

- Data Summary:
  - $F_{t,t+12}$: Housing price growth expectations
    Survey of Consumer Expectations (SCE) by the Federal Reserve Bank of New York, monthly, 2013M6 - 2021M5.
  - ΔHP_{t+12}: Realized housing price growth
    Freddie Mac housing price index
  - Φ: Controls
    Φ_1: 30-year fixed-rate mortgage rate, total share stock price growth rate, real disposable income growth rate, and inflation rate
    Φ_2: Φ_1 + expected inflation rate, earning growth rate, income growth rate

Predictability: Deviation from Full Information Rational Expectation

Forecast Error	Median (1)	IC1 (2)	IC2 (3)	IC3 (4)
None				
$F_{t,t+12}$	-2.86^{***}	-2.10^{***}	-2.60^{***}	-2.10^{***}
	(0.48)	(0.42)	(0.54)	(0.53)
Adjusted R^2	0.43	0.36	0.45	0.51
Φ_1				
$F_{t,t+12}$	-2.43^{***}	-1.17^{***}	-1.76^{***}	-1.44^{***}
	(0.57)	(0.41)	(0.32)	(0.24)
Adjusted R^2	0.50	0.48	0.51	0.56
Φ_2				
$F_{t,t+12}$	-2.97^{***}	-1.52^{***}	-1.82^{***}	-1.42^{***}
	(0.53)	(0.37)	(0.34)	(0.25)
Adjusted R^2	0.57	0.55	0.50	0.56
Obs	82	82	82	82

Table 1: Forecast errors on forecasts, with and without expectation controls

Predictability: Deviation from Full Information

Following Coibion and Gorodnichenko (2015), rational expectation with **information rigidity** indicates theoretical $\beta_b > 0$.

$$Forecast\ Revision \propto Expectation\ Adjustment$$

$$Forecast\ Error \propto Expectation\ Adjustment + Shock$$

$$\Delta HP_{t+h} - F_{t;t,t+h} = c + \beta_b(F_{t;t,t+h} - F_{t-1;t,t+h}) + e_t \tag{4}$$

- Data Summary:
  - $F_{t;t,t+h} - F_{t-1;t,t+h}$: Forecast revision
    Time t and $t-1$ forecast for the housing price growth rate from t to $t+h$, monthly and quarterly data constructed from Freddie Mac forecast reports, 2014Q1 - 2021Q1.

Predictability: Deviation from Full Information

Forecast Revision	h=1	h=2	h=3
	(1)	(2)	(3)
$F_{t;t,t+h} - F_{t-1;t,t+h}$	-0.97	-0.10	-0.15
	(0.70)	(0.10)	(0.45)
Adjusted R^2	0.13	-0.03	-0.03
Obs	37	36	35

Table 2: Forecast error on forecast revision

Empirical Evidence: Summary

- **Effect of irrational expectation**
  Significantly negative $\hat{\beta}_a$; Insignificant $\hat{\beta}_b$.

- **Same results among income groups motivate two-agent framework**
  No significant differences of $\hat{\beta}_a$ across income groups; Match the empirical finding that prime borrowers and investors take the responsibility.

- **Diagnostic expectation as an explanation**
  Incorporate diagnostic expectation into a New Keynesian model

Model: Belief

- **Naivete** (O'Donoghue and Rabin, 1999)
  Belief: diagnostic expectation $\mathbb{E}^{\theta}[\dots]$
  Behave: rational expectation $Policy(\mathbb{E}^{\theta}[\dots])$

The approach to characterize the equilibrium system under **naivete**, (Bianchi et al. , 2021)

- *Step 1.* Construct the system under RE as shadow system
- *Step 2.* Construct the system under DE by substituting RE with its DE counterparts and solve the optimal policy rule

$$\mathbb{E}_t^{\theta}(\omega_{t+1}) = \mathbb{E}_t(\omega_{t+1}) + \theta[\mathbb{E}_t(\omega_{t+1}) - \mathbb{E}_{t-1}(\omega_{t+1})] \tag{5}$$

Two version of reference point:

- $DE1$ Short-memory: $E_{t-1}(\omega_{t+1})$
- $DE11$ Three-year memory: $\sum_{j=1}^{J} \vartheta_j \mathbb{E}_{t-j}(\omega_{t+1})$, $J = 11$

Model: Summary

- Households: investor and saver
- Monopolistically competitive firms with Calvo's sticky price, produce normal consumption goods and use industrial housing as input

$$Y_{jt} = A_t K_{j,t-1}^{\alpha} (1 - \phi_{t-1}) H_{j,t-1}{}^{\kappa} N_{j,t}^{1-\alpha-\kappa} \quad (6)$$

- Constant housing supply
- Monetary authority: 2 versions of Taylor Rule
  - Taylor rule 1:

$$\frac{R_t}{R} = (\frac{R_{t-1}}{R})^{a_1} [(\frac{\pi_t}{\pi})^{a_2}]^{1-a_1} e^{\nu_t} \quad (7)$$

  - Taylor Rule 2

$$\frac{R_t}{R} = (\frac{R_{t-1}}{R})^{a_1} [(\frac{\mathbb{E}_t^{\theta}(\pi_{t+1})}{\pi})^{a_2} X_t^{a_3}]^{1-a_1} e^{\nu_t} \quad (8)$$

Model: Households

$$\max_{C_{it},N_{it},K_{it},H_{it},\phi_{it},b_t} \mathbb{E}_0^\theta \sum_{t=0}^{\infty} \beta_i^t [lnC_{it} + Jln(\phi_{it}H_{it}) - \chi \frac{N_{it}^{1+\eta}}{1+\eta}]$$

$i=1$ for saver and $i=2$ for investor, subject to the budget constraint:

$$\begin{aligned} s.t.\ & C_{it} + K_{it} + q_t(H_{it} - H_{i,t-1}) + (\mathbb{I}_1 - \mathbb{I}_2)b_t + \frac{\varphi_k}{2}(\frac{I_{it}}{K_{i,t-1}} - \delta)^2 K_{i,t-1} \\ & = r_{i,k,t}K_{i,t-1} + r_{i,h,t}(1-\phi_{i,t-1})H_{i,t-1} + w_{it}N_{it} + (1-\delta)K_{i,t-1} + \Pi_t \\ & + (\mathbb{I}_1 - \mathbb{I}_2)\frac{R_{t-1}}{1+\pi_t} b_{t-1} \end{aligned} \tag{9}$$

The investors as the borrowers are restricted by the credit constraint:

$$b_t \leq m_t \mathbb{E}_t^\theta (q_{t+1} \frac{H_{2t}}{R_t}) \tag{10}$$

TFP shock, liquidity shock, and monetary policy shock follow AR(1) processes separately.

Model: Calibration

Description	Parameter	Value
Discount factor for saver	β_1	0.99
Discount factor for investor	β_2	0.98
Weight on housing preference	J	0.075
Industrial housing share in production	κ	0.03
Diagnostic expectation	θ	1

Table 3: Calibrated Parameter Values

Model: Estimation

- The parameters related to shocks and capital adjustment cost are estimated using method of moment with variance-covariance matrix of (Y, C, I, N, q). Full

Shock	Value(%)	IRF
Empirical Identified Shocks		
TFP shock σ_a	0.8	5 to 10%
Monetary policy shock σ_v	0.14	-5 to -10%
Taylor Rule 1		
TFP shock σ_a	0.85	3 %
Monetary policy shock σ_v	0.13	-3%
Taylor Rule 2		
TFP shock σ_a	0.81	3.5 %
Monetary policy shock σ_v	0.14	-3.5%

Table 4: Shocks Comparison

Housing Demand Decomposition

- **Substitution Effect**: relative price
- **Income Effect** : budget constraint

$$JH_{i,t}^{-1} + \beta_i \mathbb{E}_t^{\theta}[C_{i,t+1}^{-1}(r_{i,h,t+1}(1-\phi_{i,t}) + q_{t+1})] + \mathbb{I}_2 m_t \psi_t \mathbb{E}_t^{\theta} q_{t+1} = C_{i,t}^{-1} q_t \quad (11)$$

$$J\phi_{it}^{-1} = \beta_i \mathbb{E}_t^{\theta}[C_{i,t+1}^{-1} r_{i,h,t+1} H_{it}] \quad (12)$$

- **DE makes the housing demand more volatile relative to RE**
- **DE amplifies the income effect through overreaction in expectations**

Comparison: Unconditional Variance

- Housing price growth rate volatility $var(\Delta q)$

Variance	Empirical	RE	DE1	DE11
Taylor Rule 1	30.24	3.18	7.38	6.79
Taylor Rule 2	30.24	6.16	14.55	13.48

Table 5: Variance Comparison, Annualized Percentage

Impulse Response Functions: Empirical

- Significant response of real housing price growth rate to TFP shock (+) and monetary policy shock (−).

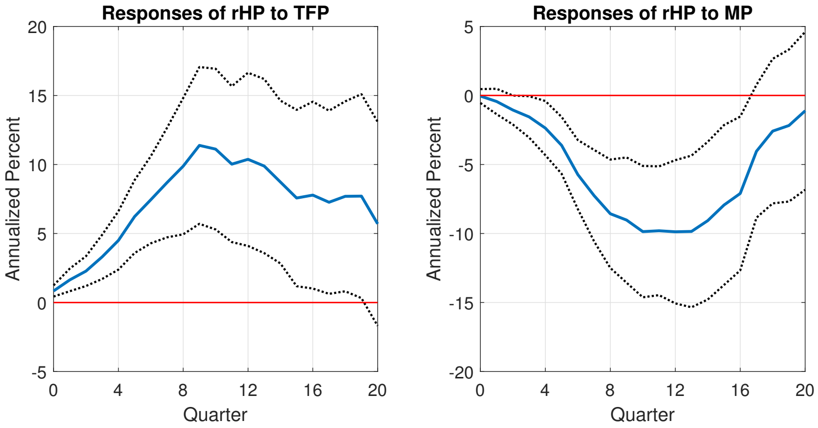

Figure 1: Local projection, Real Housing Price, 1 s.t.d Shock, 90% CI

Impulse Response Functions: Empirical

- Significant response of residential housing value share to TFP shock (+) and monetary policy shock (−).

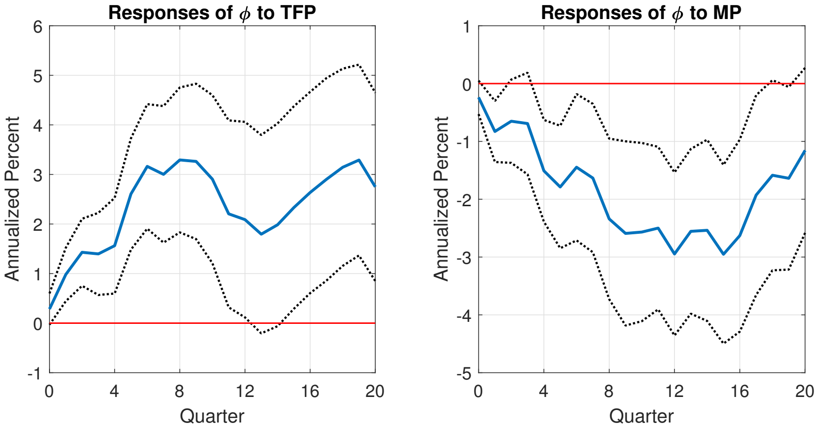

Figure 2: Local projection, Residential Housing Value Share, 1 s.t.d Shock, 90% CI

Impulse Response Functions: Model Simulated

- Housing price growth rate $\hat{q}_t$ & Housing value share $\hat{\phi}_t$

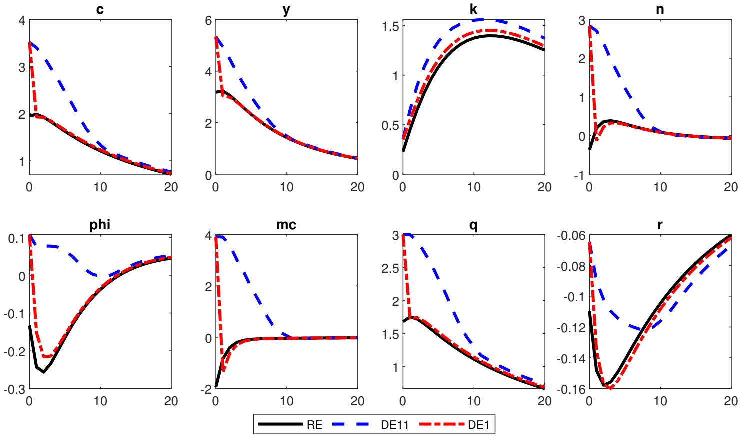

Figure 3: Impulse Response Functions, 1 s.t.d TFP shock, Taylor Rule 1

separateIRF1 TFP,TR2 MP standardNK

Conclusion & Future Directions

- Conclusion
  - Predictability of forecast errors in the housing market
  - Representative heuristic leads to more persistence and significant responses in housing price to TFP shocks
  - Overestimation, especially from investors, leads to an overreaction in consumption, investment, housing demand, and can resolve the pro-cyclical residential housing value share.
- Future Directions
  - Connection of data to model
  - Solution method for limited DE
  - Policy implication

Formula

- Probability density function under DE

$$h_t^{\theta}(\hat{\omega_{t+1}}) = h(\hat{\omega_{t+1}}|\omega_t = \hat{\omega}_t)\left[\frac{h(\hat{\omega_{t+1}}|\omega_t = \hat{\omega}_t)}{h(\hat{\omega_{t+1}}|\omega_t = b\hat{\omega_{t-1}})}\right]^{\theta}\frac{1}{Z} \tag{13}$$

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Empirical FEVDs

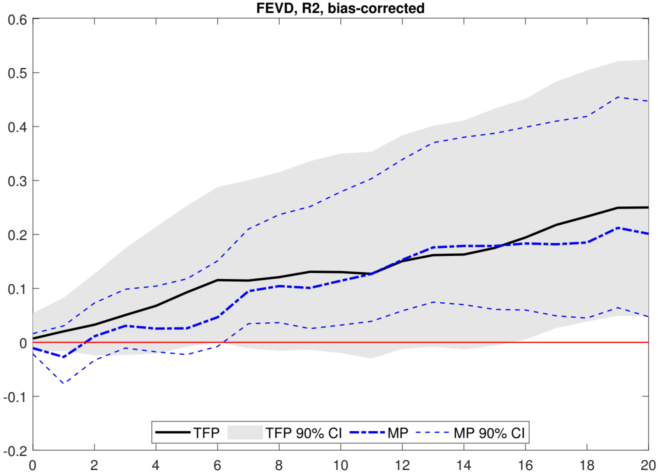

Figure 4: Empirical Forecast Error Variance Decomposition, Real Housing Price

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Test 1 on Different Income Groups

$$FE_{i,t,t+12} = c_2 + \alpha_{i,1}\mathbb{D}_i + \beta_{i,2}F_{i,t} + \alpha_{i,2}\mathbb{D}_i \times F_{i,t} + \alpha_{i,3}controls_{i,t} + \alpha_{i,4}controls_t + e_{i,t} \quad (14)$$

Forecast Error	$i = 1$	$i = 2$	$i = 3$
	(1)	(2)	(3)
$\mathbb{D}_i \times F_{i,t}$	-0.5878	-0.3528	-0.2389
	(0.6152)	(0.7652)	(0.6811)
Obs	164	164	164

Table 6: Tests of the degree of predictability among income groups

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Model: A Toy Model

- Housing consumers: C
- Housing investors: $K\delta_{p,t}$, $\delta_{p,t} = Prob(p_{t+1} > p_t)$.

- Fundamental Housing Price: $p_{t+1} = \rho p_t + \epsilon_{t+1}$
- Expected Housing Price: $\mathbb{E}_t^{\theta}(p_{t+1}) = \rho p_t + \theta \rho \epsilon_t$
- Realized Housing Price: $p_{t+1} = \rho^2 p_t + (\rho + \theta\rho)\epsilon_{t+1}$

- Revealed predictability:

$$\hat{\beta}_a \equiv \frac{Cov[p_{t+1} - \mathbb{E}_t^{\theta}(p_{t+1})}{var[\mathbb{E}_t^{\theta}(p_{t+1})]} = -\frac{\theta^2\rho^2\sigma^2}{\frac{\rho^2}{1-\rho^2}\sigma^2 + \theta^2\rho^2\sigma^2} < 0$$

Model: Estimation

Description	Parameter	Taylor Rule 1	Taylor Rule 2
Autocorrelation of $logA_t$	ρ_a	0.8797	0.9312
Autocorrelation of $logm_t$	ρ_m	0.8483	0.9893
Autocorrelation of $log\nu_t$	ρ_v	0.6427	0.5213
std of $logA_t$	σ_a	0.0085	0.0081
std of $logm_t$	σ_m	0.0476	0.0574
std of $log\nu_t$	σ_v	0.0013	0.0014
capital adjustment cost	φ	5.2468	5.5275

Table 7: Estimated Parameter Values

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IRFs to TFP Shock, Taylor Rule 1, Separate

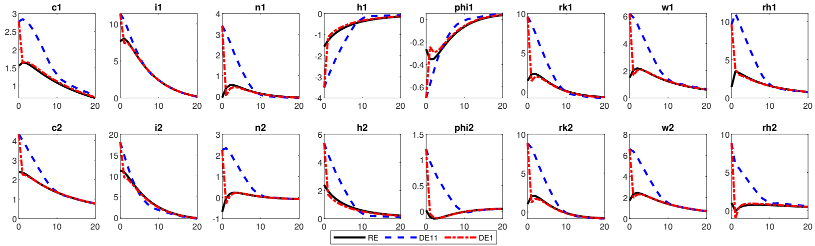

Figure 5: Separate Impulse Response Functions, 1 s.t.d TFP shock, Taylor Rule 1

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IRFs to TFP Shock, Taylor Rule 2

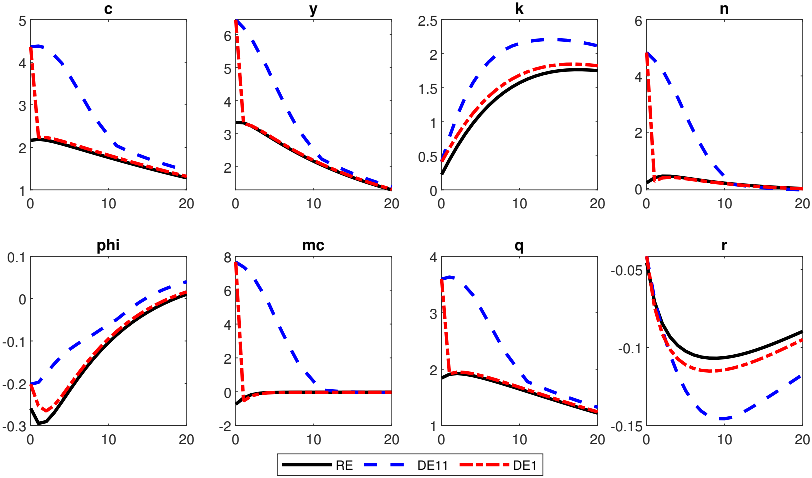

Figure 6: Impulse Response Functions, 1 s.t.d TFP shock, Taylor Rule 2

IRFs to TFP Shock, Taylor Rule 2, Separate

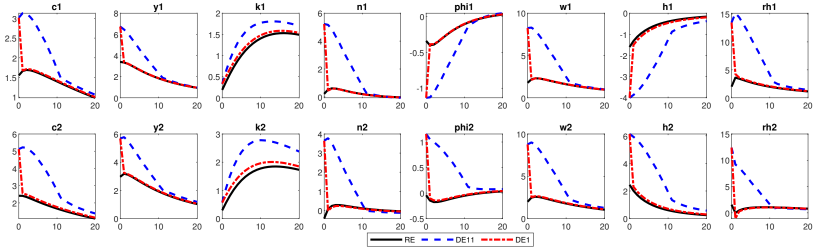

Figure 7: Separate Impulse Response Functions, 1 s.t.d TFP shock, Taylor Rule 2

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IRFs to Monetary Policy Shock, Taylor rule 1

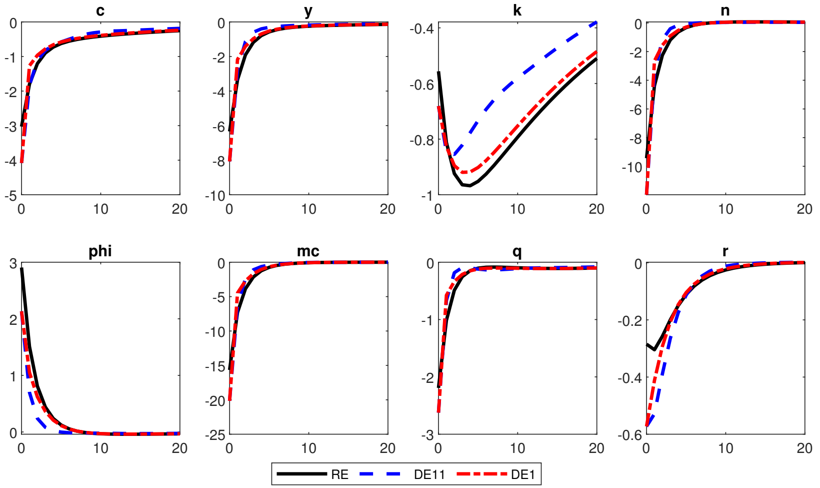

Figure 8: Impulse Response Functions, 1 s.t.d Monetary Policy Shock, Taylor Rule 1

IRFs to Monetary Policy Shock, Taylor rule 2

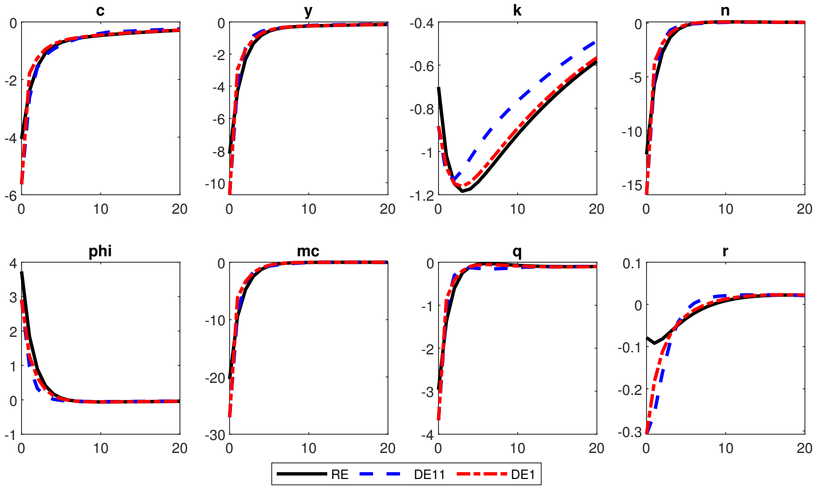

Figure 9: Impulse Response Functions, 1 s.t.d Monetary Policy Shock, Taylor Rule 2

IRFs to Monetary Policy Shock, Taylor rule 1, Separate

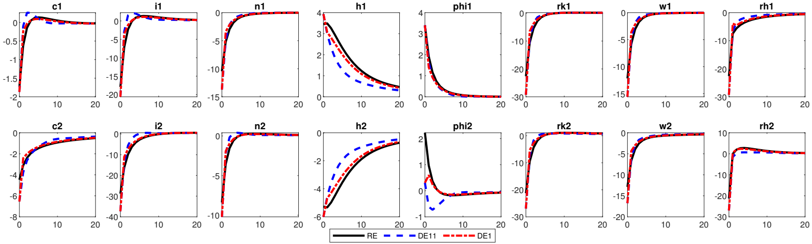

Figure 10: Separate Impulse Response Functions, 1 s.t.d TFP shock, Taylor Rule 1

IRFs to Monetary Policy Shock, Taylor rule 2, Separate

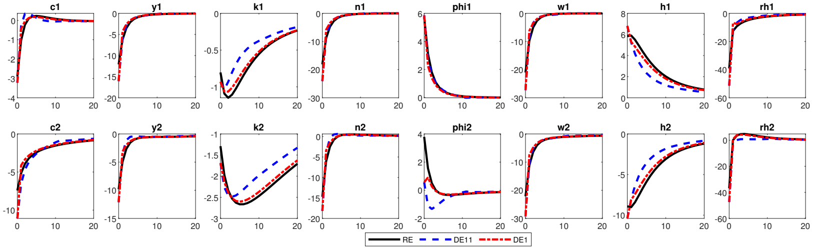

Figure 11: Separate Impulse Response Functions, 1 s.t.d TFP shock, Taylor Rule 2

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IRF: Representative NK with Adjustment Cost

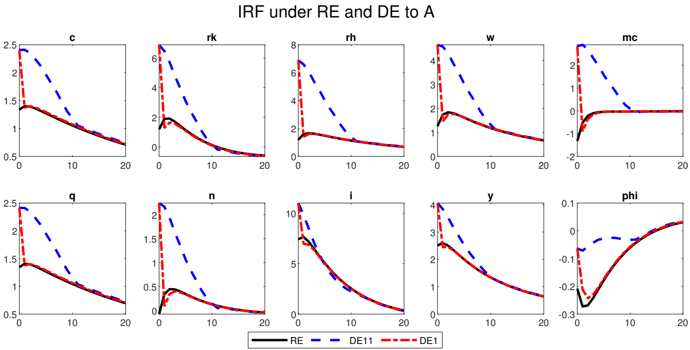

Figure 12: Impulse Response Functions, 1 s.t.d TFP shock, standard NK model

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