Monetary Policy and Sovereign Risk in Emerging Economies (NK-Default)

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Motivation for NK-Default

- Many emerging markets adopted *inflation targeting* in early 2000s
  - Monetary policy targets nominal rates to keep inflation in band

- *New Keynesian theory* toolkit for monetary policy implementation
  - Theory for developed countries, mainly perfect capital markets
  - Useful for transmission of monetary policy to inflation and output

- Standard NK theory silent on interactions with *sovereign risk*
  - Emerging markets history of recurring sovereign debt crises
  - Both policies affect consumption, output, inflation

New Keynesian model with sovereign default risk

Emerging Markets Inflation Targeters

	Means		Correlation with Spread		
	Inflation	Govt Spread	Inflation	Domestic Rate	Output
Brazil	5.9	2.6	59	59	-62
Chile	3.0	1.4	30	39	-49
Colombia	5.2	3.2	74	76	-60
Indonesia	6.6	2.8	17	75	-62
Korea	2.6	1.1	44	74	-30
Mexico	4.3	2.3	48	27	-54
Peru	2.8	3.0	50	55	-33
Philippines	3.9	2.9	17	82	-26
Poland	3.0	1.7	59	52	-11
South Africa	5.8	1.9	54	20	-49
Mean	**4.4**	**2.4**	**45**	**58**	**-38**

- Single digit inflation and $ govt bonds carry spread over US bonds
- Govt spread positively correlates with inflation and domestic rates sovereign dollar spreads and local currency interbank rate
- Govt spread negatively correlates with output

Default Risk Matters for Monetary Policy

- New Keynesian model with option to default, *NK-Default*
  - Govt borrows foreign-currency debt with default risk
  - Monetary policy is a nominal interest rate rule to target inflation
- Default Amplification: Govt default risk increases monetary frictions
  - High default risk depresses consumption and increases inflation
  - Nominal rates remain high to fight inflation
  - $\Rightarrow$ Lower output and larger monetary frictions
- Monetary Discipline: Monetary frictions discourage borrowing
  - Govt internalizes the effects of its policy on domestic outcomes

Quantitative Toolkit

- Model predictions consistent with emerging market data
  - Positive co-movement of spreads, nominal rates, inflation
  - Low productivity leads to high spreads $\rightarrow$ high nominal rates

- Properties of NK-Default
  - More volatile inflation and nominal rates than without default

    default amplification
  - Lower spreads and debt accumulation than real version

    monetary discipline

- Rationalize Brazilian experience with 2015 monetary tightening
  - Counterfactual low rates $\rightarrow$ moderate recession but increase in inflation and spreads
- Evaluate alternative interest rate rules and debt denomination
  - Large weight on inflation and local currency debt is best

Literature

- New Keynesian models for small open economies: Gali-Monacelli (2005), Aoki-Benigno-Kyotaki (2016), Devereux-Young-Yu (2019)
- Sovereign default: Aguiar-Gopinath (2006), Arellano (2008), Reinhart-Rogoff (2009), Chatterjee-Eyigungor (2012)
- Default risk & dilution: Hatchondo-Martinez-Sosa Padilla (2016), Aguiar-Amador-Hopenhayn-Werning (2018), Hatchondo-Martinez-Roch (2018)
- Inflation as default for local currency debt: Calvo (1988), Aguiar-Amador-Farhi-Gopinath (2013), Corsetti-Dedola (2016), Hur-Kondo-Perri (2018)
- Downward rigid nominal wages & default risk: Na-Schmitt-Grohe-Uribe-Yue (2018), Bianchi-Ottonello-Presno (2018), Bianchi-Mondragon (2018)

  Here NKPC with inflation expectations + nominal rates target inflation

NK-Default: Monetary policy targets inflation with sovereign default risk

Model

Small open economy: private sector, monetary auth, and fiscal govt

- Private sector:
  - Households: value domestic and imported goods, supply labor
  - Intermediate goods firms: produce with labor, subject to price-setting frictions (Rotemberg)
  - Final good: consumed domestically and exported
- Monetary authority:

  Follows interest rate rule, inflation target
- Government:

  Borrows long-term internationally, in foreign currency, can default

Households

- Values consumption of domestic and foreign goods, supply labor

$$\max \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t u(C_t, C_t^f, N_t)$$

$$\text{s.t.} \quad P_t^d C_t + P_t^f C_t^f + q_t^d B_{t+1}^d \leq W_t N_t + B_t^d + \Phi_t + T_t$$

- Domestic nominal bonds with price q_t^d, in zero net supply
- Receive profits from firms Φ_t, and transfers from government T_t
- Optimality conditions:

$$\frac{u_{C^f,t}}{u_{C,t}} = e_t, \qquad \frac{u_{N,t}}{u_{C,t}} = w_t, \qquad u_{C,t} = \beta i_t \mathbf{E}_t \left[\frac{u_{C,t+1}}{\pi_{t+1}} \right]$$

Nominal rate $i_t = 1/q_{t+1}^d$ is monetary instrument

Inflation $\pi_{t+1} = P_{t+1}^d / P_t^d$, terms of trade $e_t = P_t^f / P_t^d$ ($\uparrow$ depreciation)

Intermediate Goods Firms

- Monopolistic competition facing CES demand $y_{it} = \left(\frac{p_{it}}{P_t^d}\right)^{-\eta} Y_t$
- Produce with labor n_{it} and face productivity shocks z_t

$$y_{it} = z_t n_{it}$$

- Costly to change prices relative to target inflation $\bar{\pi}$ (Rotemberg)
- Dynamic choice of n_{it} and prices p_{it} (NKPC)

$$(\pi_t - \bar{\pi})\,\pi_t = \left(\frac{w_t}{z_t} - 1\right)\frac{\eta - 1}{\varphi} + \mathbf{E}_t\left[\beta \frac{u_{c,t+1}}{u_{c,t}} \frac{Y_{t+1}}{Y_t} (\pi_{t+1} - \bar{\pi})\,\pi_{t+1}\right]$$

- Monetary frictions hinder efficient production

$$1 + \text{monetary wedge} = \frac{z_t}{w_t} = \frac{z_t u_{C,t}}{u_{N,t}}, \qquad (> 0 \text{ depressed output})$$

- Monetary wedge linked to dynamics of inflation

Goods Market and Monetary Policy

- Economy faces elastic demand for its exports

$$X_t = e_t^{\rho} \xi$$

- Domestic good used for consumption and exports

$$z_t N_t = C_t + X_t + \langle \text{price-setting costs} \rangle_t$$

- Monetary policy is an interest rate rule

$$i_t = \bar{i} \left(\frac{\pi_t}{\overline{\pi}} \right)^{\alpha_P} m_t$$

- Targets inflation $\overline{\pi}$, subject to shocks m_t

Government

- Govt borrows abroad in foreign-currency $q_t \ell_t$ pays coupons B_t
- Capital flows used to finance imports net of exports

$$C_t^f = X_t / e_t + q_t \ell_t - B_t$$

- Bonds are long-term perpetuities with decay rate δ and law of motion

$$B_{t+1} = \delta B_t + \ell_t$$

- Govt can default on its debt
  - Debt eliminated, balanced trade
  - Productivity reduced to $z_t^d \leq z_t$ and temporary market exclusion
- Bond price schedule $q(z_t, B_{t+1})$ compensates for default risk

Recursive Markov Equilibrium

- States: shocks $s = (z, m)$ and debt B
- Gov chooses policies to default D and borrow B'

$$V(s, B) = \max \left\{ W(s, B),\ W^d(s^d) \right\}$$
$$W(s, B) = \max_{B'} \left\{ u(C, C^f, N) + \beta \mathbf{E} V(s', B') \right\}$$

- Subject to private and monetary equilibrium
- Takes as given future government policies
- Bond price schedule reflects default

$$q(s, B') = \frac{1}{1 + r^*} \mathbf{E} \left[1 - D(s', B') \right] \left[1 + \delta q(s', B''(s, B')) \right]$$

- With long-term debt also depend on future borrowing

Private and Monetary Equilibrium

NKPC: $$(\pi - \overline{\pi})\,\pi = \left(\frac{u_N}{z u_C} - 1\right)\frac{\eta - 1}{\varphi} + \beta \mathbf{E}\frac{z' N' u'_C}{z N u_C}\,(\pi' - \overline{\pi})\,\pi'$$

Domestic Euler: $$u_C = \beta\, i\, \mathbf{E}\left[\frac{u'_C}{\pi'}\right]$$

Interest rate rule: $$i = \bar{i}\left(\frac{\pi}{\overline{\pi}}\right)^{\alpha_P} m$$

Relative consumption: $$u_{C^f} / u_C = e$$

Balance of payments: $$X/e = e^{\rho - 1}\xi = C^f + B - q(s, B')(B' - \delta B)$$

Resource constraint: $$C + X = \left[1 - \frac{\varphi}{2}(\pi - \overline{\pi})^2\right] zN$$

- Govt understands how its borrowing B' impacts economy
- Govt borrowing affects default risk and capital flows

Default Amplification: Tension

Default creates a tension for monetary policy

- A default reduces productivity: decrease consumption, increase inflation
- Expectations about default outcomes affect choices for consumption and inflation

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Domestic Euler: $$u_C = \beta\, i\, \mathbf{E}\left[\frac{u'_C}{\pi'}\right]$$

- A high i helps to bring down inflation but worsens monetary wedge
- Interest rate rule that targets inflation gives rise to inefficient production

Default Amplification: Monetary Wedge

(With rigid prices and log separable preferences)

Large borrowing B' and high default risk D' affect monetary friction

Domestic Euler: $$\frac{1}{C} = \beta \bar{i} \left(\mathbf{E}_{D'(B')=0} \frac{1}{C'(s', B')} + \mathbf{E}_{D'(B')=1} \frac{1}{C'_d(s')} \right)$$

Relative consumption: $$\frac{C}{C^f} \propto e$$

Balance of payments: $$X/e = e^{\rho-1}\xi = C^f + B - q(B')(B' - \delta B)$$

Resource constraint: $$C + X = zN$$

A higher B' increases default risk D' and increases the monetary wedge

- Consumption: Lower expected consumption, more likely low C'_d and lower $C(B')$
  - Domestic Euler calls for decline in current domestic consumption C
- Export-Import: More capital inflows appreciate e, lower exports
- Lower $(C + X)$ lowers labor $N \rightarrow$ increases monetary wedge

Large borrowing and default risk increase monetary frictions

Govt Borrowing

$$u_{C_f}\left[q \qquad\qquad\qquad\qquad\right] \qquad = \beta \mathbf{E} \qquad u'_{C_f}(1+\delta q')$$

- International borrowing smooths MU imported consumption u_{C_f}
  - Reference model with no sovereign debt as in Gali-Moncelli 2005

Govt Borrowing

$$u_{C_f}\left[q + q_{B'}B' - q_{B'}\delta B\right] \qquad = \beta \mathbf{E}(1 - D')u'_{C_f}(1+\delta q')$$

- International borrowing smooths MU imported consumption u_{C_f}
  - Reference model with no sovereign debt as in Gali-Moncelli 2005
- Default risk makes prices respond to borrowing
  - Bond prices decrease with $q_{B'} \leq 0$
  - Long-term debt allows dilution: low price lowers legacy debt value
  - Overborrowing with dilution (Hatchondo, Martinez, Sosa-Padilla 2015)

Govt Borrowing: Monetary Discipline

$$u_{C_f}\left[q + q_{B'}B' - q_{B'}\delta B\right](1-\tau_m^X) - \tau_m^C = \beta \mathbf{E}(1-D')u'_{C_f}(1+\delta q')(1-\tau_m^{X\prime})$$

- Borrowing wedges τ_m^C and τ_m^X from monetary frictions
- Increasing with monetary wedge (perfect rigid prices)

$$\tau_m^C \propto \text{monetary wedge} \times \frac{\partial \mathbf{E} u_C(s', B')}{\partial B'} \frac{\beta i}{G} \qquad \text{[consumption channel]}$$

$$\tau_m^X \propto \text{monetary wedge} \times u_C G^X \qquad \text{[exports-imports channel]}$$

- Reduce B' to improve monetary wedge (from proposition)
  - τ_m^C: to reduce default risk and boost domestic consumption
  - τ_m^X: to depreciate terms of trade and boost exports

Monetary frictions reduce govt's incentive to borrow

Quantitative Analysis

- Parameterize model to Brazil (output, inflation, spreads)
- Compare NK-Default to two reference models
  - *NK-Reference model*: similar as Gali-Monacelli (2005)

$$u_{C_f} q = \beta \mathbf{E} u'_{C_f} (1 + \delta q')$$

    (only monetary frictions)

  - *Default-Reference model*: real model with default
    (only default risk frictions)

- IRF productivity shocks
- Event analysis and counterfactual monetary policy for 2015 recession
- Extended models: local currency debt, richer interest rate rules

Parameterization, Functional Forms, Computation

- Preference

$$u(C,\ C^f, N) = \log\left[\left(\theta C^{\frac{\rho-1}{\rho}} + (1-\theta)(C^f)^{\frac{\rho-1}{\rho}}\right)^{\frac{\rho}{\rho-1}}\right] - \frac{N^{1+1/\zeta}}{1+1/\zeta}$$

- CPI-based Inflation and Nominal Devaluation Rate:

$$\text{Inflation} = \pi \frac{\left[\theta^\rho + (1-\theta)^\rho e^{1-\rho}\right]^{1/(1-\rho)}}{\left[\theta^\rho + (1-\theta)^\rho e_{-1}^{1-\rho}\right]^{1/(1-\rho)}}, \qquad \text{NER} = \pi \frac{e}{e_{-1}}$$

- Default productivity loss follows Chatterjee and Eyigungor (2012)

$$z^d(z) = z - \max\{0, \lambda_0 z + \lambda_1 z^2\}$$

- Computation algorithm
  - Discrete choice multinomial logit: taste shocks for $\{B', D\}$
  - Sovereign default: Dworkin et al. (2018) and Gordon (2018)

▸ Computation with Taste Shocks

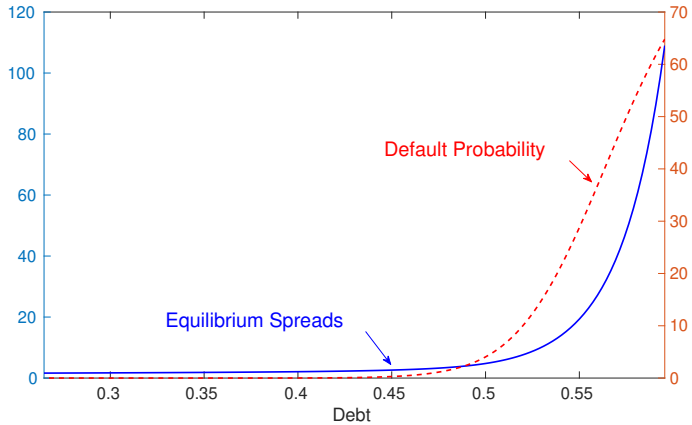
Parameterization and Moment Matching

- Assign some parameters to get means and from literature
  - Financial: mean international rate $r^* = 2\%$, mean inflation $\overline{\pi} = 6.3\%$, mean nominal rate $\beta = .99$, exclusion length 6 years, $\iota = 1/24$, debt duration 6 years $\delta = 0.9631$
  - Price frictions: Markups $\eta/(\eta - 1) = 1.2$, frequency of price adjustment $\varphi = 58$, Frisch labor elasticity $\zeta = .33$
  - Trade import share $1 - \theta = .38$, trade elasticity $\rho = 5$, productivity persistence $\rho_z = .9$
- Moment matching parameters: shock volatility, default penalty parameters, govt discounting, default shock variance, interest rate rule coefficient

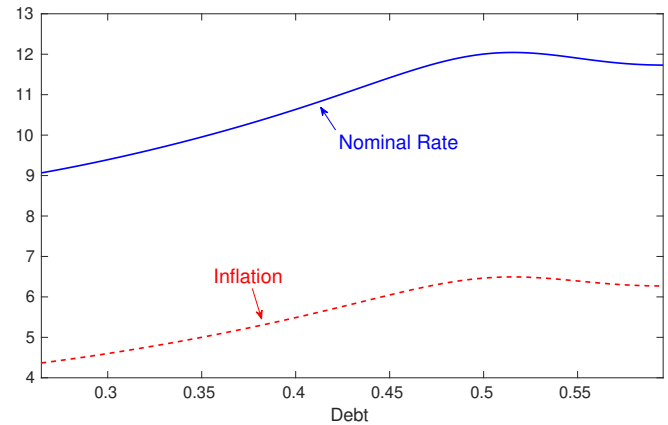
	Data	NK-Default
Mean inflation	5.9	5.9
Mean domestic rate	11.2	11.1
Mean spread	2.6	2.6
Volatility of inflation	1.8	1.8
Volatility of spread	0.9	0.9
Volatility of output	1.9	1.9
Volatility of consumption	1.8	2.0
Output, spread correlation	−62	−60

Parameters

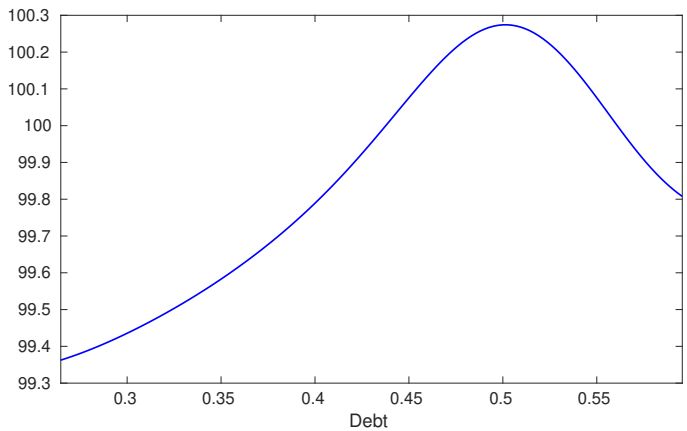
Policy Rules



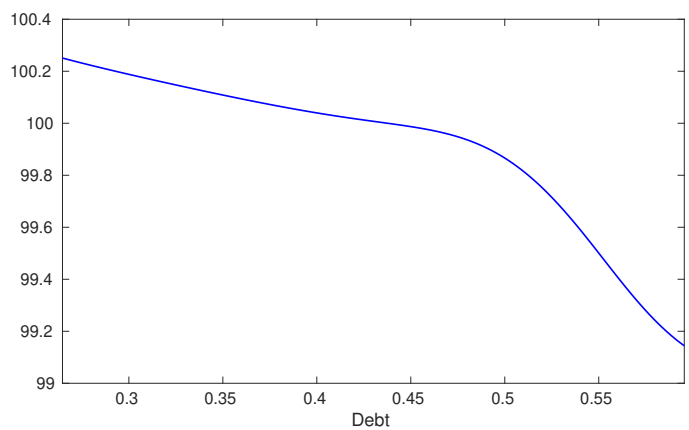
(a) Spreads and Default Risk



(b) Nominal Rate and Inflation

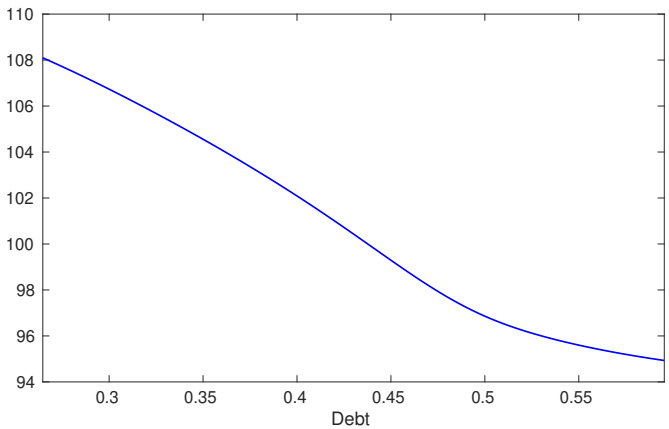


(c) Output

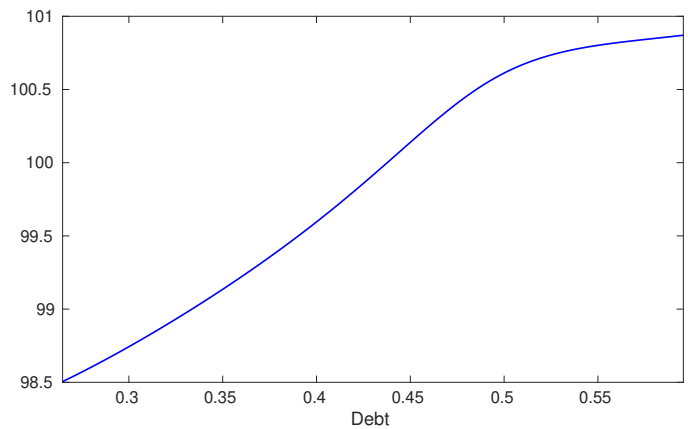


(d) Domestic Consumption

Policy Rules

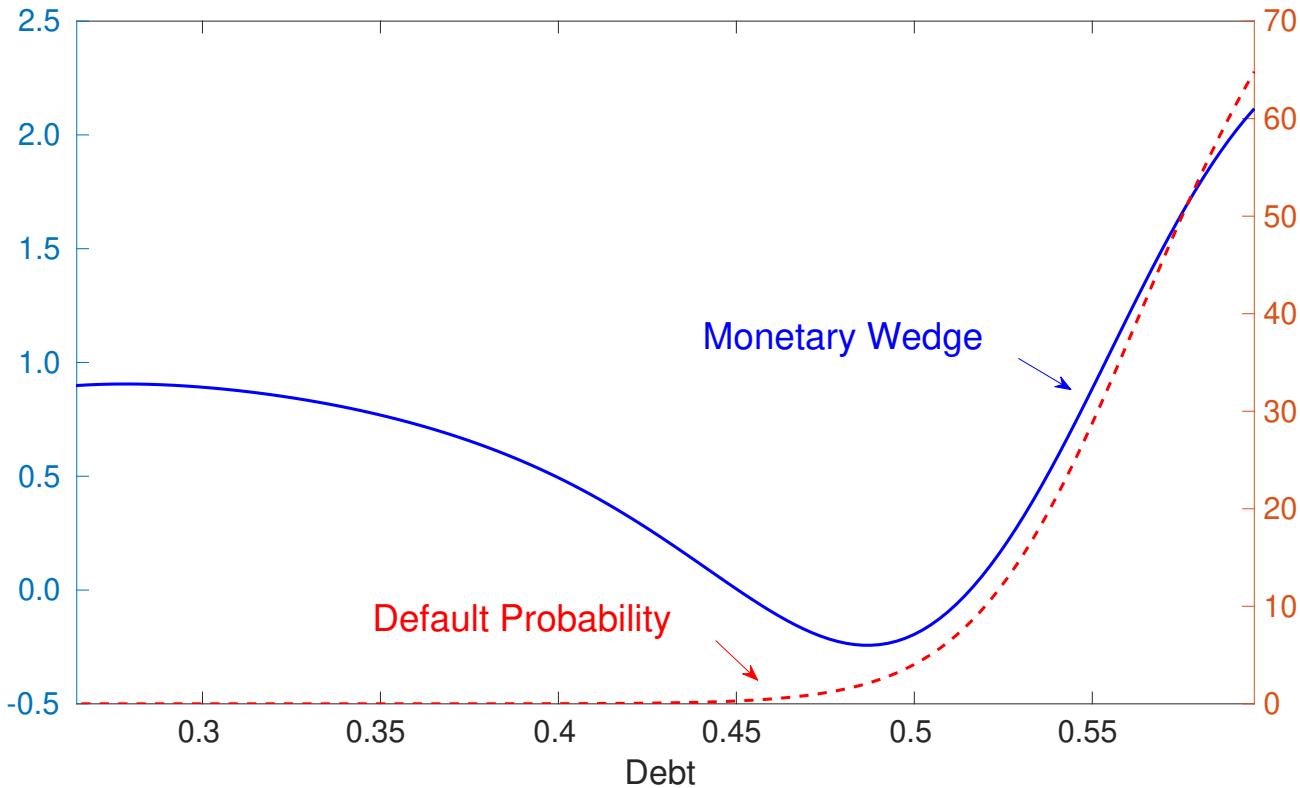


(e) Imported Consumption



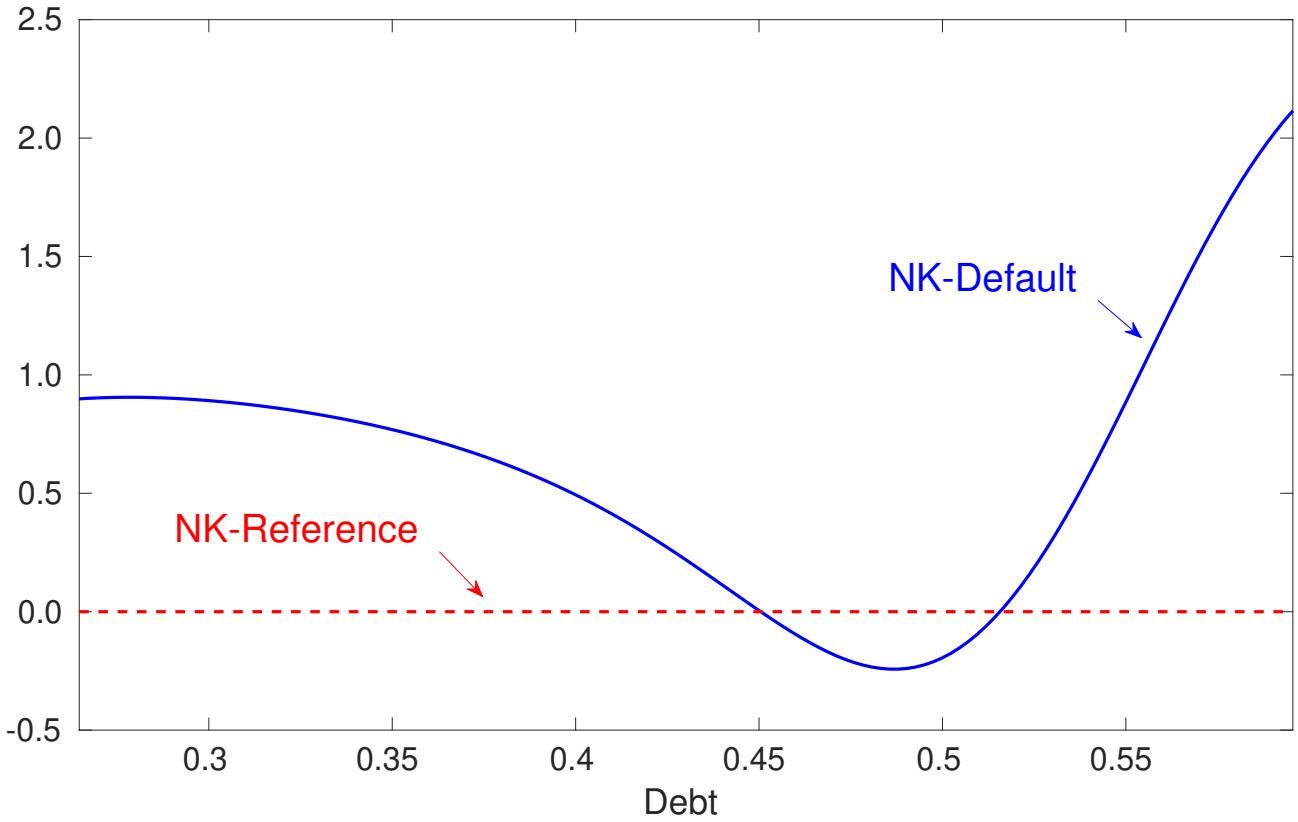
(f) Terms of Trade

Default Amplification: Monetary Wedge



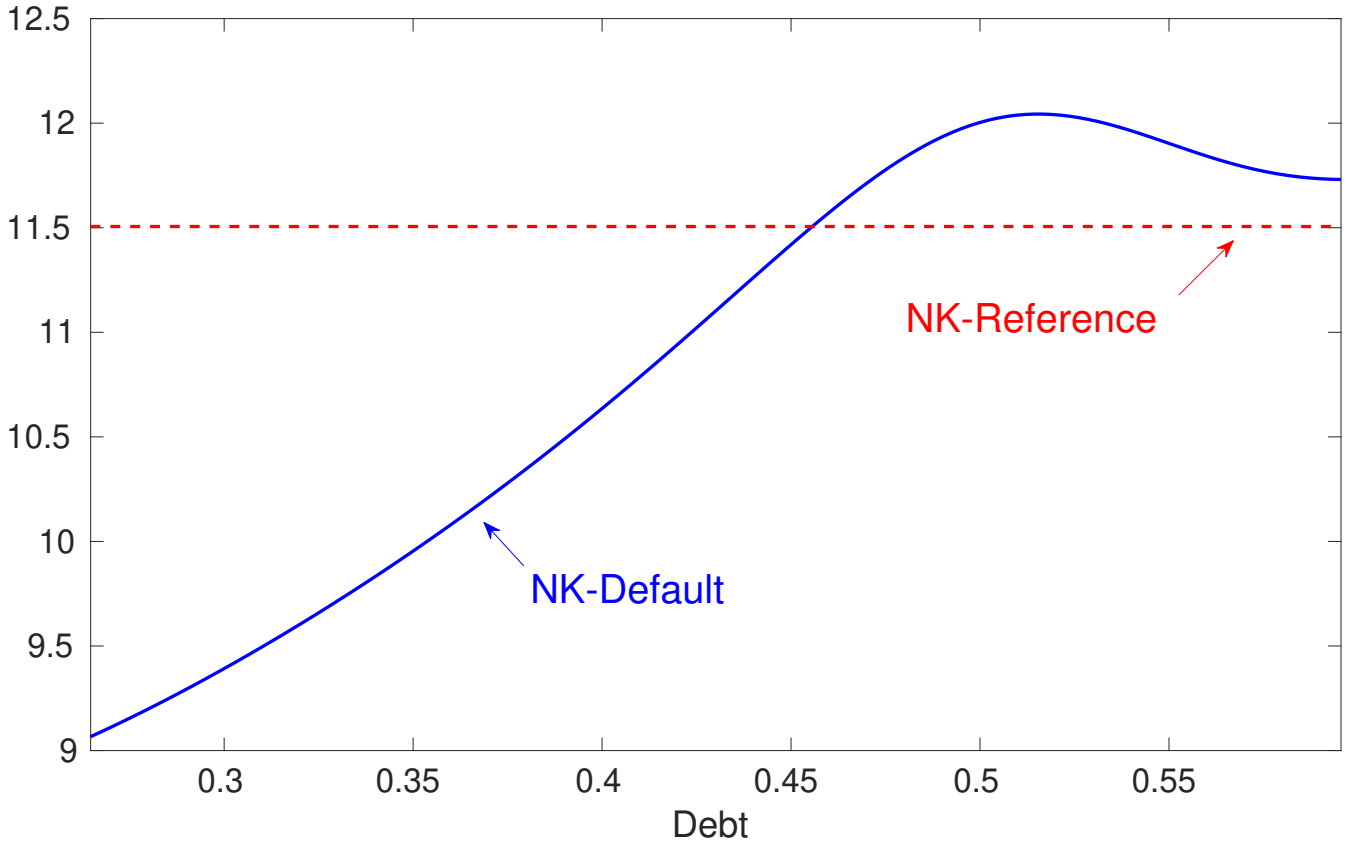
- High default zone: increasing monetary wedge
  - Default tomorrow associated with low C' and high $\pi' \rightarrow$ depresses C
- Low default zone: decreasing monetary wedge
  - Labor increases to export, pay debt, avoid default

Default Amplification: Monetary Wedge



- NK-Reference: Monetary friction not responsive to debt (lax borrowing)

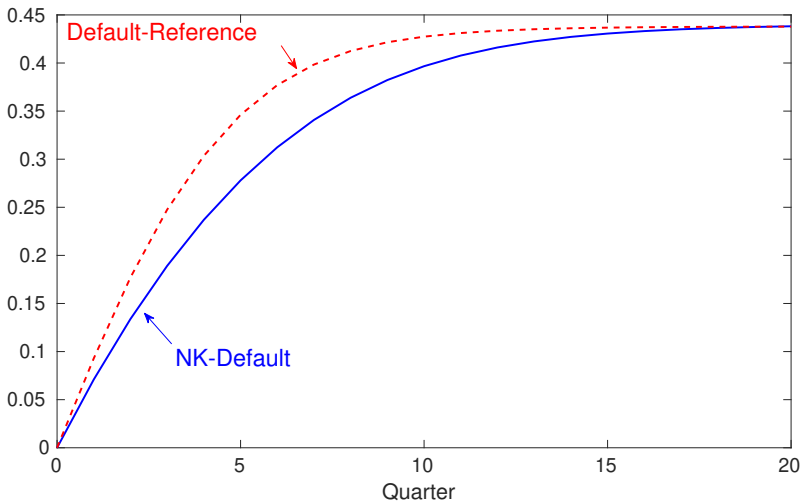
Default Amplification: Nominal Rates



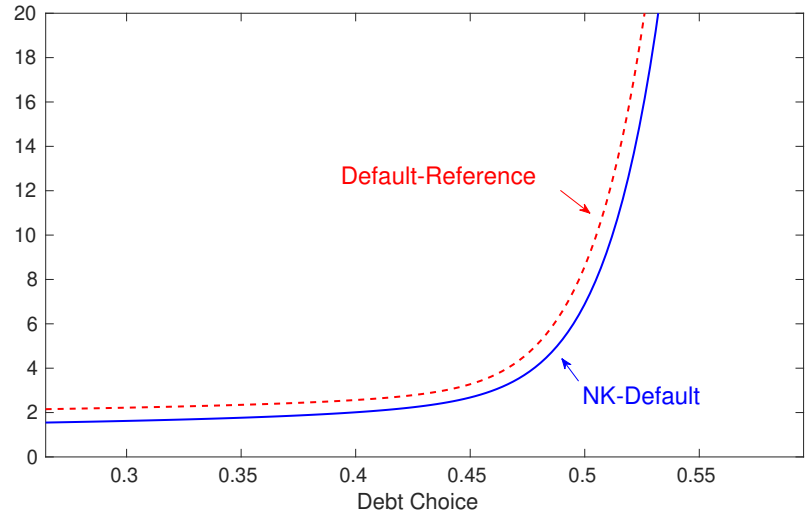
- NK-Reference: Nominal rates not responsive to debt (no tension)
- NK-Default: High nominal rates with high default risk
- High default zone: Nominal rates prevent increase in π but large monetary wedge
- Low default zone: Higher rates with higher π + lower monetary wedge

Default risk induces variability in inflation and nominal rates

Govt Borrowing: Monetary Discipline



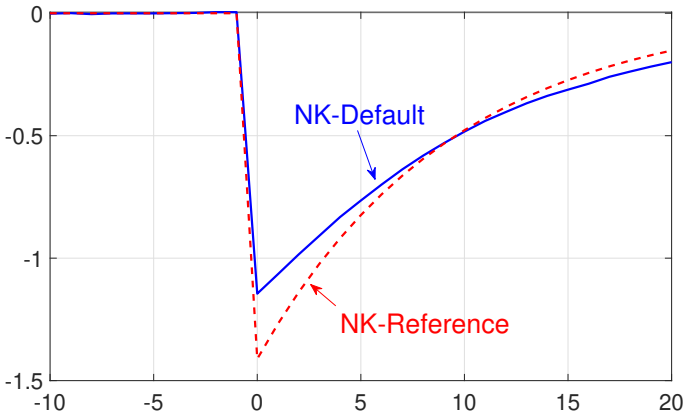
(g) Debt Accumulation



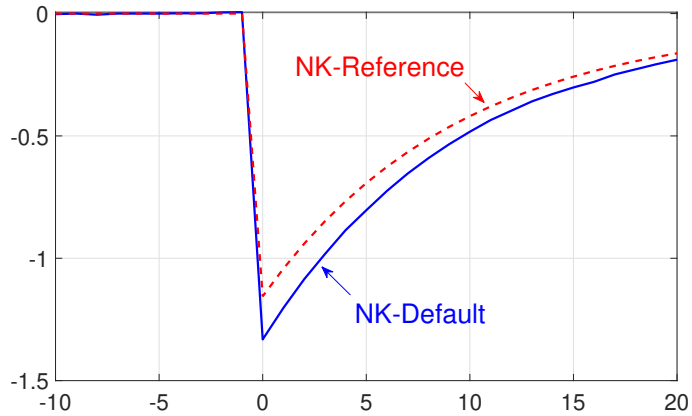
(h) Spread Schedule

- Debt accumulates more slowly in NK-Default model relative to real
- Lower borrowing makes spread schedules looser in NK-Default

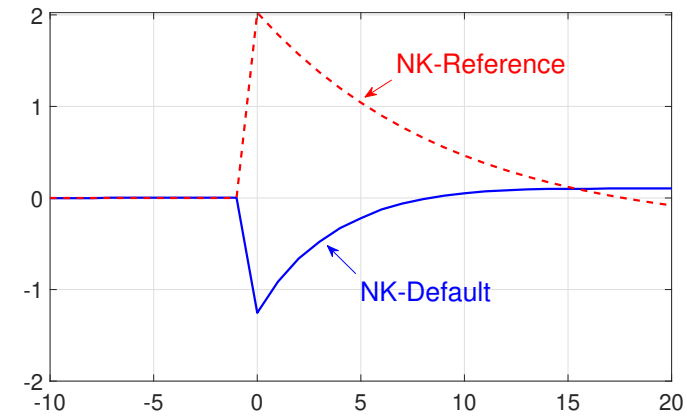
Impulse Responses to Productivity Shock



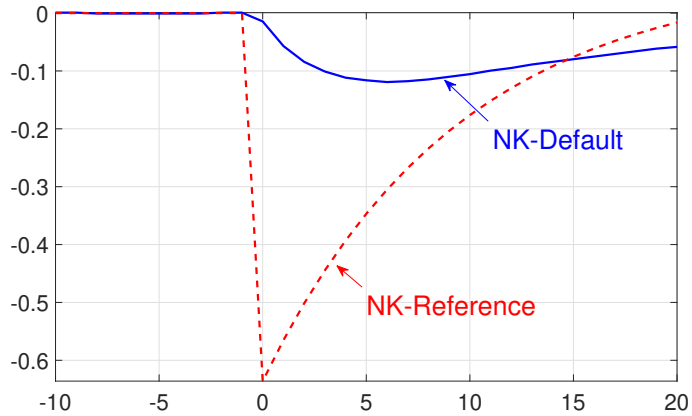
(a) Output



(b) Domestic Consumption (C)



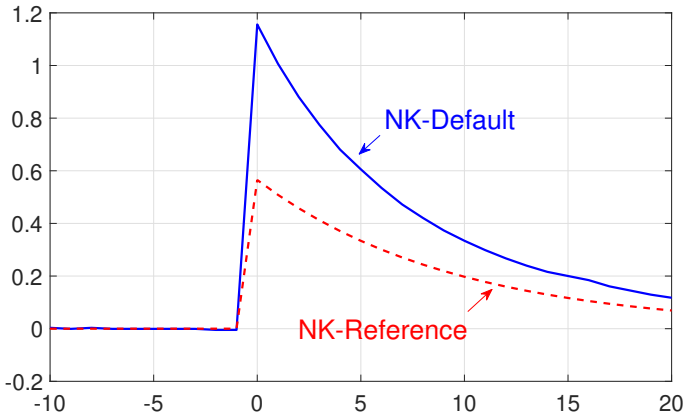
(c) Imported Consumption (C^f)



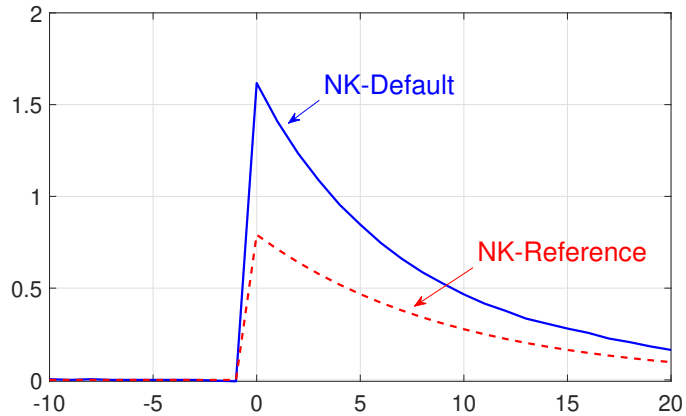
(d) Terms of Trade (e)

- Decline in domestic and imported consumption
- Smaller appreciation in benchmark $\Rightarrow$ more muted decline in export

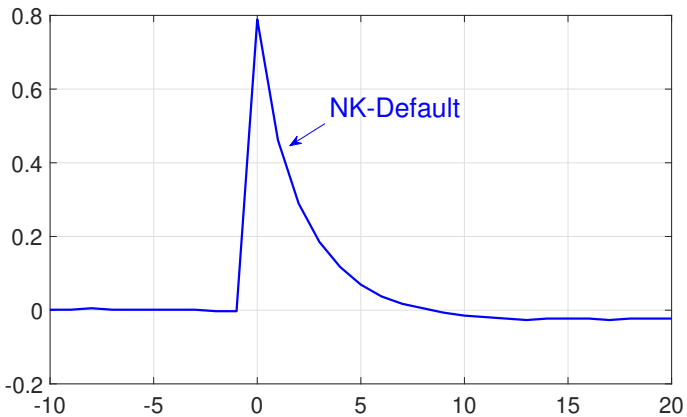
Impulse Responses to Productivity Shock



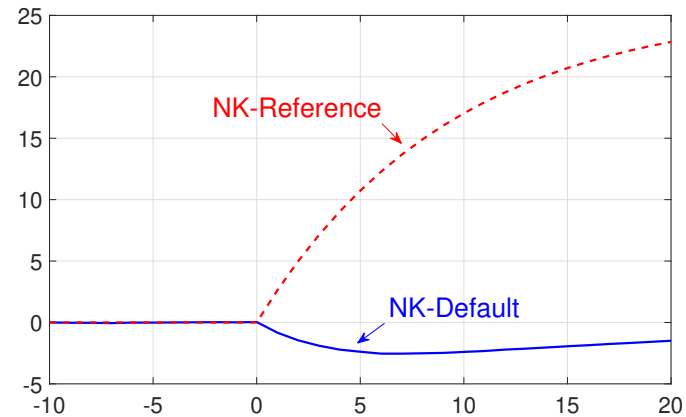
(a) Inflation (π)



(b) Nominal Interest Rate (i)



(c) Spread



(d) Debt (B)

- High nominal rates and spreads
  - Associated with recession and high inflation
- **Nominal rates respond more forcefully with default risk**

Business Cycle Moments

Mean	Data (%)	NK-Default	NK-Reference	Default-Reference
Spread	2.6	2.6	—	3.2
Standard Deviation				
CPI Inflation	1.8	1.8	1.0	0.6
Domestic Rate	2.2	2.5	1.3	1.8
Spread	0.9	0.9	—	0.8
Output	1.9	1.9	2.4	2.1
Trade Balance	0.9	0.3	1.9	0.5
Correlation with Spread				
CPI Inflation	59	60	—	−1
Domestic Rate	59	64	—	18
Output	−62	−60	—	−42
Trade Balance	61	35	—	33

- NK-Default: positive co-movement of inflation, nominal rates, and spreads
- NK-Reference: silent on spread and volatile trade balance
  - Less volatile inflation & nominal rates
  - Default risk amplifies monetary response
- Default-Reference: higher spreads without disciplining monetary friction
  - Corr of domestic rate and spread only a third

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  - Less volatile inflation & nominal rates
  - Default risk amplifies monetary response
- Default-Reference: higher spreads without disciplining monetary friction
  - Corr of domestic rate and spread only a third

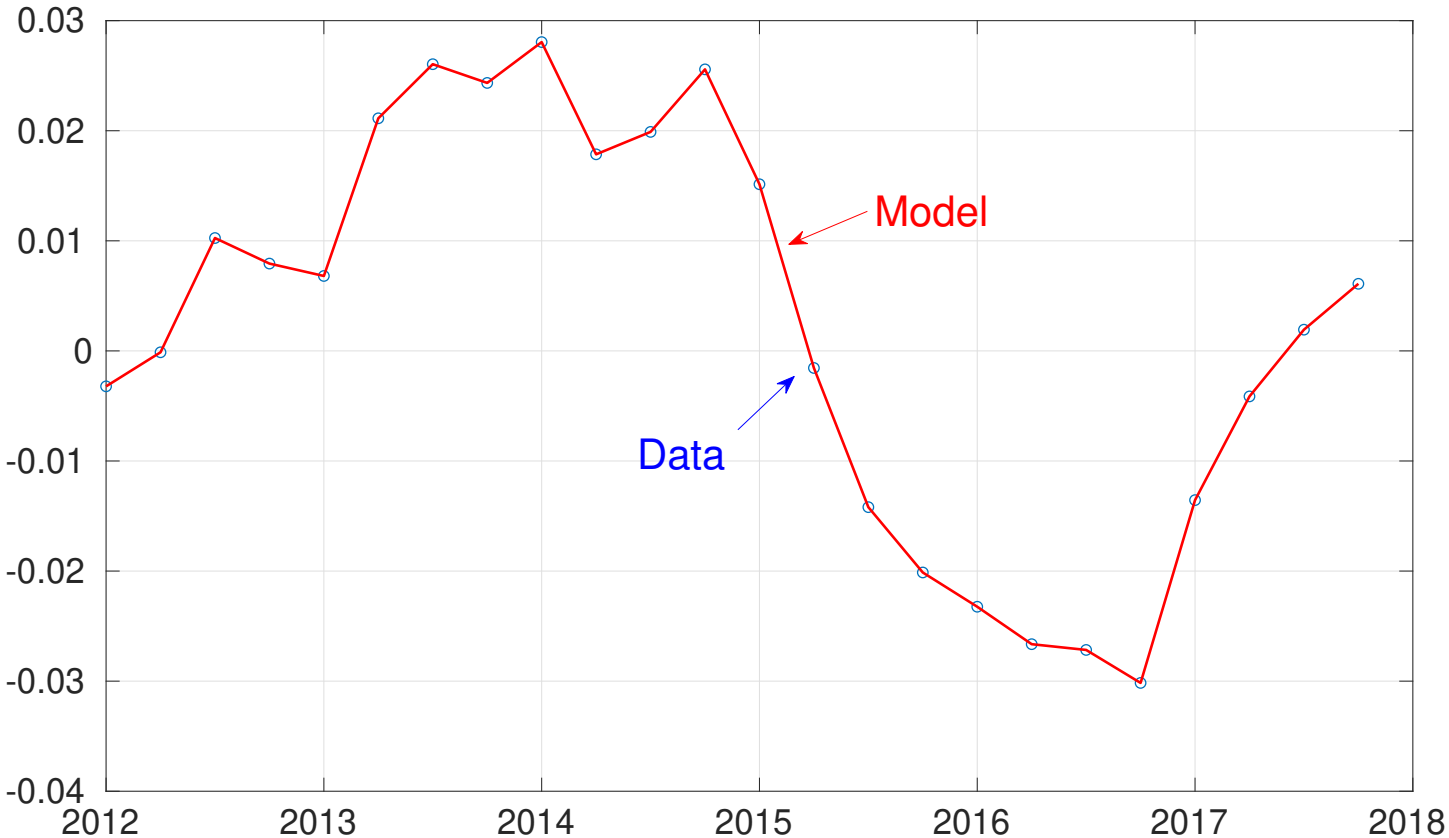
Mean	Data (%)	NK-Default	NK-Reference	Default-Reference
CPI Inflation	5.9	5.9	6.1	0.0
Domestic Rate	11.2	11.1	11.5	5.3
Spread	2.6	2.6	—	3.2
Standard Deviation				
CPI Inflation	1.8	1.8	1.0	0.6
Domestic Rate	2.2	2.5	1.3	1.8
Spread	0.9	0.9	—	0.8
Output	1.9	1.9	2.4	2.1
Trade Balance	0.9	0.3	1.9	0.5
Nominal Exchange Rate	14.7	2.4	2.0	1.9
Correlation with Spread				
CPI Inflation	59	60	—	−1
Domestic Rate	59	64	—	18
Output	−62	−60	—	−42
Trade Balance	61	35	—	33
Nominal Exchange Rate	51	45	—	−1
Correlation with GDP				
CPI Inflation	−16	−88	−81	7
Domestic Rate	−23	−96	−98	−60
Trade Balance	−77	−18	62	−23
Nominal Exchange Rate	−18	−62	−28	7

- NER right comovement with spread and output, not volatile enough
- With default risk, corr-s of TB and NER with output are more strongly negative

Event Study

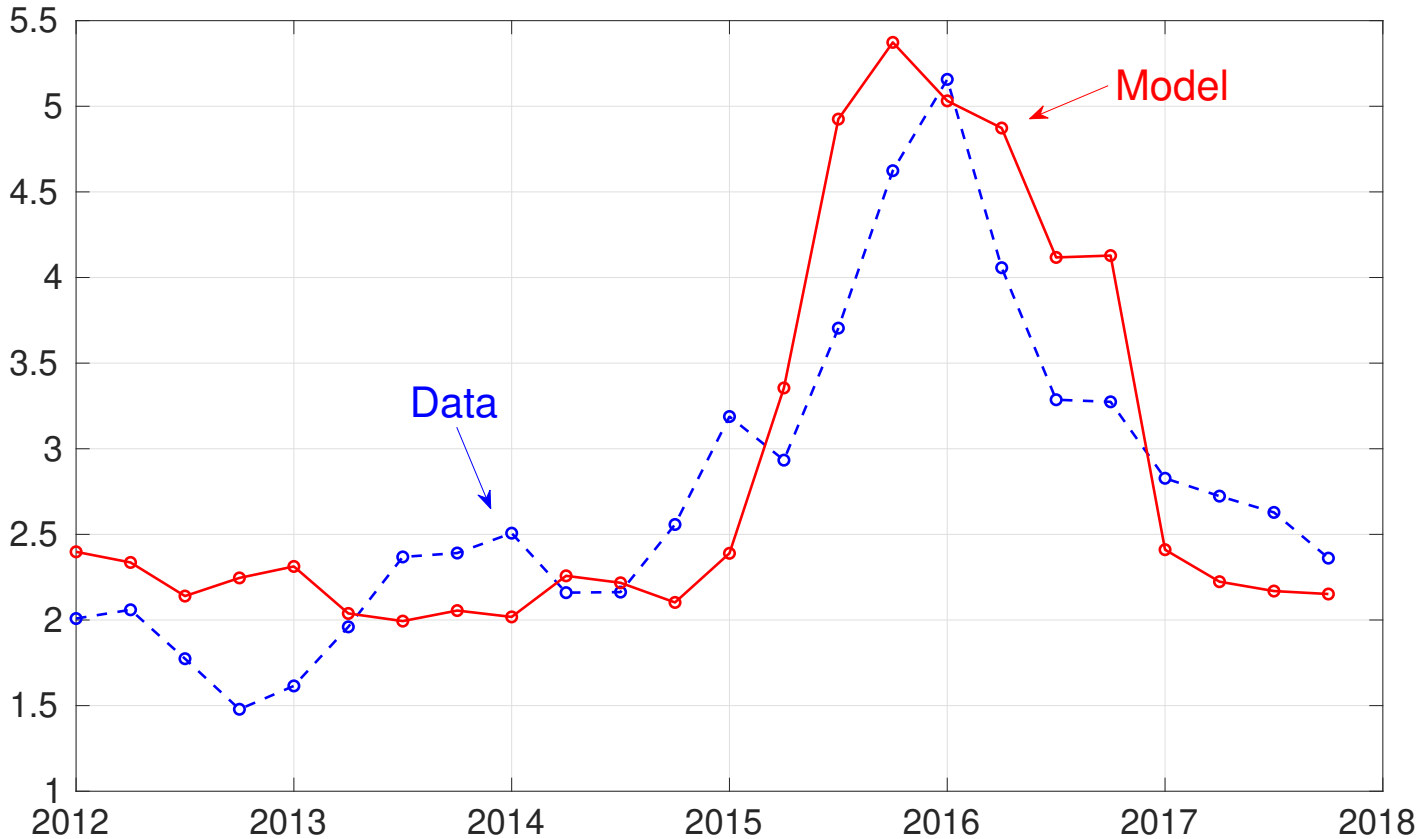
- Use Brazil data from 2012 to 2017
- Feed in a sequence of productivity shocks to replicate output path
- Model implications on inflation, spreads, and nominal rates
- Simulate counterfactual:
  loose monetary policy with low nominal rates throughout

Event: Output



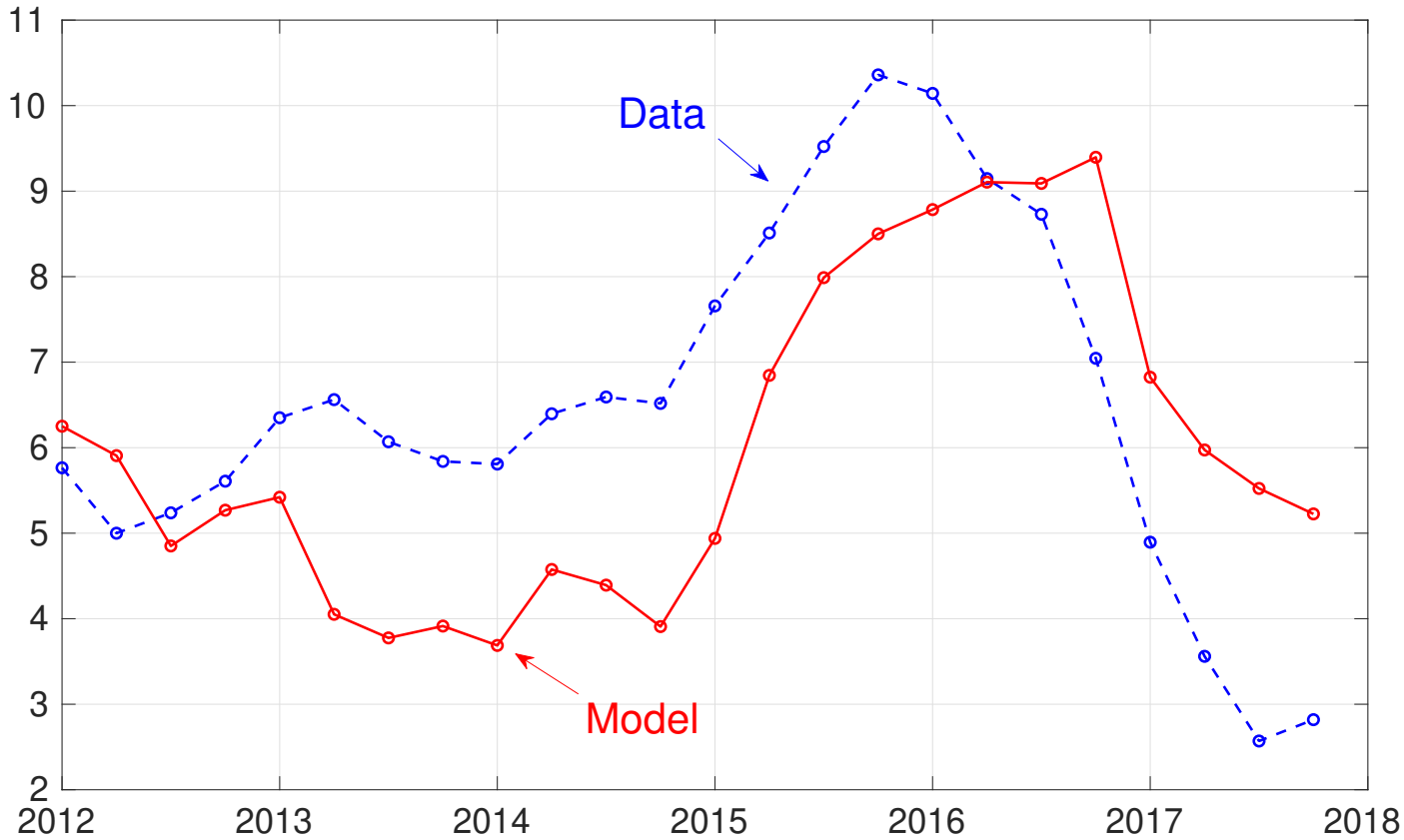
- Sequence of productivity shocks such that model matches output

Event: Spread



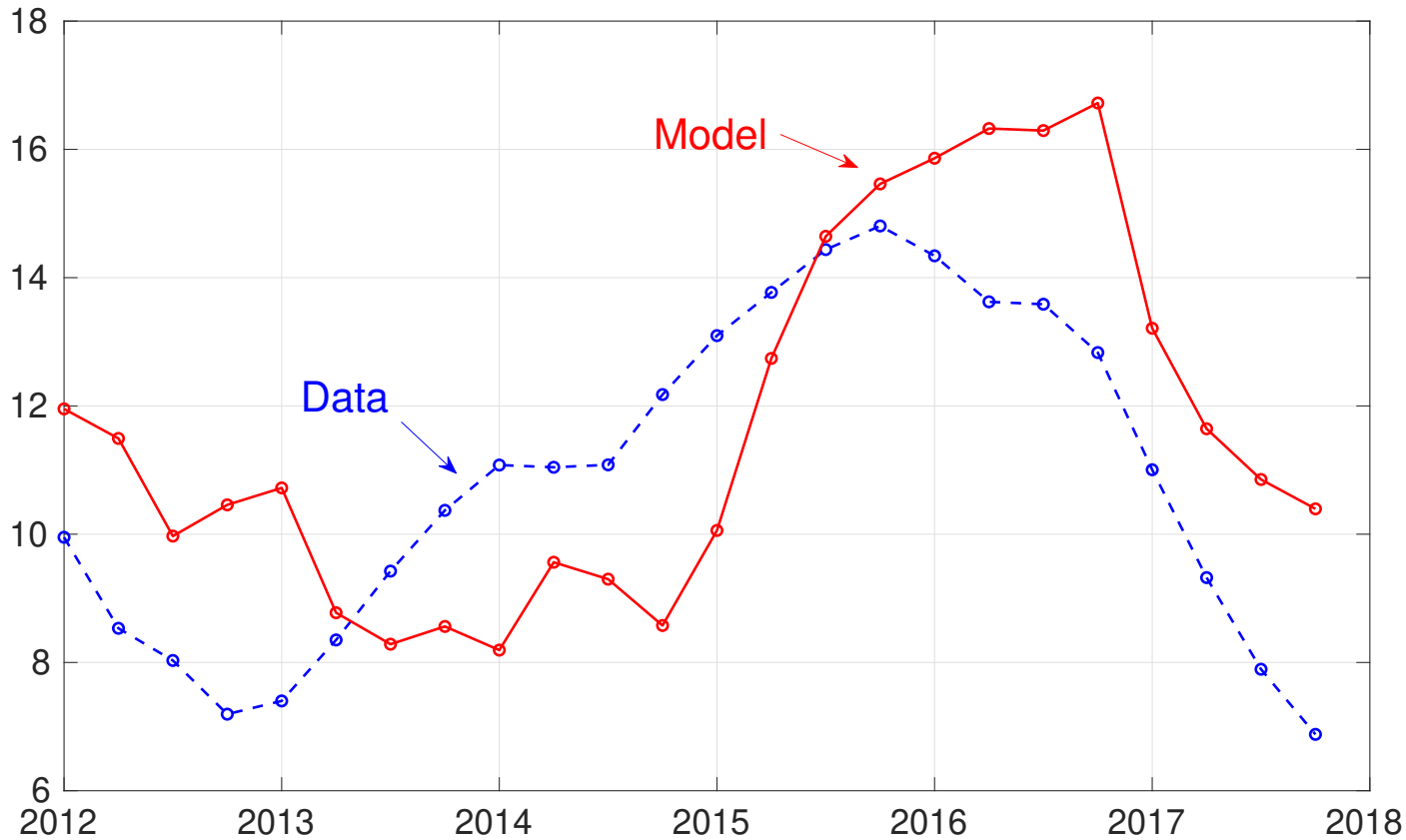
- Model generates similar increase in spreads

Event: Inflation



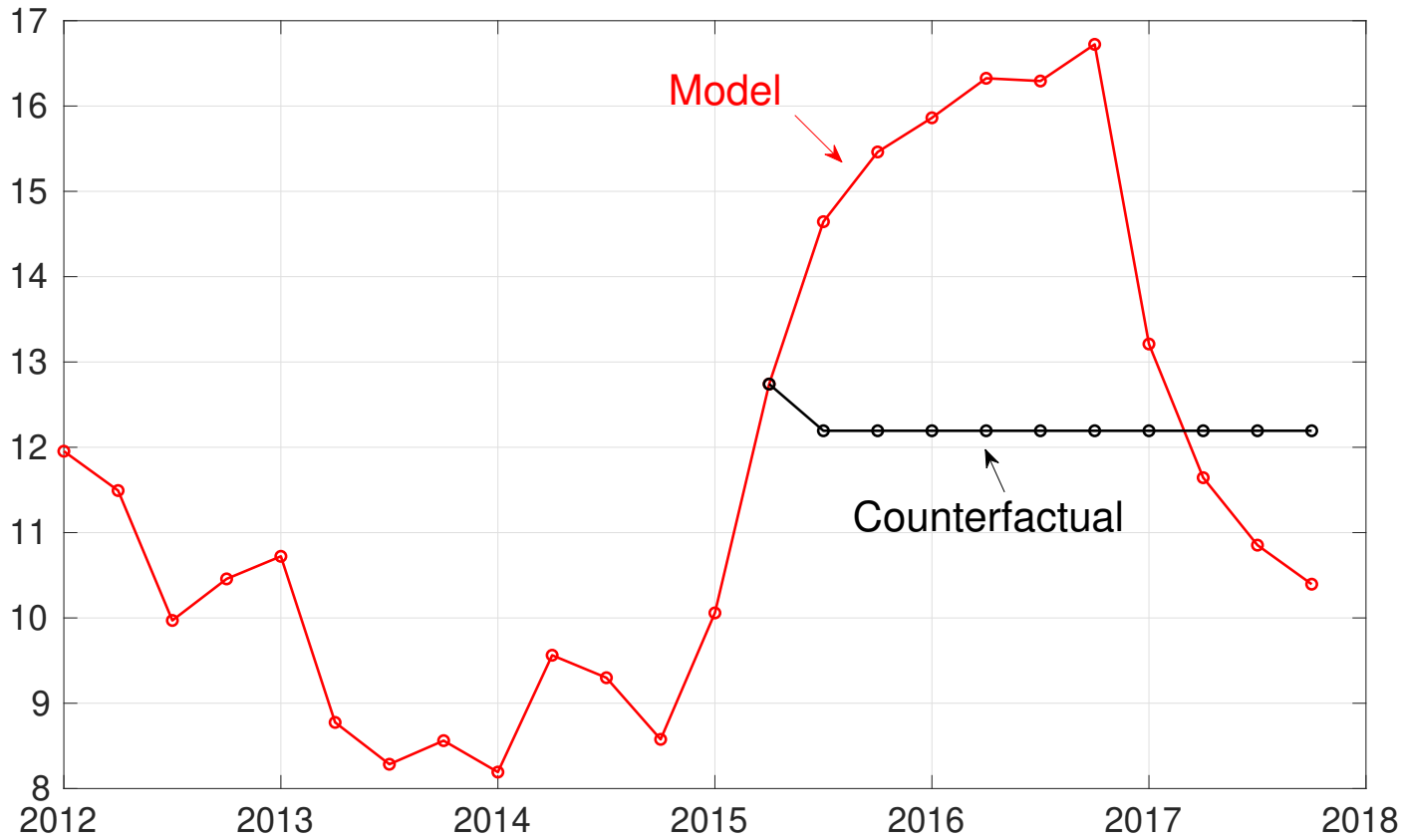
- Model generates similar increase in inflation as in the data
  higher than without default

Event: Nominal Rate



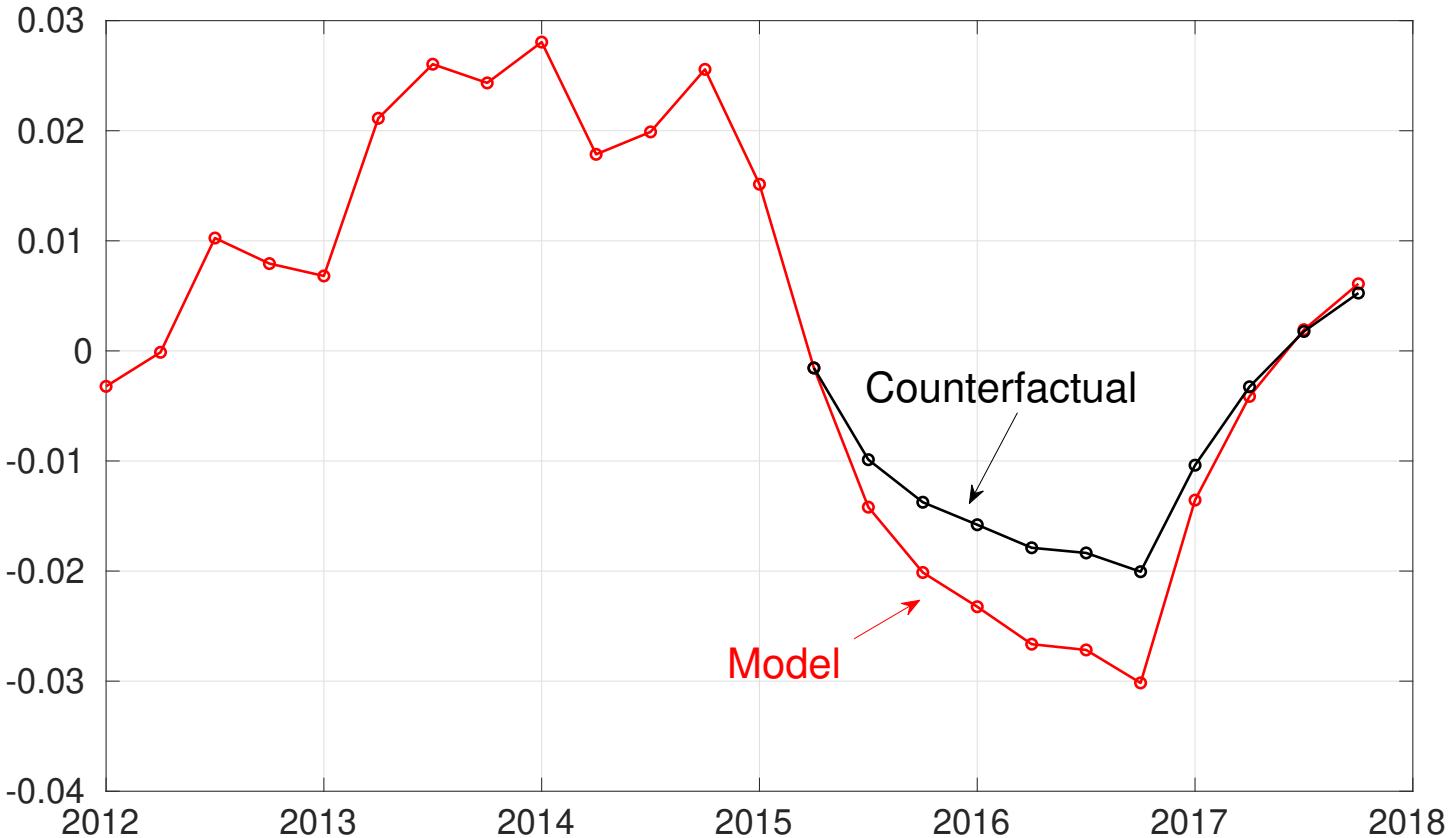
- Nominal rate increases to fight inflation
  (more aggressive than without default)

Counterfactual: Nominal Rate



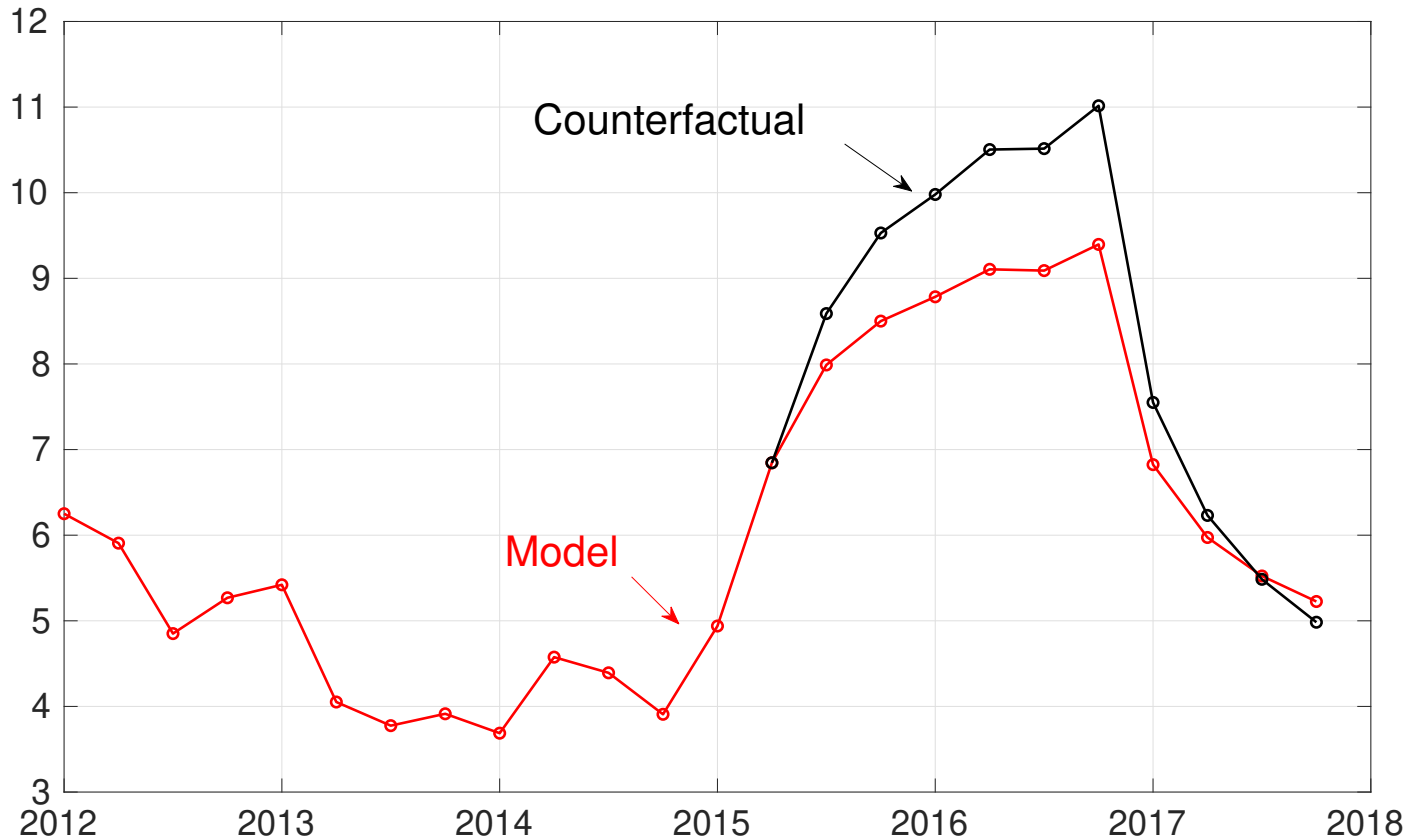
- Feed in same productivity sequence
- Keep nominal rates low

Counterfactual: Output



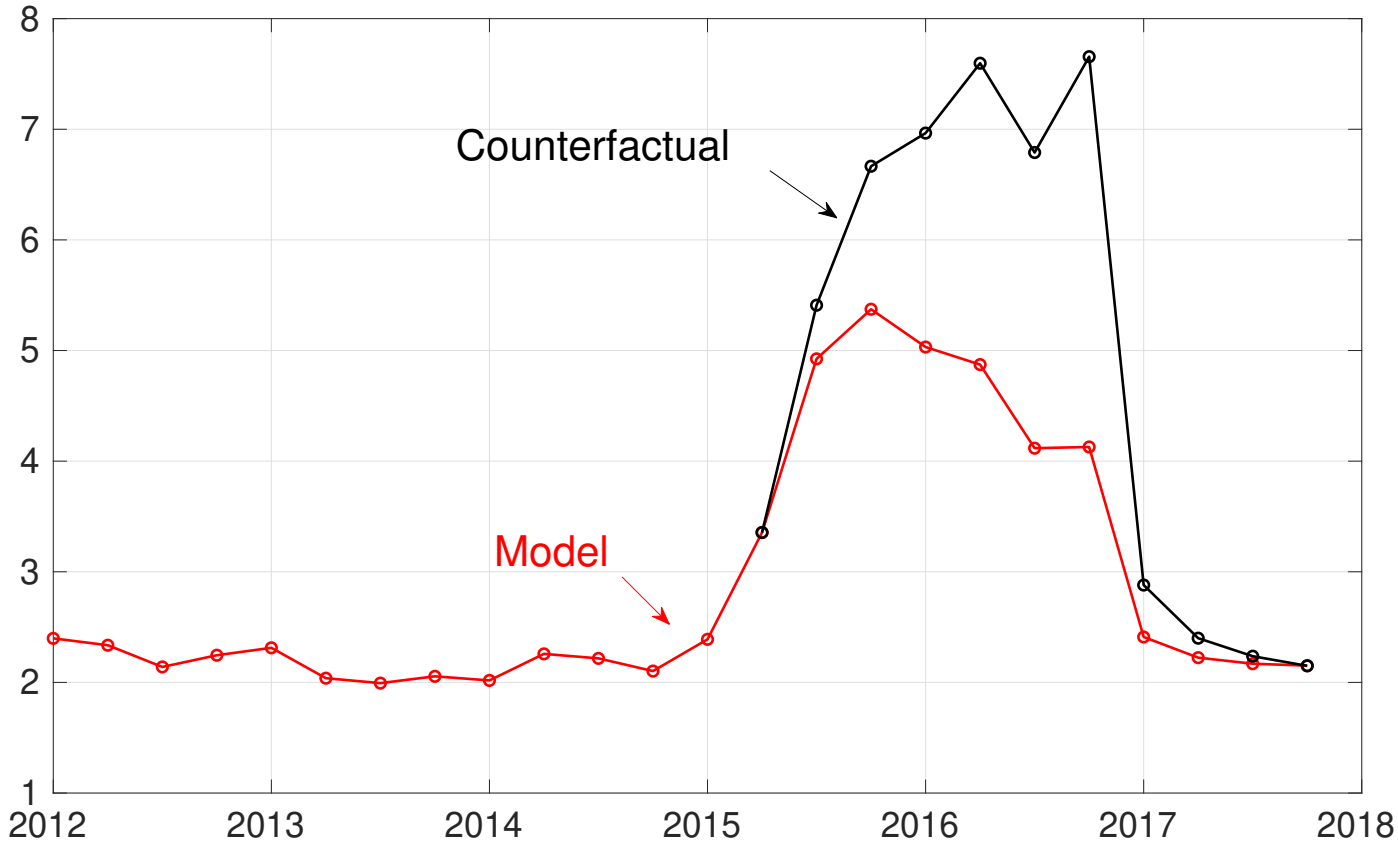
- Output falls by less with expansionary monetary policy

Counterfactual: Inflation



- Inflation increases by more with expansionary monetary policy

Counterfactual: Spread



- Expansionary monetary policy worsens the debt crisis
- Brazil's monetary policy helped with inflation and debt crisis

Robustness: Local Currency

- Local currency government debt

  balance of payment condition becomes

$$P_t^f C_t^f = P_t^d X_t + q_t(\tilde{B}_{t+1} - \delta \tilde{B}_t) - \tilde{B}_t$$

  Divided by P_t^d

$$e_t C_t^f = e_t^\rho \xi + q_t \left(B_{t+1} - \delta \frac{B_t}{\pi_t} \right) - \frac{B_t}{\pi_t}$$

  bond price schedule becomes (lender values dollar)

$$\frac{q_t}{E_t} = \frac{1}{1+r^*} \mathbf{E} \left[\frac{1}{E_{t+1}} (1 - D_{t+1})(1 + \delta q_{t+1}) \right].$$

  Replace $E_t = e_t P_t^d$

$$q_t = \frac{1}{1+r^*} \mathbf{E} \left[\frac{e_t}{e_{t+1}\pi_{t+1}} (1 - D_{t+1})(1 + \delta q_{t+1}) \right].$$

Robustness: Extended Rules

- Variants on the interest rate rule
  - Larger weight on inflation
  - Weight on output gap

$$i = \bar{i} \left(\frac{\pi_t}{\overline{\pi}} \right)^{\alpha_P} \left(\frac{Y_t}{Y_t^{\text{flex}}} \right)^{0.5} m_t$$

Robustness: Local Currency and Extended Rules

Mean	Benchmark	Local currency	Rule with larger α_P	Rule with output gap
Spread	2.6	1.9	2.9	2.7
Standard Deviation				
Inflation	1.8	1.9	1.0	1.5
Domestic Rate	2.5	2.5	1.7	2.2
Spread	0.9	0.4	0.9	0.9
Correlation with Spread				
Inflation	60	57	54	72
Domestic Rate	64	61	66	76
Welfare rel to no monetary frictions				
	$-.02$	$+.02$	$+.01$	$-.01$

Robust predictions for default amplification and monetary discipline

- Nominal nominal rates always more volatile with default (NK-reference 1.3)
- Spreads always lower with monetary frictions (Default-reference 3.2)

Welfare: Tradeoff between monetary frictions and default risk frictions

- Strict inflation targeting (no monetary frictions) not optimal
- High weight on inflation α_P and local currency debt are best

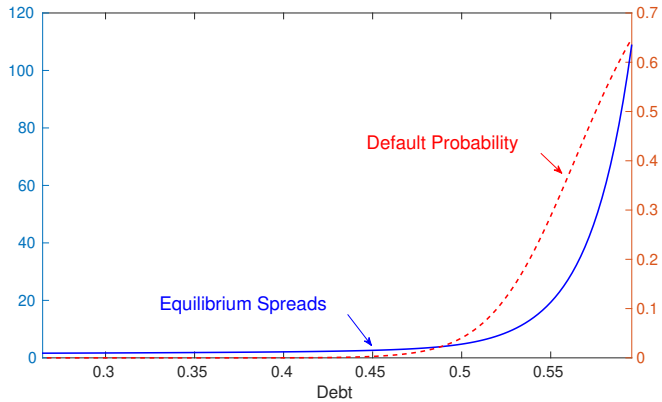
Conclusion

- Integrated framework of monetary policy and sovereign risk

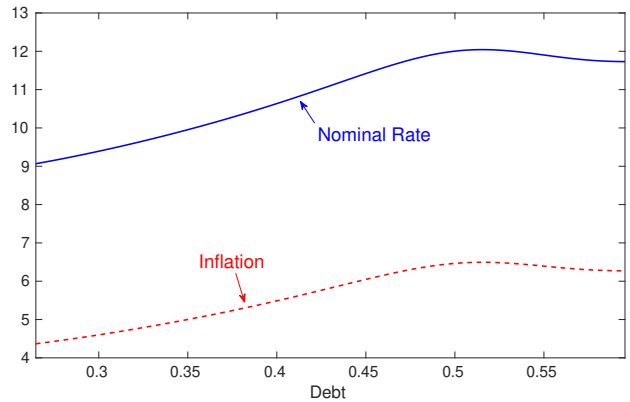
  New Keynesian model with default

- Important interactions between monetary frictions and default risk
  - Default risk amplifies monetary frictions and response
  - Monetary frictions discipline borrowing
- Model consistent with emerging market data
- Framework potentially useful for central banks

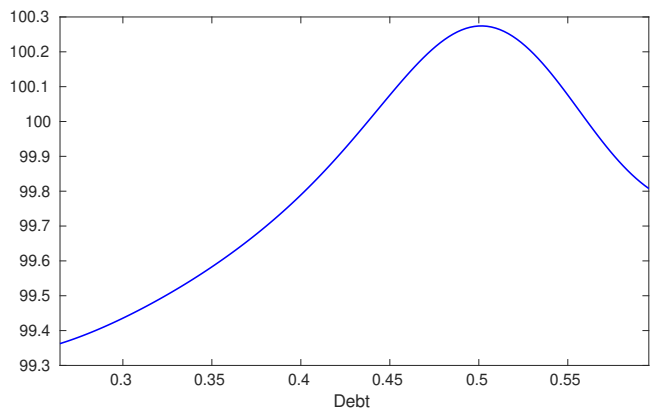
Policy Rules



(e) Spreads and Default Risk

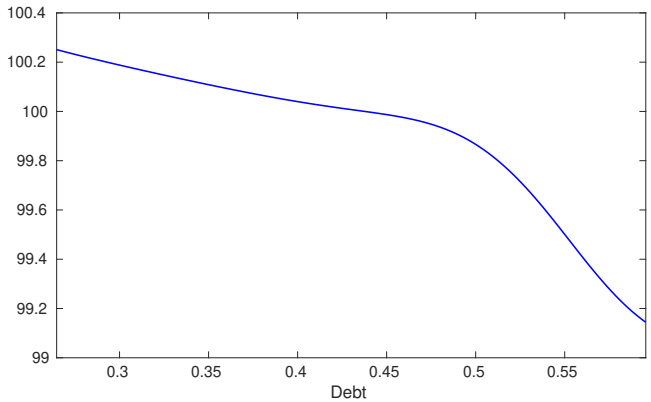


(f) Nominal Rate and Inflation

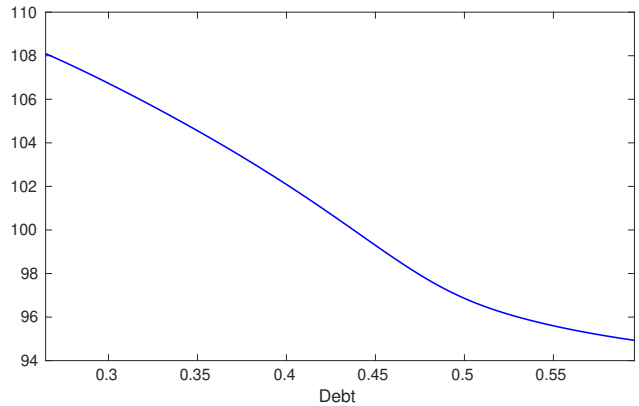


(g) Output

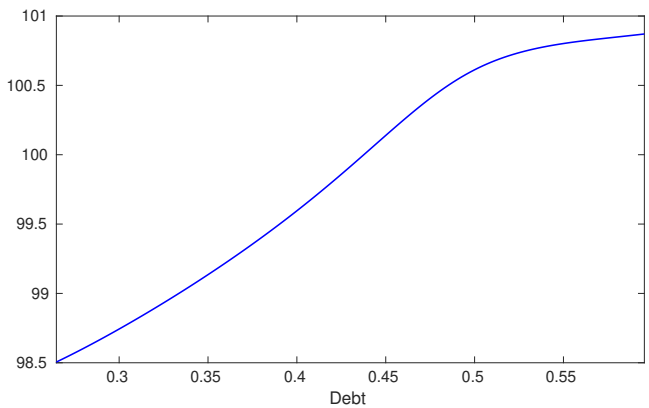
Policy Rules



(h) Domestic Consumption

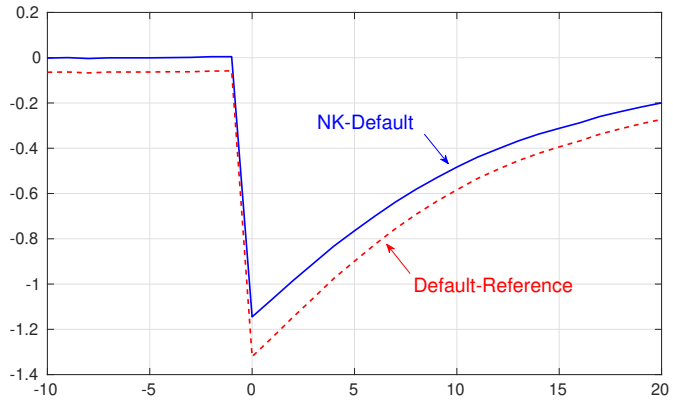


(i) Imported Consumption

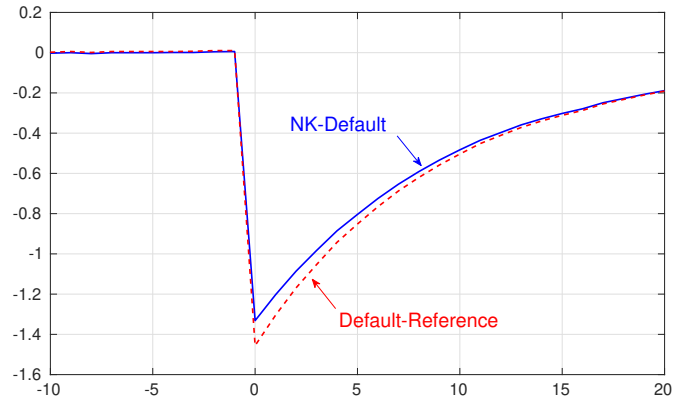


(j) Terms of Trade

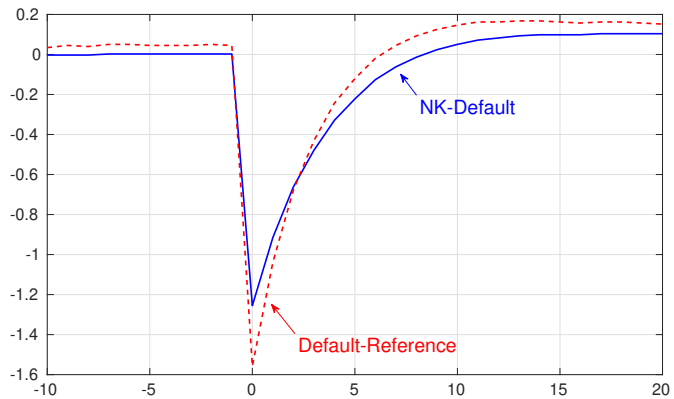
Impulse Responses to Productivity Shock



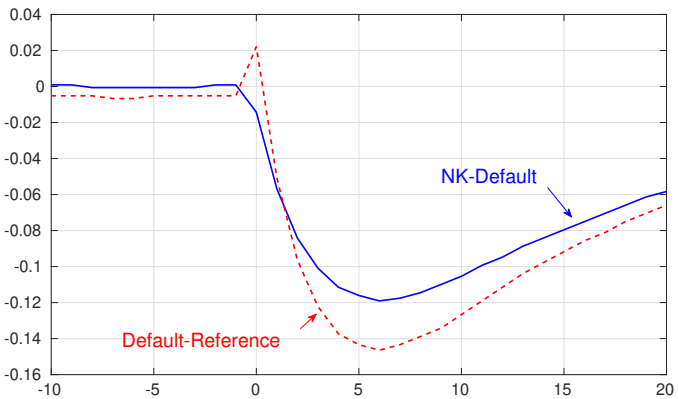
(k) Output



(l) Domestic Consumption (C)

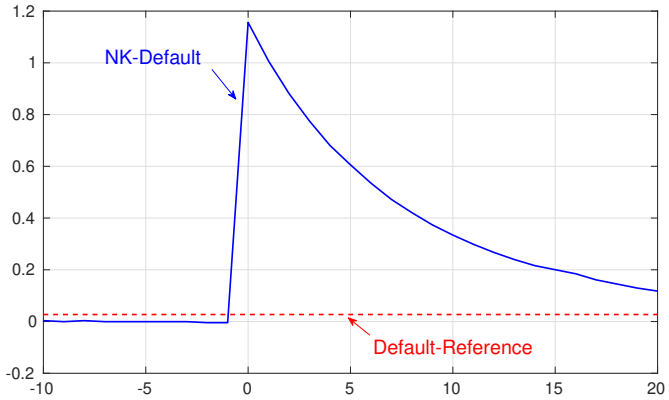


(m) Imported Consumption (C^f)

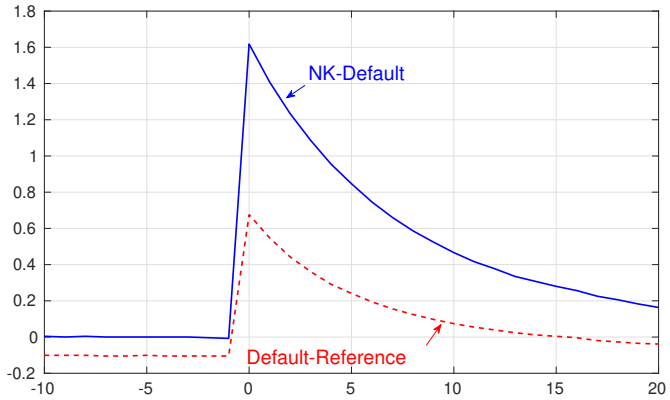


(n) Terms of Trade (e)

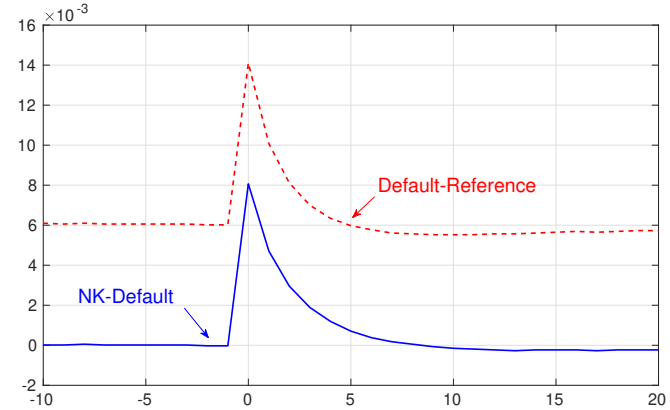
Impulse Responses to Productivity Shock



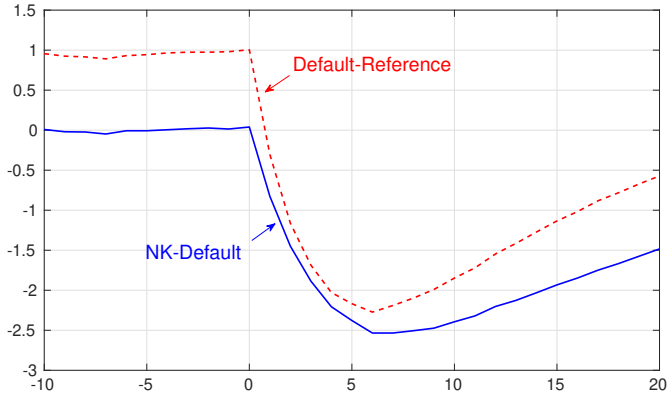
(o) Inflation (π)



(p) Nominal Interest Rate (i)



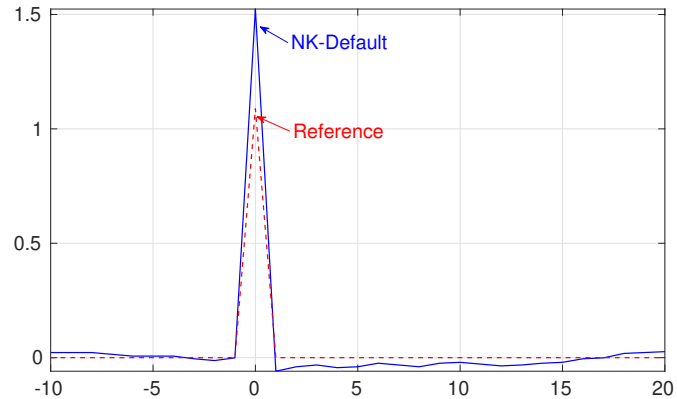
(q) Spread



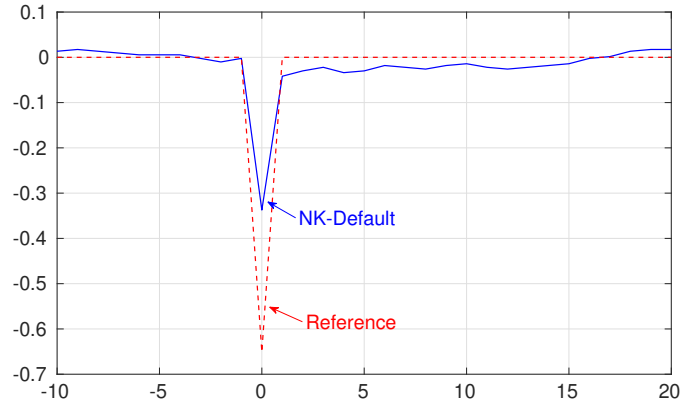
(r) Debt (B)

Real model: More muted response of inflation and nominal rates

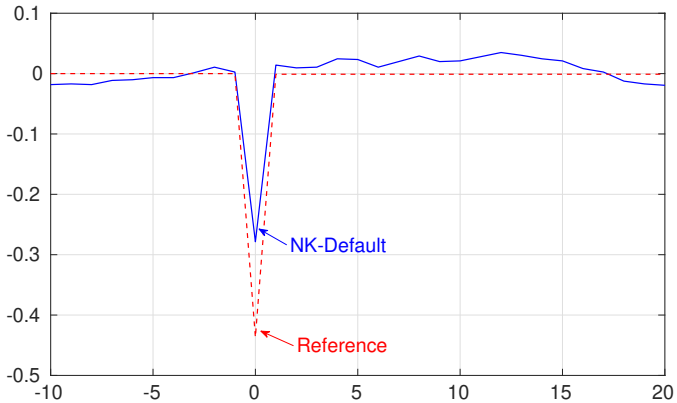
Impulse Responses to Money Shock



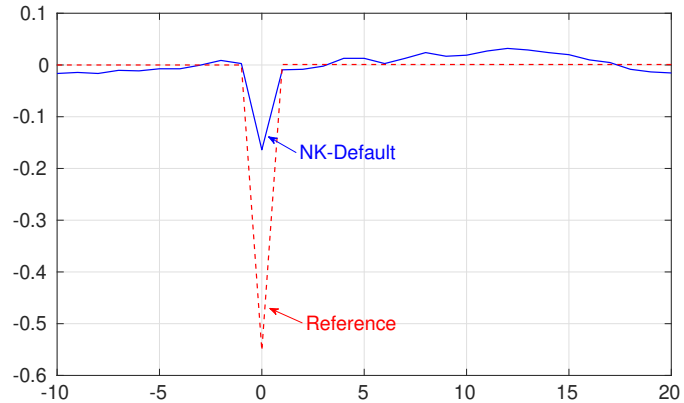
(a) Nominal Interest Rate



(b) Inflation



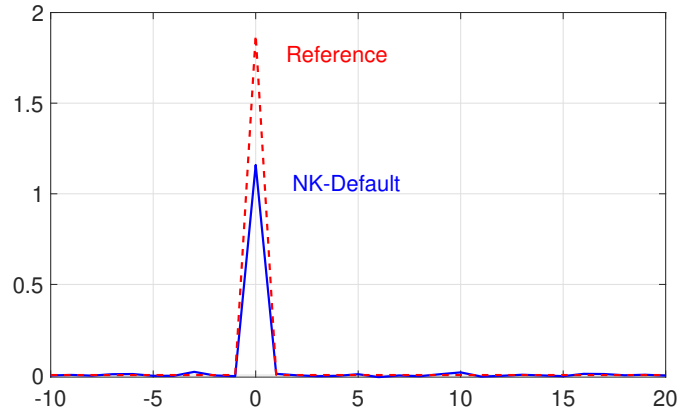
(c) Domestic Consumption



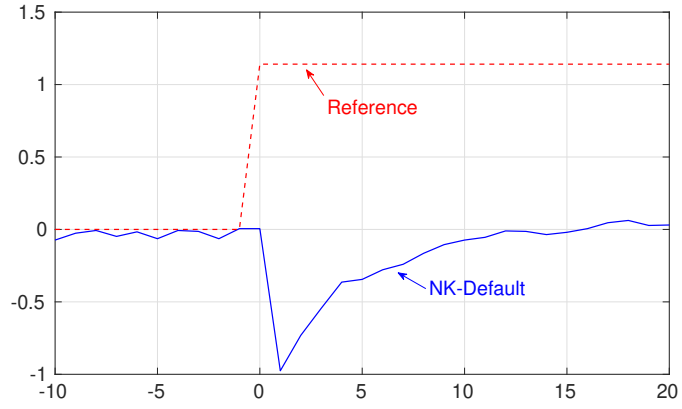
(d) Output

- High nominal rates depress inflation, consumption, and output (standard)
- NK-Default larger response of nominal rates

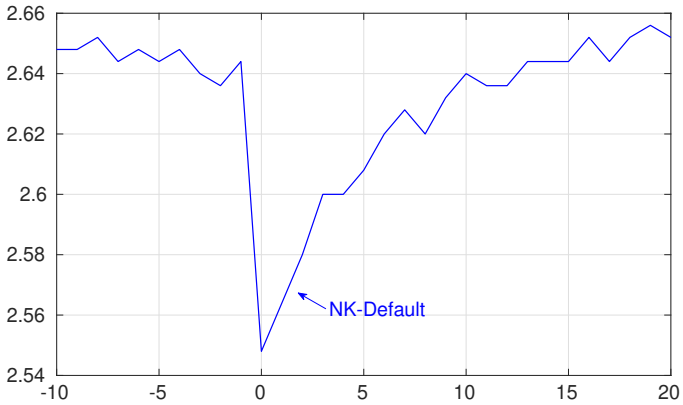
Impulse Responses to Money Shock



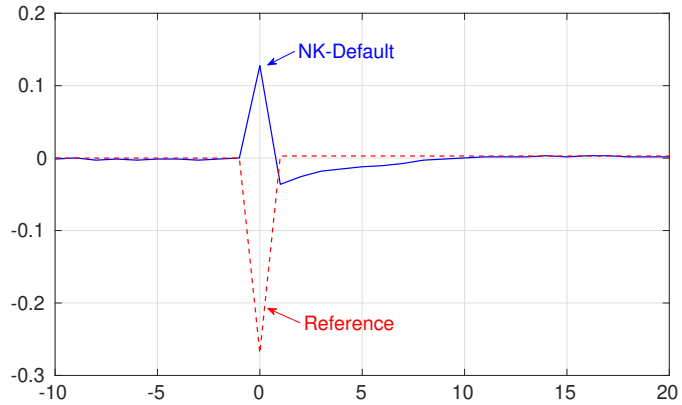
(a) Labor wedge



(b) Borrowing



(c) Spread



(d) Terms of Trade

- High i increases labor wedge $\Rightarrow$ reduces borrowing and spread (new)
- Monetary friction disciplines borrowing
- Low borrowing leads to depreciation (UIP violated in our model) ▶ TFP IRF

Parameter Values

Assigned Parameters	
Share domestic in consumption	$\theta = 0.62$
Frisch elasticity	$\zeta = 0.33$
Persistence of productivity	$\rho_z = 0.9$
Trade elasticity	$\rho = 5$
Export demand level	$\xi = 1$
Varieties elasticity	$\eta = 6$
Interest rate rule intercept	$\bar{i} = \overline{\pi}/\beta$
International rate	$r^* = 0.5\%$
Market reentry probability	$\iota = 4.17\%$
Price adjustment cost	$\varphi = 58$
Parameters from Moment Matching	
Private discount factor	$\beta = 0.9866$
Government discount factor	$\beta_g = 0.9766$
Inflation target	$\overline{\pi} = 1.015$
Interest rate rule	$\rho = 1.4$
Std of productivity shock	$\sigma_z = 0.95\%$
Productivity in default	$\lambda_0 = -0.17$
	$\lambda_1 = 0.19$
Enforcement shock	$\varrho_D = 1e^{-4}$

Back

Computation with Taste Shocks

- Sov default: Dworkin et al. (2018), Gordon (2018) and
- Consumer credit: Chatterjee et al. (2015)
- Common in structural work: multinomial logit

$$W(s,B) = \max_{B'} \left\{ H(s,B,B') + \nu_B \varepsilon_{B'} \right\}$$

Choice probabilities:

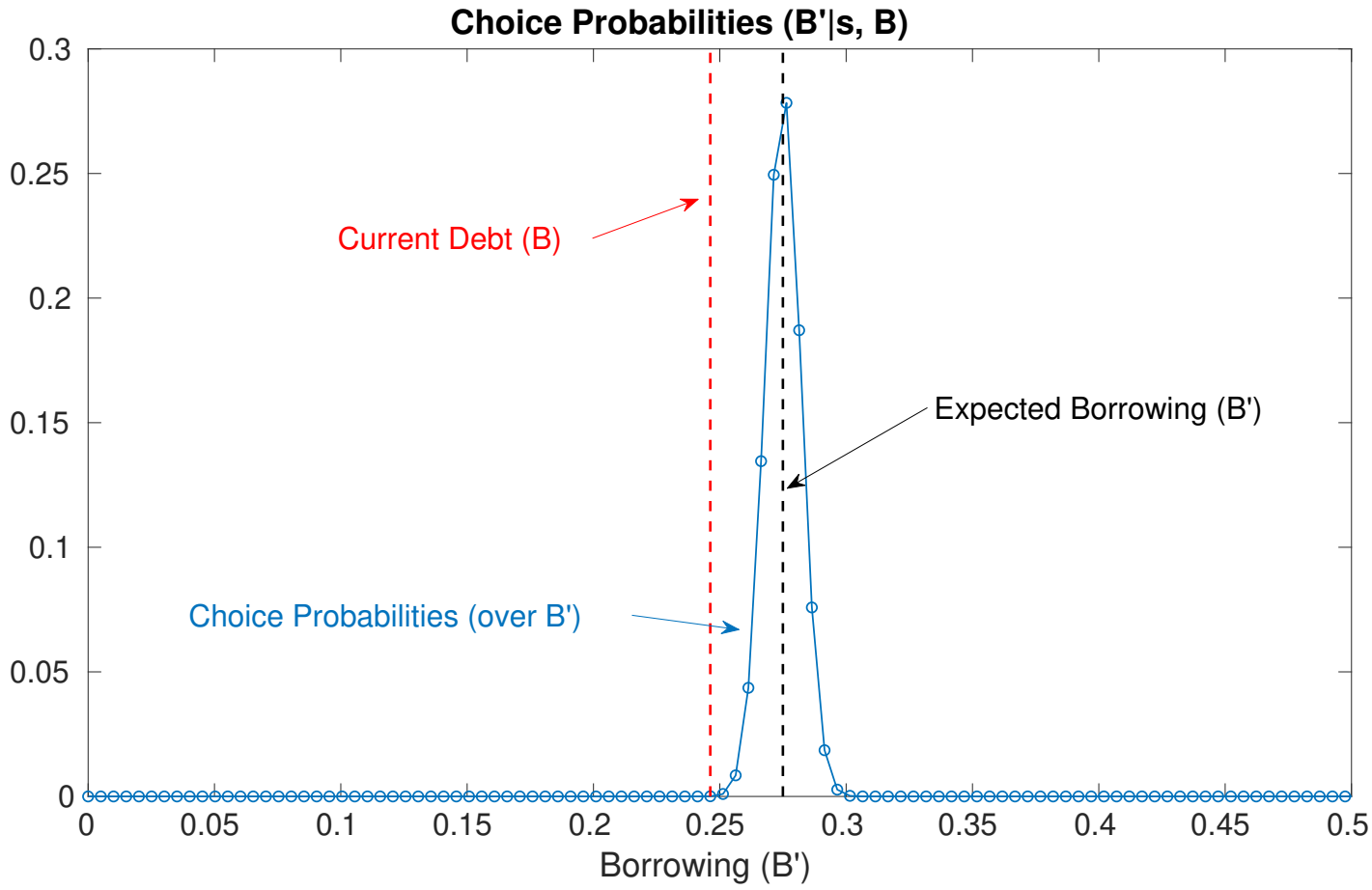
$$\Pr(B' = x) = \frac{\exp\left[\left(H(s,B,x) - \overline{H}(s,B)\right)/\nu_B\right]}{\sum_{B'} \exp\left[\left(H(s,B,B') - \overline{H}(s,B)\right)/\nu_B\right]}$$

with $\overline{H}(s,B) = \max_{B'} H(s,B,B')$ and expected value

$$W(s,B) = \overline{H}(s,B) + \nu_B \log\left\{ \sum_{B'} \exp\left[\left(H(s,B,B') - \overline{H}(s,B)\right)/\nu_B\right] \right\}$$

With $\nu_B \to 0$ recover model without taste shocks. As $\nu_B \to +\infty$ uniform choice probabilities over B'.

Back


Choice Probabilities (B'|s, B)
0.3
0.25
0.2
0.15
0.1
0.05
0
Current Debt (B)
Expected Borrowing (B')
Choice Probabilities (over B')
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Borrowing (B')

Computation with Taste Shocks II

- The default decision:

$$V(s,B) = \max\left\{W(s,B) + \nu_D \varepsilon_{\text{Repay}},\ W^d(s^d,0) + \nu_D \varepsilon_{\text{Default}}\right\}$$

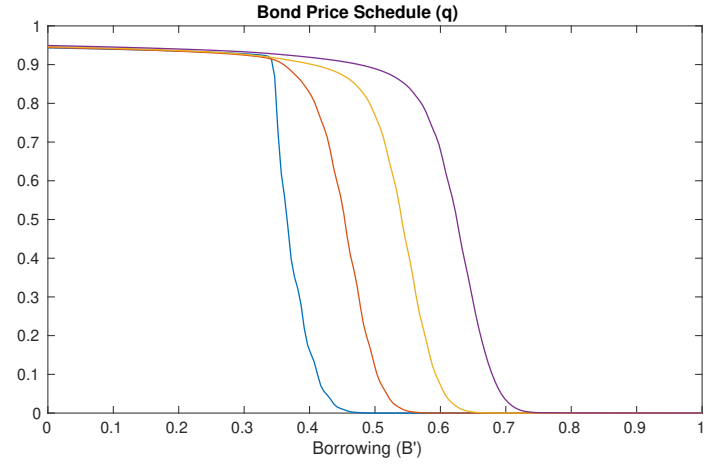
Default probability (*within* state):

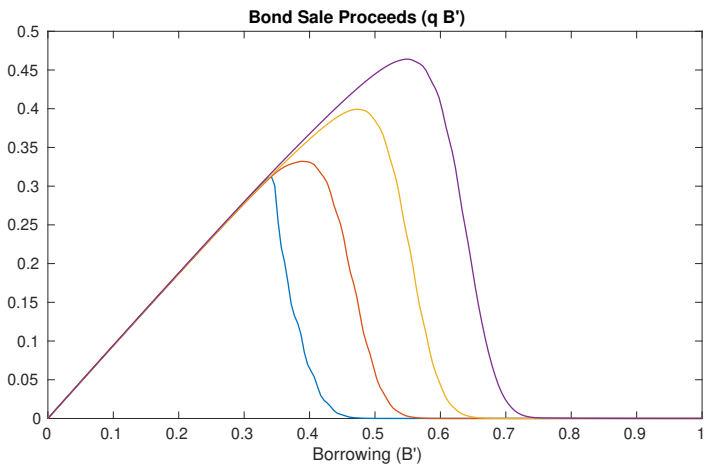
$$\tilde{D}(s,B) = \frac{\exp\left[W^d(s^d,B)/\nu_D\right]}{\exp\left[W^d(s^d,B)/\nu_D\right] + \exp\left[W(s,B)/\nu_D\right]} \in (0,1)$$

1-period ahead default probability:

$$\mathbf{E}_{s'|s}\tilde{D}(s',B')$$

Back


Bond Price Schedule (q)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Borrowing (B')


Bond Sale Proceeds (q B')
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Borrowing (B')

Monetary wedge

$$u_{Cf}\left[q+\frac{dq}{dB'}\left(B'-\delta B\right)\right]\left(1-\tau(s,B')\right)$$
$$=\beta\mathbf{E}_{s'|s}\left\{(1-H_D(s',B'))u'_{Cf}\left[1+\delta q(s',H_B(s',B'))\right]\left[1-\hat{\tau}(s',H_B(s',B'))\right]\right\}.$$

$$\hat{\tau}(s,B')=\hat{G}_\kappa(s,B')\kappa(s,B')+\hat{G}_\gamma(s,B')\gamma(s,B')$$
$$\tau(s,B')=\hat{\tau}(s,B')+G_\kappa(s,B')\frac{\partial M(s,B')}{\partial B'}\kappa(s,B')+G_\gamma(s,B')\frac{\partial F(s,B')}{\partial B'}\gamma(s,B')$$

$$\hat{G}_\kappa(s,B')=m_\ell(s,B')u_C$$
$$\hat{G}_\gamma(s,B')=m_\ell(s,B')\left(\frac{u_n}{zu_C}+\frac{1}{zNu_C}F(s,B')\right)$$
$$G_\kappa(s,B')=\frac{u_C}{M(s,B')u_{Cf}\left[q+\frac{dq}{dB'}\left(B'-(1-\delta)B\right)\right]}$$
$$G_\gamma(s,B')=\frac{1}{u_CzNu_{Cf}\left[q+\frac{dq}{dB'}\left(B'-(1-\delta)B\right)\right]}$$
$$m_\ell(s,B')=\left[\frac{1}{\rho}\frac{\rho\frac{1}{\rho-1}e^{1-\rho}C^f+1}{\rho\frac{1}{\rho-1}e^{1-\rho}u_CCC^f+u_CC+u_{Cf}C^f}+\frac{\rho-1}{\rho}\right]$$

Back

Simple Model

Simple Example

- Two periods
- Fully rigid prices in period 1, flexible in period 2
- Preferences linear in imported goods

$$u(C_t, C_t^f, N_t) = \log C_t + C_t^f - \frac{N_t^{1+1/\zeta}}{1+1/\zeta}$$

- Only shock: default cost shock ν in period 2
- Central bank fixes nominal rate at i_1

Period 2 (Flexible Prices)

- Private equilibrium under govt repayment

$$C_2 + e_2^{\rho} = zN_2, \quad C_2 = \frac{\rho}{\rho - 1} e_2, \quad \frac{u_{N_2}}{u_{C_2}} = N_2^{\frac{1}{\zeta}} C_2 = z, \quad e_2^{\rho} = e_2 \left(C_2^f + B \right)$$

- Private equilibrium under govt default

$$C_{2d} + e_{2d}^{\rho} = z_d N_{2d}, \quad C_{2d} = \frac{\rho}{\rho - 1} e_{2d}, \quad \frac{u_{N_{2d}}}{u_{C_{2d}}} = N_{2d}^{\frac{1}{\zeta}} C_{2d} = z_d, \quad e_{2d}^{\rho} = e_{2d} C_{2d}^f$$

- Domestic consumption is lower under default, $C_{2d} \leq C_2$

Period 2 (Flexible Prices)

- Private equilibrium under govt repayment

$$C_2 + e_2^\rho = zN_2, \quad C_2 = \frac{\rho}{\rho - 1} e_2, \quad \frac{u_{N_2}}{u_{C_2}} = N_2^{\frac{1}{\zeta}} C_2 = z, \quad e_2^\rho = e_2 \left(C_2^f + B \right)$$

- Private equilibrium under govt default

$$C_{2d} + e_{2d}^\rho = z_d N_{2d}, \quad C_{2d} = \frac{\rho}{\rho - 1} e_{2d}, \quad \frac{u_{N_{2d}}}{u_{C_{2d}}} = N_{2d}^{\frac{1}{\zeta}} C_{2d} = z_d, \quad e_{2d}^\rho = e_{2d} C_{2d}^f$$

- Domestic consumption is lower under default, $C_{2d} \leq C_2$
- Default cost shock and threshold

$$\max \left\{ W_2(B), W_2^d - \nu \right\} \quad \Rightarrow \quad \nu^*(B) = \underbrace{\mathcal{U}(C_{2d}, z_d) - \mathcal{U}(C_2, z)}_{\text{independent of } B} + B$$

- Bond price schedule

$$q(B) = \frac{1}{1 + r} \left[1 - \Phi(\nu^*(B)) \right]$$

Private and Monetary Equilibrium in Period 1

Domestic Euler: $\frac{1}{C_1} = \frac{\beta i_1}{\tilde{\pi}_2}\left[\frac{1-\Phi(\nu^*(B_1))}{C_2} + \frac{\Phi(\nu^*(B_1))}{C_{2d}}\right]$

Relative consumption: $C_1 = \frac{\rho}{\rho-1} e_1$

Balance of payments: $e_1^{\rho-1} = C_1^f - q(B_1)B_1$

Resource constraint: $C_1 + e_1^{\rho} = z_1 N_1$

Proposition. A higher B_1 increases default risk and increases the monetary wedge

- Lower expected consumption: more likely low C_{2d}
  - Domestic Euler calls for decline in current domestic consumption C_1
- Terms of trade increase
- Lower $(C_1 + X_1)$ lowers labor $N_1 \rightarrow$ increases monetary wedge

Increasing default risk increase monetary frictions

Optimal Borrowing Without Pricing Frictions

$$\underbrace{1-\Phi(\nu^*(B_1))}_{q}\underbrace{-\phi(\nu^*(B_1))}_{\partial q/\partial B'}B_1 = (1+r)\beta_G\left(1-\Phi(\nu^*(B_1))\right)$$

$\Rightarrow$

$$h(B_1)B_1 = 1-\beta_G(1+r)$$

where

$$h(B_1) \equiv \frac{\phi(\nu^*(B_1))}{1-\Phi(\nu^*(B_1))}$$

- Hazard of default probability equal the front-loading benefit

Optimal Borrowing With Pricing Frictions

$$h(B_1)B_1 + \frac{\tau_m(i_1, B_1)}{1 - \Phi(v^*(B_1))} = 1 - \beta_G(1+r)$$

with borrowing wedge $\tau_m(i_1, B_1)$ from monetary frictions

$$\tau_m^C(i,B) = \left(1 - \frac{u_{N_1}(B)}{u_{C_1}(B)}\right) \underbrace{[1 + (\rho-1)e_1(B)^{\rho-1}]C_1(B)\phi(v^*(B))\frac{\beta i}{\tilde{\pi}}\left(\frac{1}{C_{2d}} - \frac{1}{C_2}\right)}_{>0}$$

Using the definition of monetary wedge m.wedge $= zu_C/u_N - 1$

$$\tau_m(i_1, B_1) = \left(\frac{\text{m. wedge}}{1 + \text{m. wedge}}\right) \underbrace{[1 + (\rho-1)e_1(B_1)^{\rho-1}]C_1(B_1)\phi(v^*(B_1))\frac{\beta i_1}{\tilde{\pi}_2}\left(\frac{1}{C_{2d}} - \frac{1}{C_2}\right)}_{>0}$$

where $B_1 \uparrow \Rightarrow$ m. wedge $\uparrow$ and $i_1 \uparrow \Rightarrow$ m. wedge $\uparrow$

Under zero monetary wedge, the borrowing wedge $\tau_m = 0$.

Disciplining. Positive monetary wedge associated with positive borrowing wedge $\tau_m > 0$ and low marginal benefit of borrowing.

Government Borrowing

- **Efficient production, patient gov't:** $u_{N_1}/u_{C_1} = z_1, \beta_G = \beta$

$$h(B_1)B_1 = 1 - \beta(1+r)$$

Constrained efficient default risk
(Given market incompleteness and lack of commitment.)

- **Flexible prices or strict IT, efficient production:** $u_N/u_C = z_1 \Rightarrow \tau_m = 0$

$$h(B_1)B_1 - r(\beta - \beta_G) = 1 - \beta(1+r)$$

Overborrowing wedge $-r(\beta - \beta_G) \leq 0$ reduces marginal cost

- **Benchmark NK-Default model**

$$h(B_1)B_1 - r(\beta - \beta_G) + \frac{\tau_m(i_1, B_1)}{1 - \Phi(\nu^*(B_1))} = 1 - \beta(1+r)$$

Overborrowing wedge (< 0) &
Borrowing wedge from monetary friction (> 0 if monetary wedge > 0)

Two Sub-optimal Extremes

$$h(B_1)B_1 - r(\beta - \beta_G) + \frac{\tau_m(i_1, B_1)}{1 - \Phi(\nu^*(B_1))} = 1 - \beta(1+r)$$

- Get *production efficiency* by setting i_1 to find zero monetary wedge

$$u_{N_1}/u_{C_1} = z_1 \quad \Rightarrow \quad \tau_m = 0$$

resulting in *overborrowing*.

- Achieve constrained efficient default risk by setting i_1 to induce

$$\tau_m(i_1, B_1) = r(\beta - \beta_G)(1 - \Phi(\nu^*(B_1))) > 0$$

which requires *inefficient production*

$$\beta > \beta_G \quad \Rightarrow \quad \tau_m > 0 \quad \Rightarrow \quad z_1 > u_{N_1}/u_{C_1}$$

Best i for ex-ante household welfare? *Trade off distortions.*

Monetary Discipline

Definition

The real interest rates in the flexible price economy r^{flex} is defined as

$$\frac{1}{C_1^{\text{flex}}} = \beta r^{\text{flex}} \left[\frac{1 - \Phi^{\text{flex}}}{C_2} + \frac{\Phi^{\text{flex}}}{C_{2d}} \right]. \tag{1}$$

with the equilibrium satisfying

$$C_1^{flex} + (e_1^{flex})^{\rho} = z_1 N_1^{flex}$$
$$C_1^{flex} = \frac{\rho}{\rho - 1} e_1^{flex}$$
$$\frac{u_{N_1^{flex}}}{u_{C_1^{flex}}} = z_1 = 1$$
$$h(B_1^{flex}) B_1 = 1 - \beta_G (1 + r)$$

Assumption

$$\frac{i_1}{\tilde{\pi}_2} \geq r^{flex}.$$

Monetary Discipline

Proposition

The borrowing wedge $\tau_m^C(B) \geq 0$ *for all* $B \geq B^*_{flex}$.

Proposition

Default risk is lower with price frictions, $\Phi^* \leq \Phi^*_{flex}$.

Go Back to the General Model