A Macroeconomic Model of Equities and Real, Nominal, and Defaultable Debt

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Motivation

Goal: Show that a simple macroeconomic model (with Epstein-Zin preferences) is consistent with a wide variety of asset pricing facts

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- uncertainty: Weitzman (2007), Barillas-Hansen-Sargent (2010), et al.
- rare disasters: Rietz (1988), Barro (2006), et al.
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- rare disasters: Rietz (1988), Barro (2006), et al.
- long-run risks: Bansal-Yaron (2004) et al.
- heterogeneous agents: Mankiw-Zeldes (1991), Guvenen (2009), Schmidt (2015), et al.
- financial intermediaries: Adrian-Etula-Muir (2013)

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- structural model of asset prices (provides intuition, robustness to breaks and policy interventions)

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Two key ingredients:

- Epstein-Zin preferences
- nominal rigidities

Households

Period utility function:

$$u(c_t, l_t) \equiv \log c_t - \eta \frac{l_t^{1+\chi}}{1+\chi}$$

- additive separability between c and l
- SDF comparable to finance literature
- log preferences for balanced growth, simplicity

Flow budget constraint:

$$a_{t+1} = e^{i_t} a_t + w_t l_t + d_t - c_t$$

Calibration: (IES $= 1$), $\chi = 3$, $l = 1$ ($\eta = .54$)

Generalized Recursive Preferences

Household chooses state-contingent $\{(c_t, l_t)\}$ to maximize

$$V(a_t;\theta_t) \;=\; \max_{(c_t,l_t)} u(c_t, l_t) - \beta\alpha^{-1} \log\left[E_t \exp(-\alpha V(a_{t+1};\theta_{t+1}))\right]$$

Calibration: $\beta = .992$, RRA $(R^c) = 60 \quad (\alpha = 59.15)$

Firms

Firms are very standard:

- continuum of monopolistic firms (gross markup λ)
- Calvo price setting (probability $1 - \xi$)
- Cobb-Douglas production functions, $y_t(f) = A_t k^{1-\theta} l_t(f)^{\theta}$
- fixed firm-specific capital stocks k

Random walk technology: $\log A_t = \log A_{t-1} + \varepsilon_t$

- simplicity
- comparability to finance literature
- helps match equity premium

Calibration: $\lambda = 1.1$, $\xi = 0.8$, $\theta = 0.6$, $\sigma_A = .007$, $(\rho_A = 1)$, $\frac{k}{4Y} = 2.5$

Fiscal and Monetary Policy

No government purchases or investment:

$$Y_t = C_t$$

Taylor-type monetary policy rule:

$$i_t = r + \pi_t + \phi_\pi(\pi_t - \overline{\pi}) + \phi_y(y_t - \overline{y}_t)$$

"Output gap" $(y_t - \overline{y}_t)$ defined relative to moving average:

$$\overline{y}_t \equiv \rho_{\bar{y}}\overline{y}_{t-1} + (1 - \rho_{\bar{y}})y_t$$

Rule has no inertia:

- simplicity
- Rudebusch (2002, 2006)

Calibration: $\phi_\pi = 0.5$, $\phi_y = 0.75$, $\overline{\pi} = .008$, $\rho_{\bar{y}} = 0.9$

Solution Method

Write equations of the model in recursive form

Divide nonstationary variables (Y_t, C_t, w_t, etc.) by A_t

Solve using perturbation methods around nonstoch. steady state

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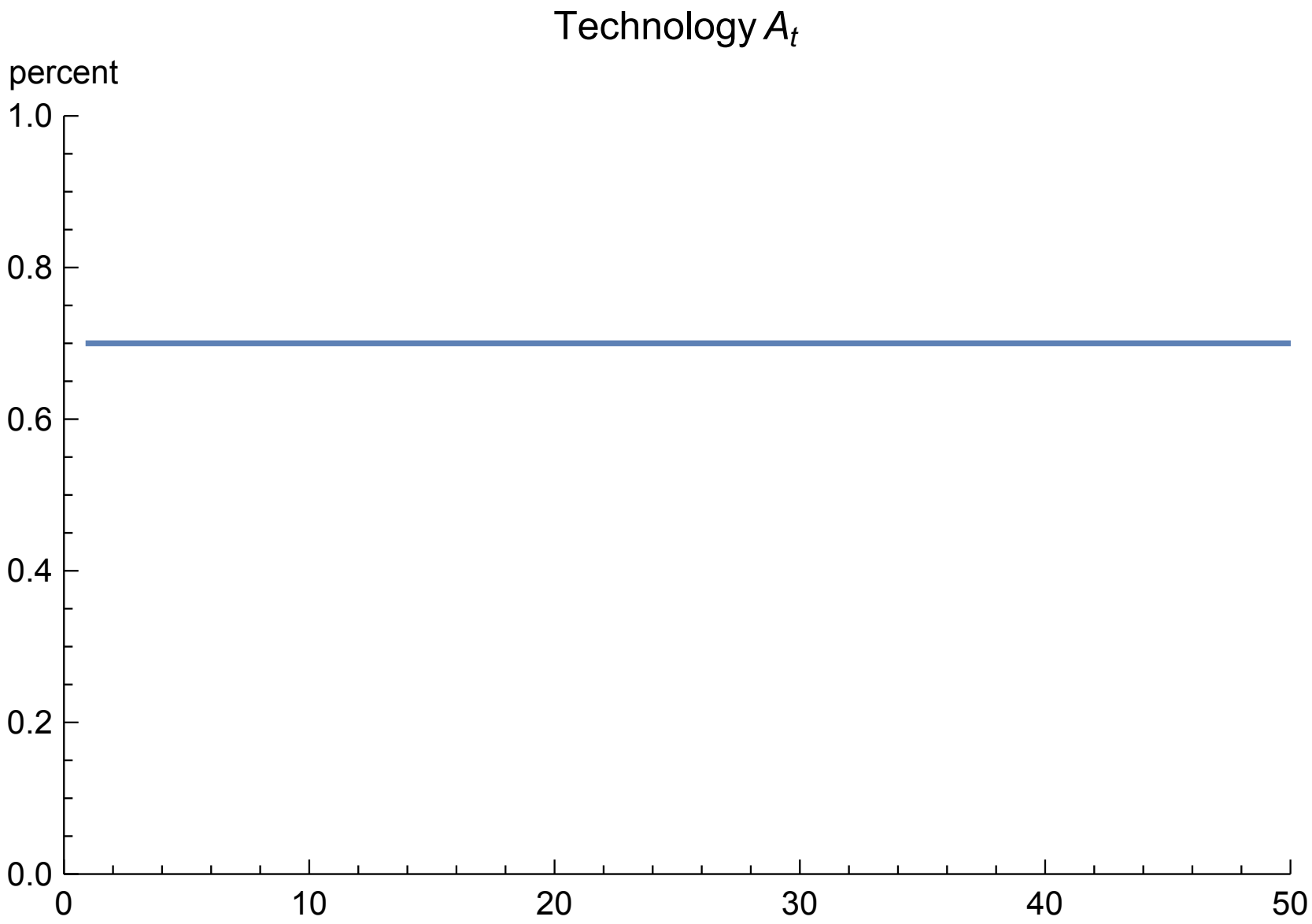
- first-order: no risk premia
- second-order: risk premia are constant
- third-order: time-varying risk premia
- higher-order: more accurate over larger region

Model has 2 state variables ($\bar{y}_t$, Δ_t), one shock (ε_t)

Impulse Responses



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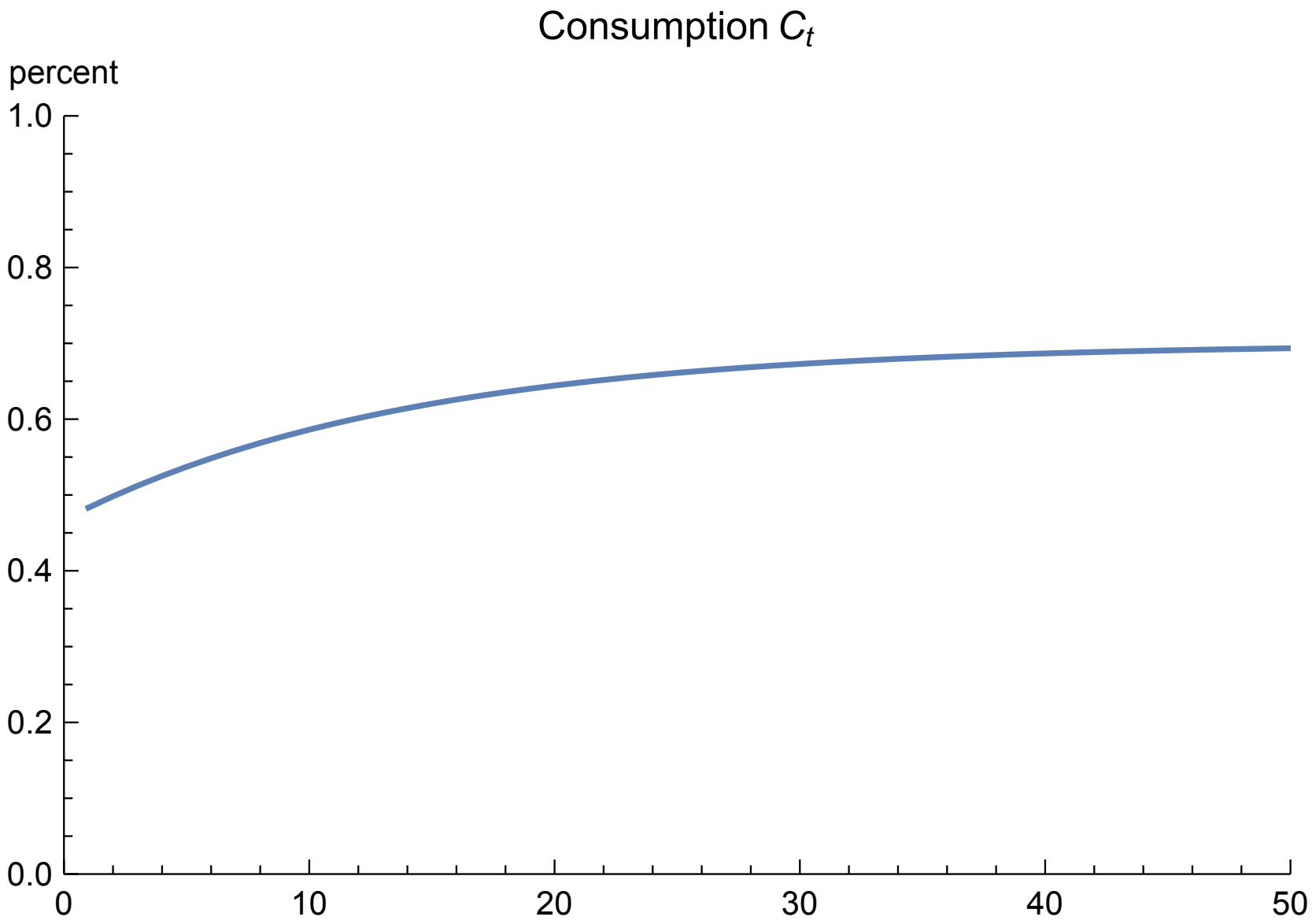

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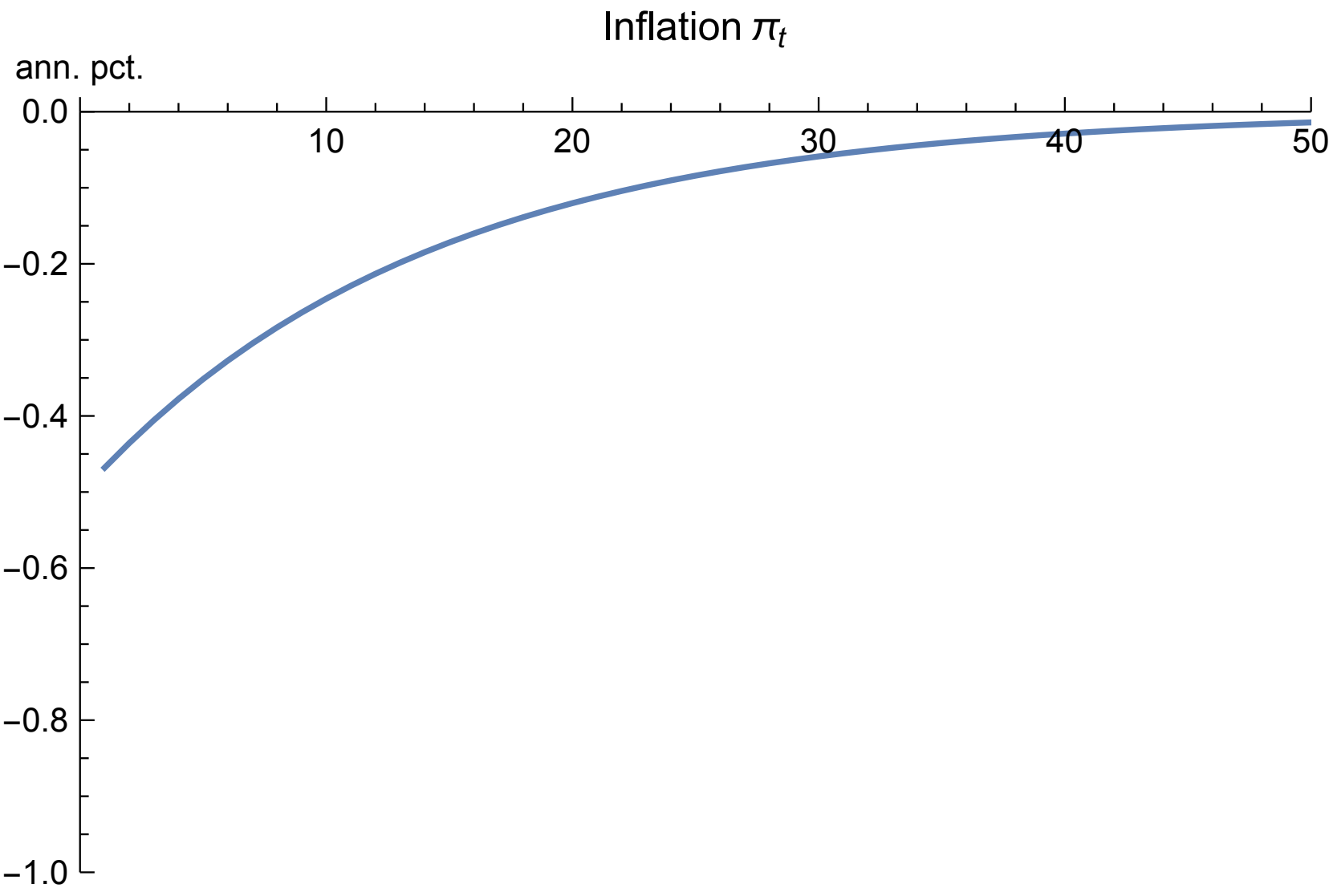

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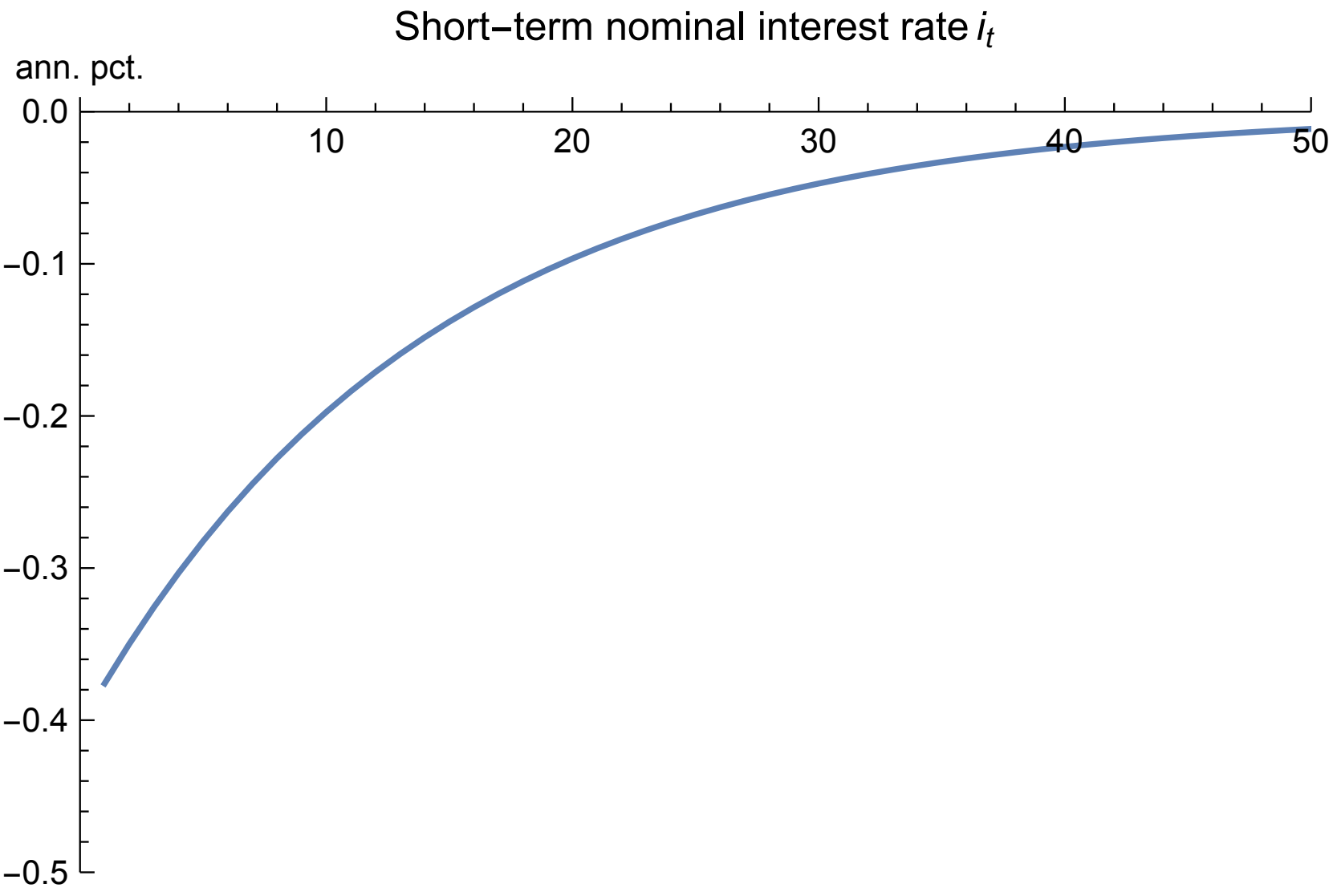

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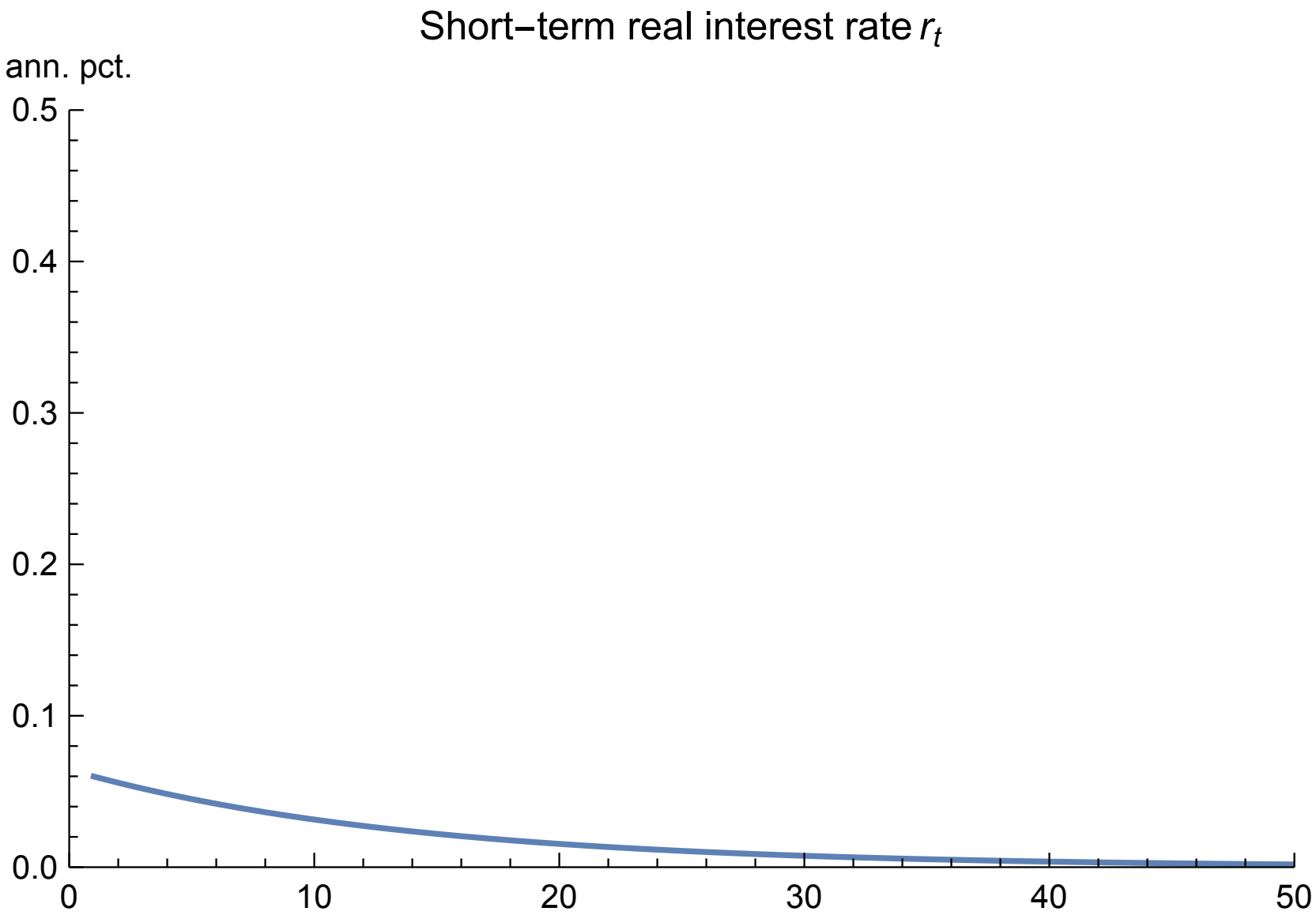
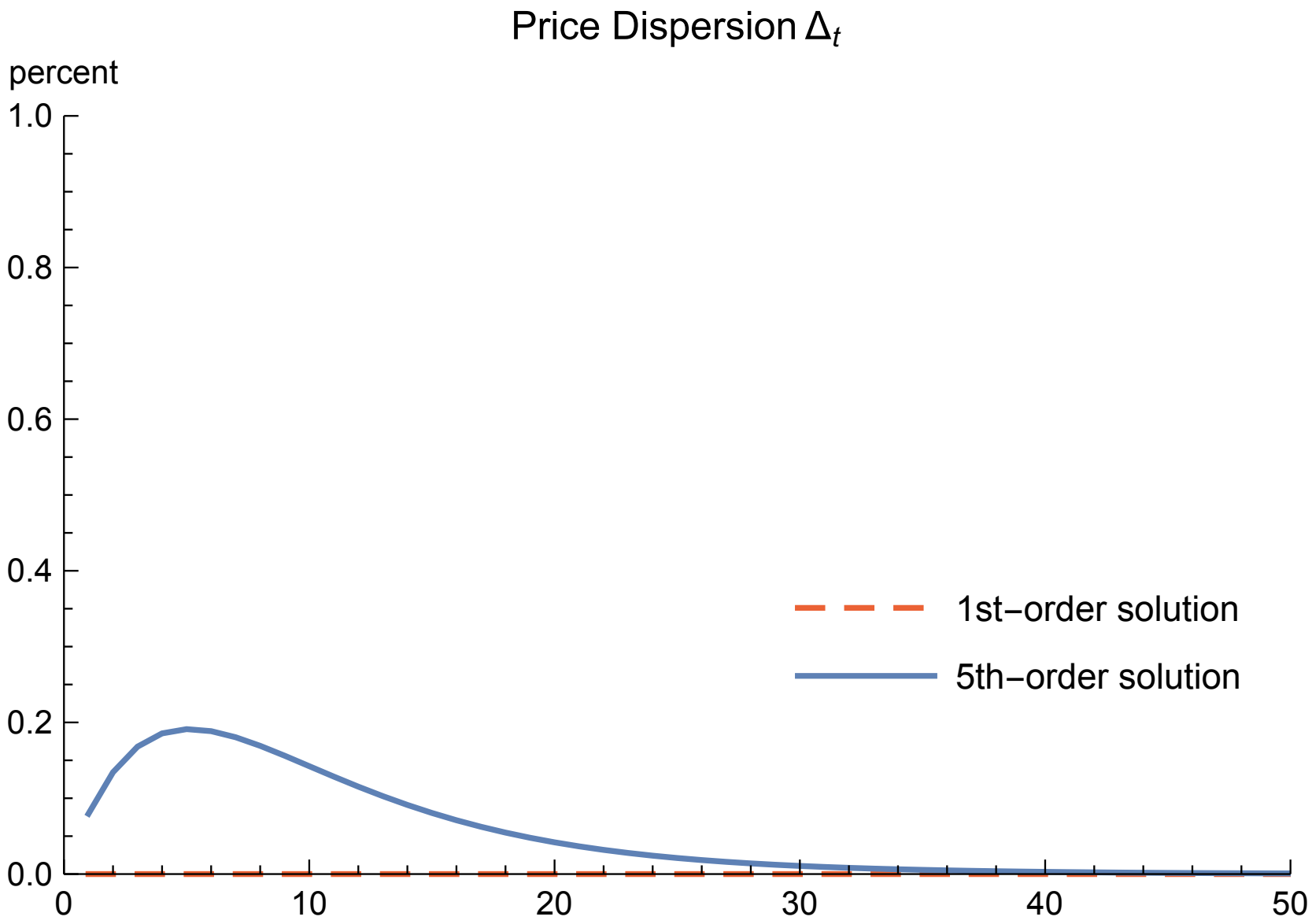
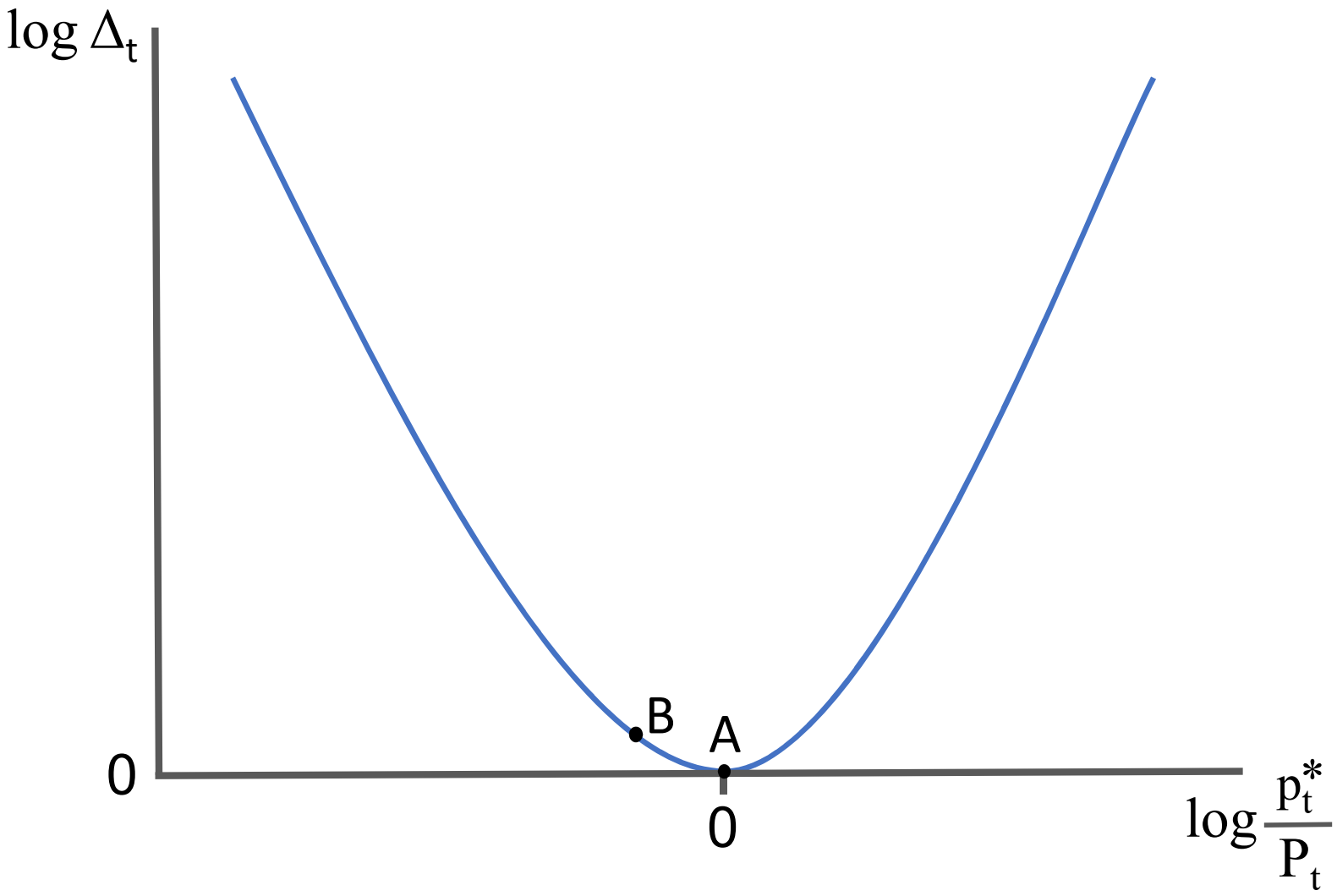


Nonlinear vs. Linear Impulse Responses



Firms' Optimal Price and Price Dispersion



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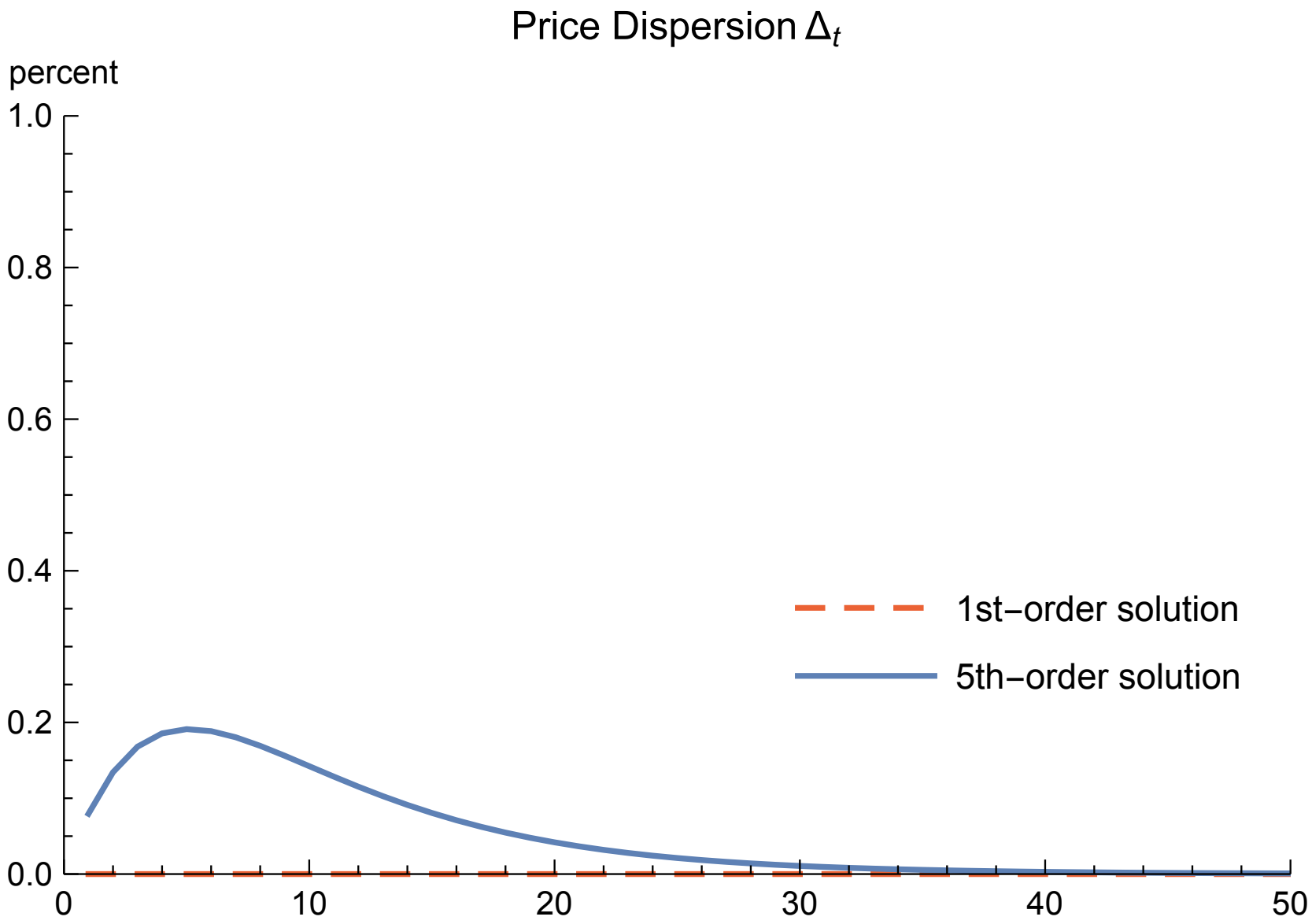

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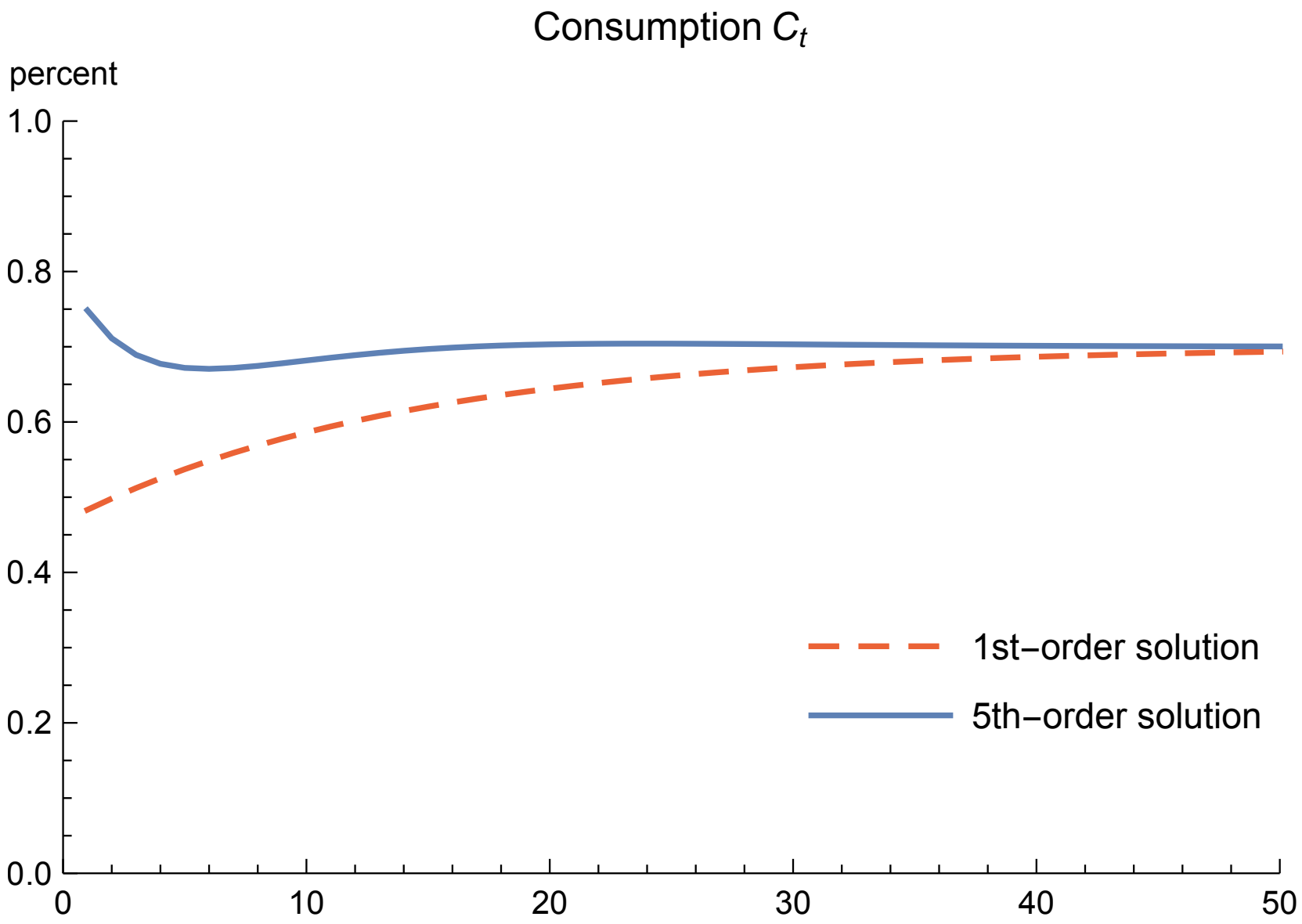

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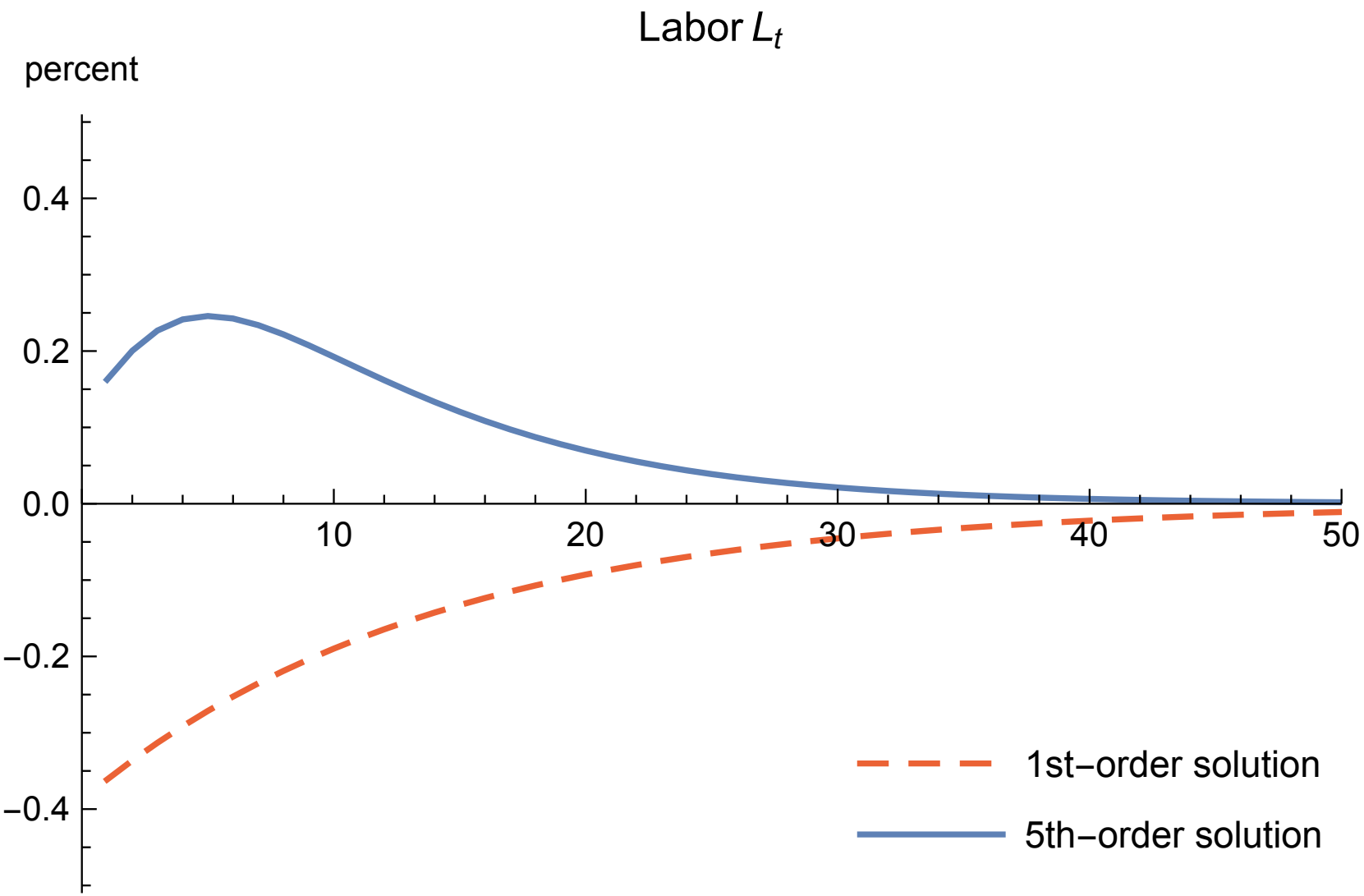

Equity: Levered Consumption Claim

Equity price

$$p_t^e = E_t m_{t+1}(C_{t+1}^{\nu} + p_{t+1}^e)$$

where ν is degree of leverage

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Calibration: $\nu = 3$

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60	.995	1.86
60	.99	1.08
60	.98	0.53
60	.95	0.17

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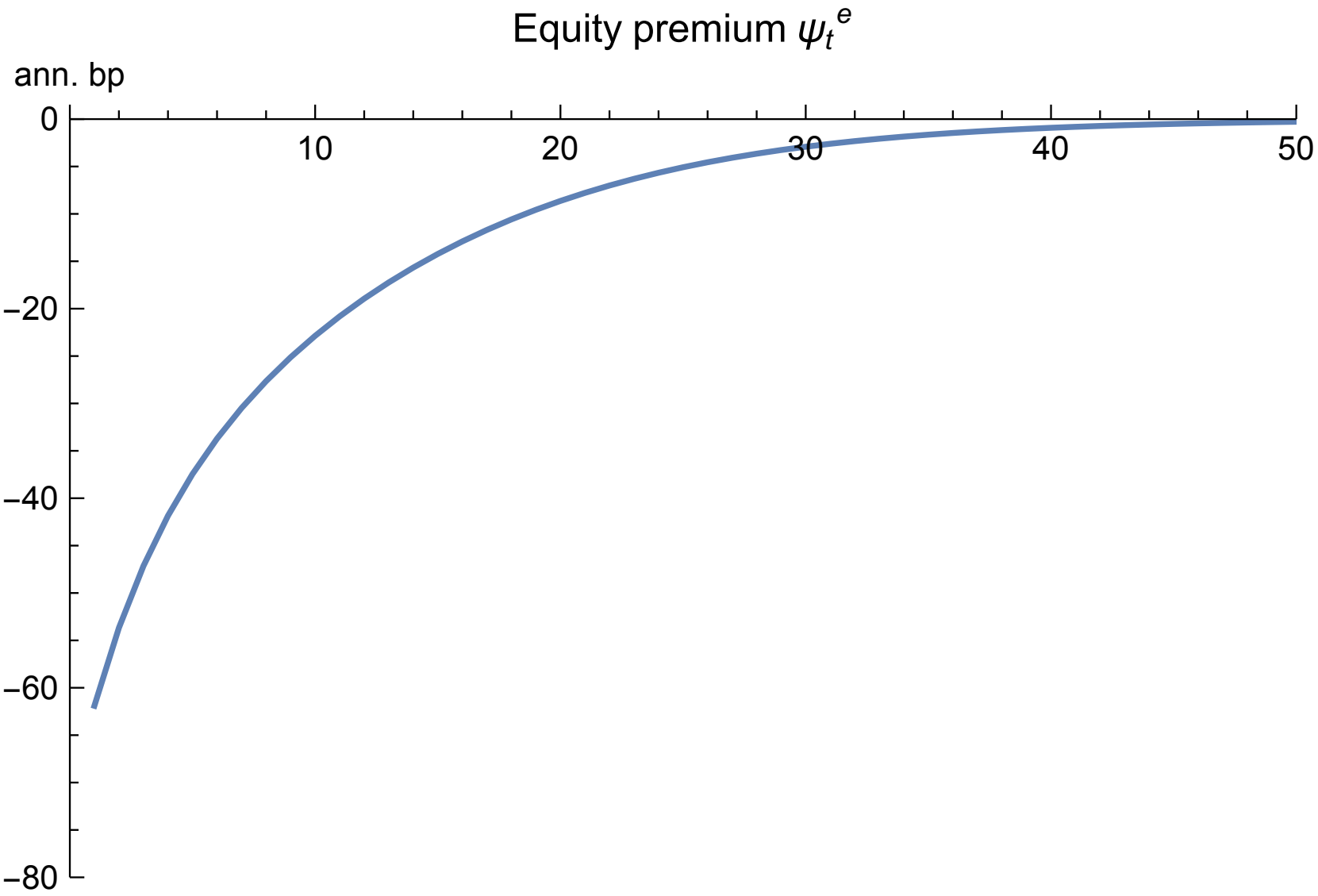

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Real n-period zero-coupon bond price:

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Real Yield Curve

Table 3: Real Zero-Coupon Bond Yields

	2-yr.	3-yr.	5-yr.	7-yr.	10-yr.	(10y)−(3y)
US TIPS, 1999–2015[a]			1.29	1.55	1.82	
US TIPS, 2004–2015[a]	0.14	0.28	0.60	0.89	1.22	0.94
US TIPS, 2004–2007[a]	1.39	1.52	1.74	1.91	2.09	0.57
UK indexed gilts, 1983–1995[b]	6.12	5.29	4.34		4.12	−1.17
UK indexed gilts, 1985–2015[c]		1.91	2.05	2.16	2.25	0.34
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macroeconomic model	1.94	1.93	1.93	1.93	1.93	0.00

[a]Gürkaynak, Sack, and Wright (2010) online dataset
[b]Evans (1999)
[c]Bank of England web site

Nominal Yield Curve

Table 4: Nominal Zero-Coupon Bond Yields

	1-yr.	2-yr.	3-yr.	5-yr.	7-yr.	10-yr.	(10y)−(1y)
US Treasuries, 1961–2015[a]	5.27	5.50	5.68	5.97	6.18		
US Treasuries, 1971–2015[a]	5.42	5.66	5.86	6.18	6.43	6.71	1.29
US Treasuries, 1990–2007[a]	4.56	4.84	5.06	5.41	5.68	5.98	1.42
UK gilts, 1970–2015[b]	6.92	7.10	7.26	7.51	7.70	7.89	0.96
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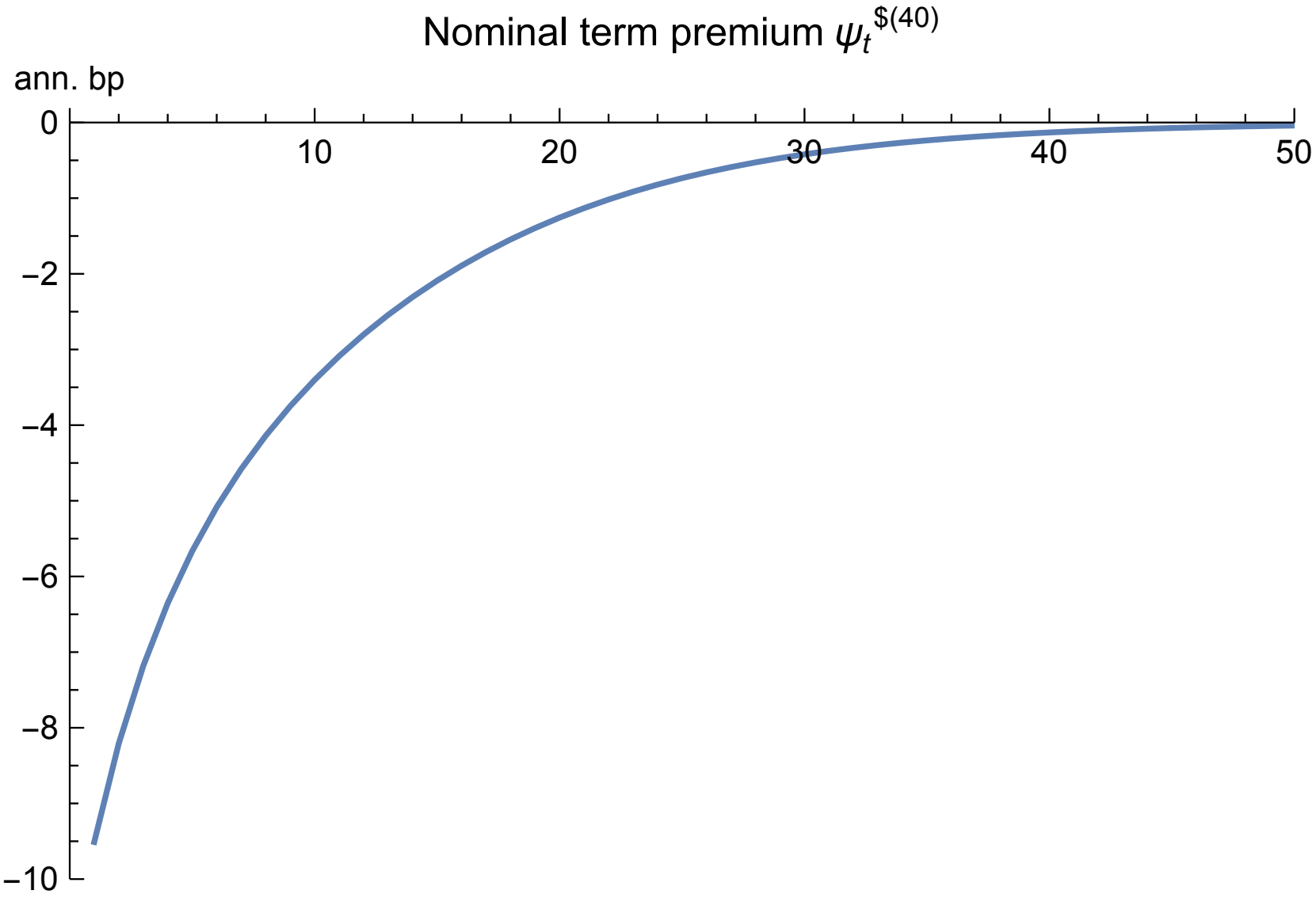
Supply shocks make nominal long-term bonds risky: inflation risk

Nominal Term Premium



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The credit spread is $i_t^d - i_t^c$

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average ann. default prob.	cyclicality of default prob.	average recovery rate	cyclicality of recovery rate	credit spread (bp)
.006	0	.42	0	34.0

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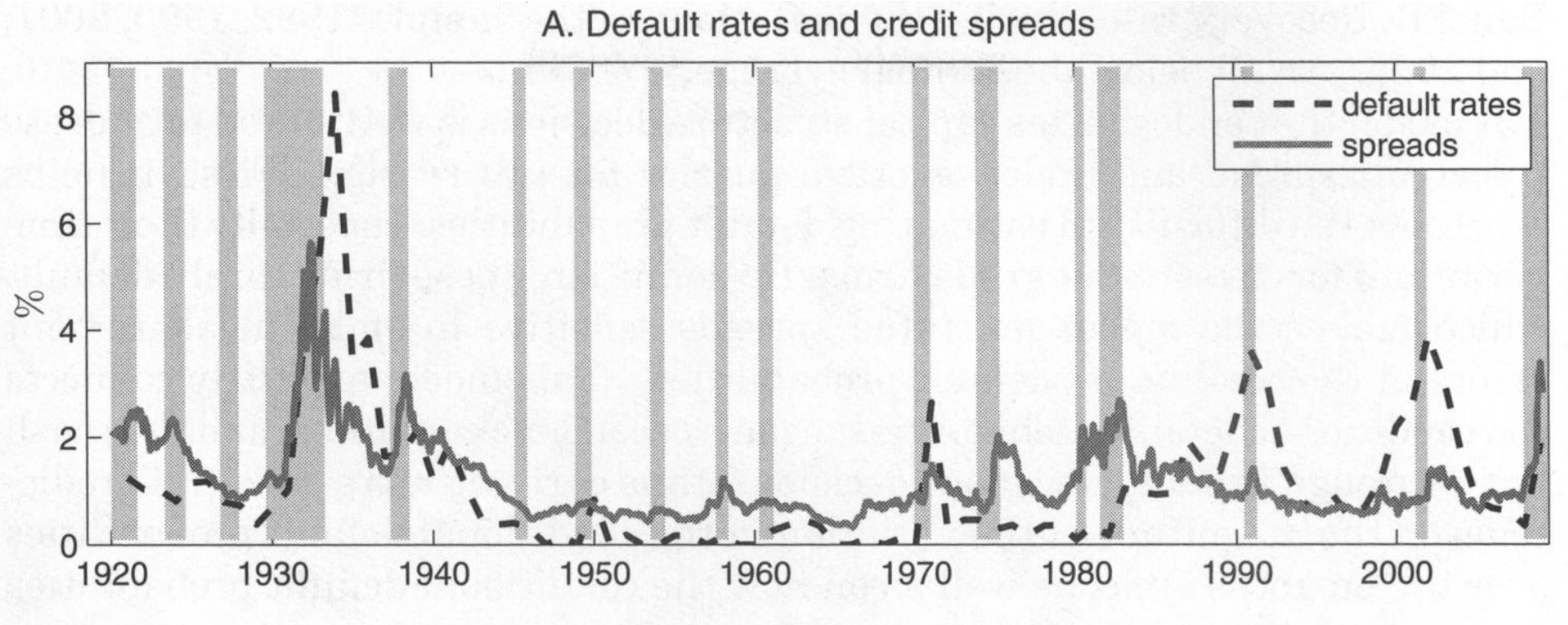
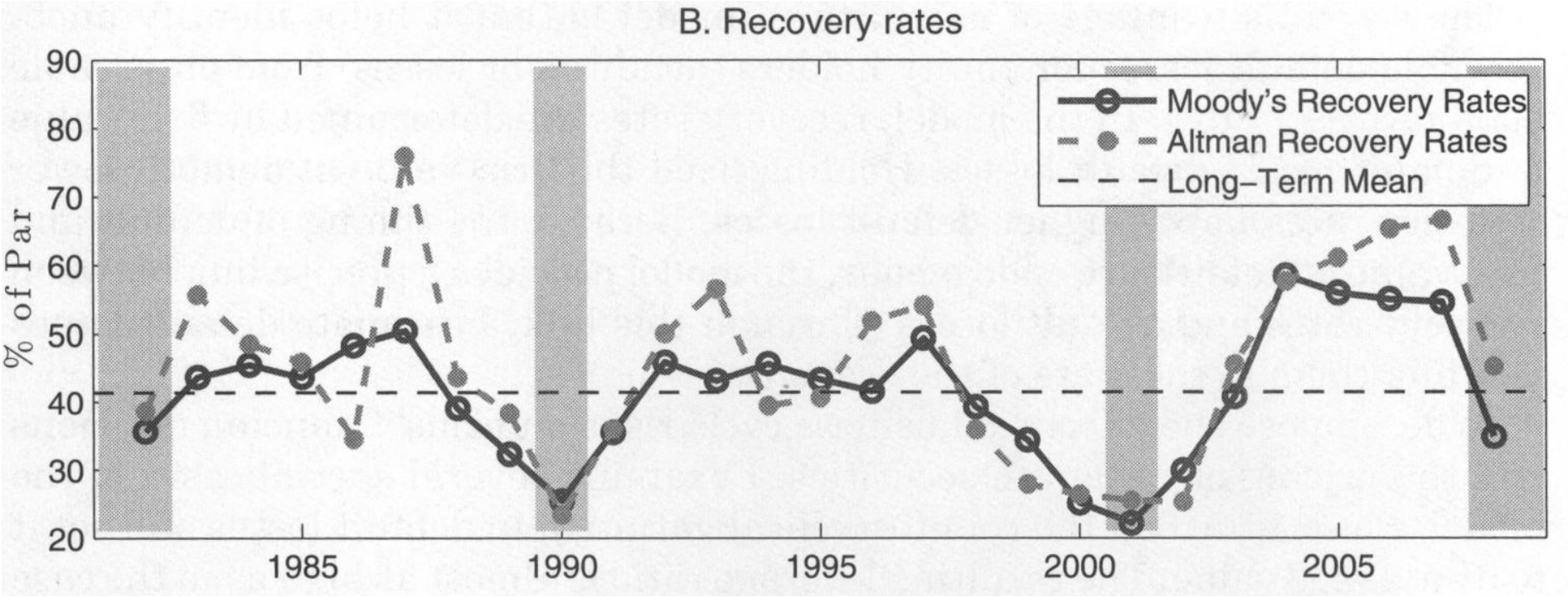
If default isn't cyclical, then it's not risky

Default Rate is Countercyclical



source: Chen (2010)

Recovery Rate is Procyclical



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.006	−0.3	.42	2.5	143.1
.006	−0.15	.42	2.5	78.9
.006	−0.6	.42	2.5	367.4
.006	−0.3	.42	1.25	137.0
.006	−0.3	.42	5	155.2

Discussion

1. IES ≤ 1 vs. IES > 1
2. Volatility shocks
3. Endogenous conditional heteroskedasticity
4. Monetary and fiscal policy shocks
5. Financial accelerator

Intertemporal Elasticity of Substitution

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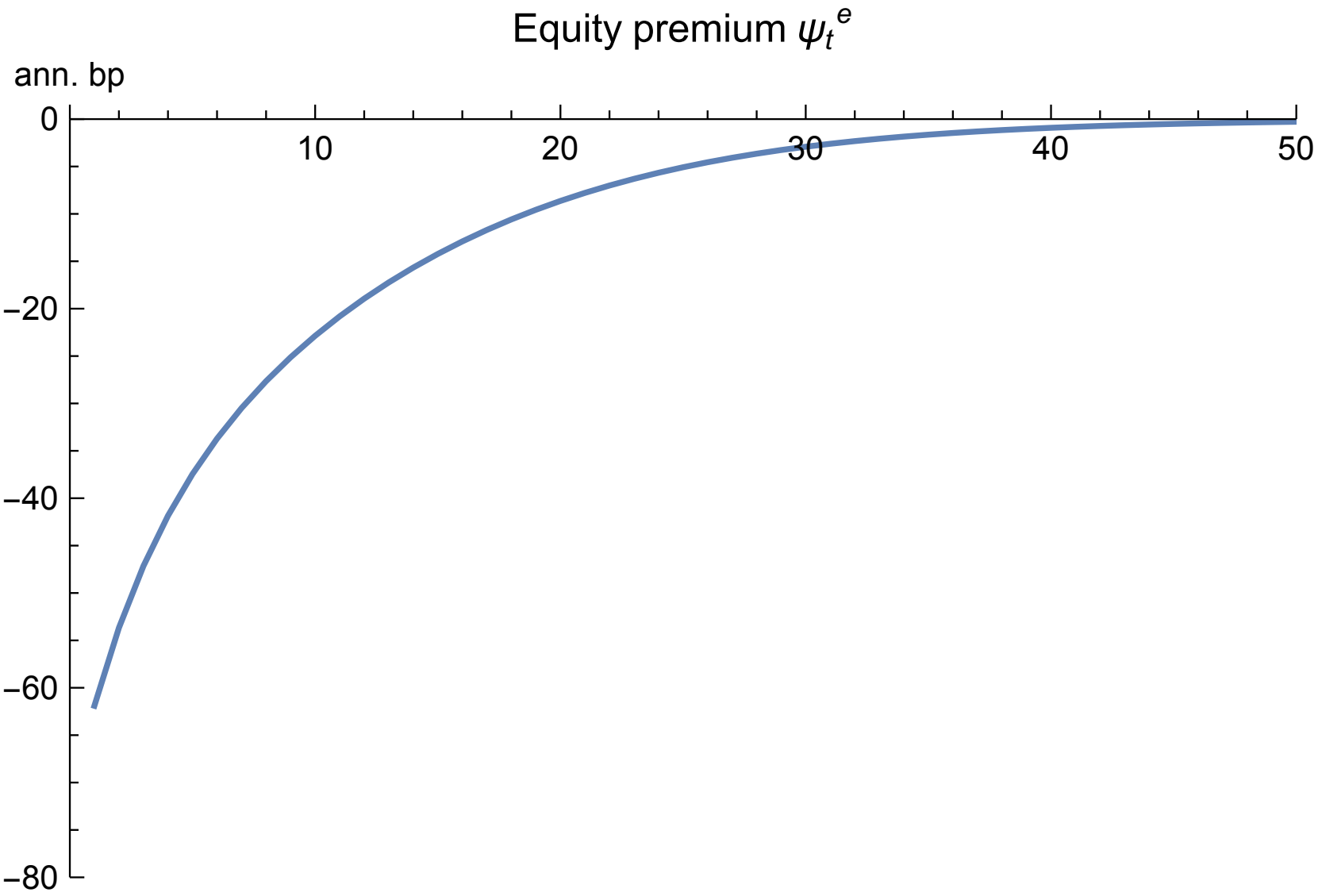
Impulse Responses to Technology Shock



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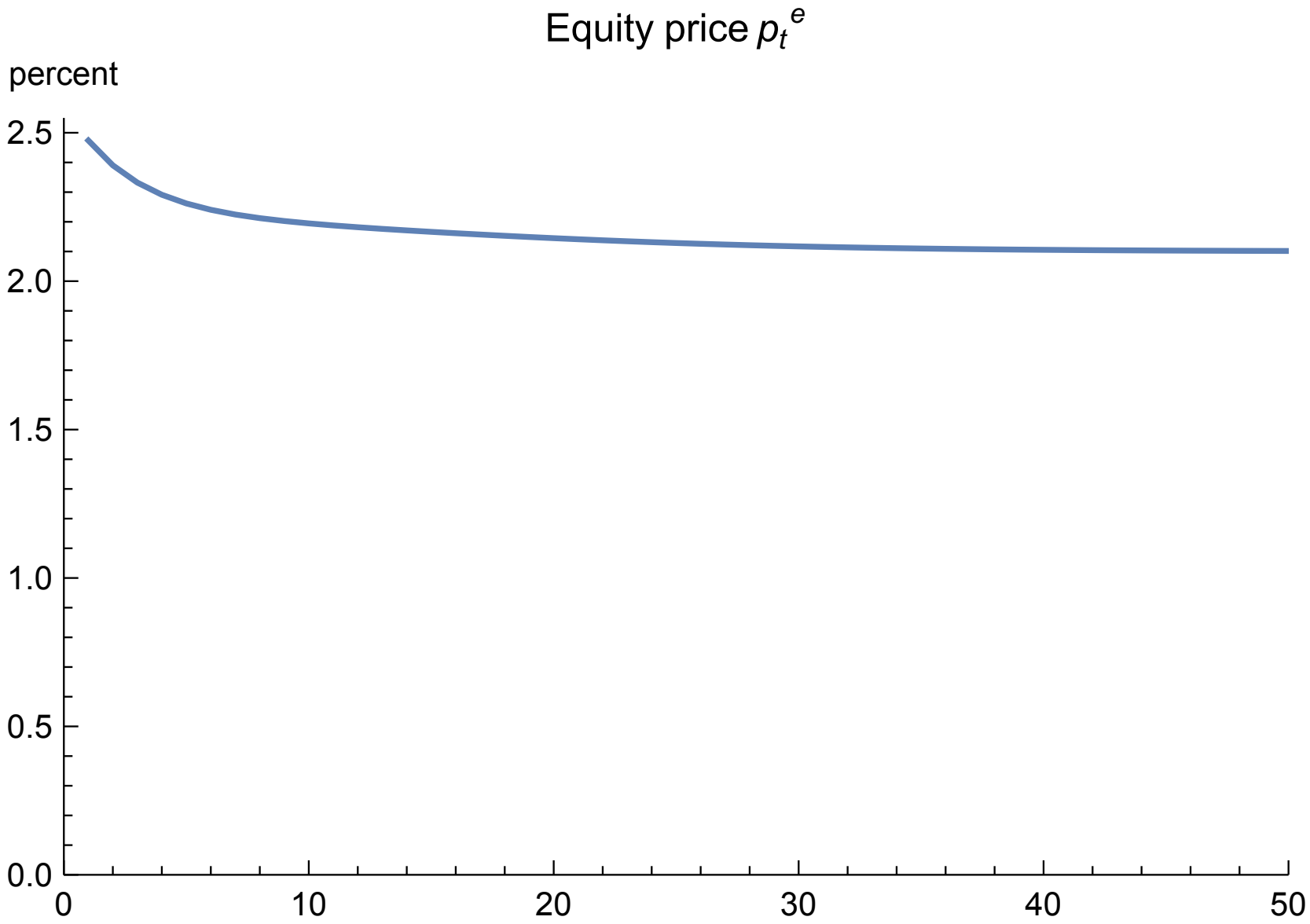

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Calibration: $\rho_\sigma = .98$, $\text{Var}(\varepsilon_t^\sigma) = (0.1)^2$

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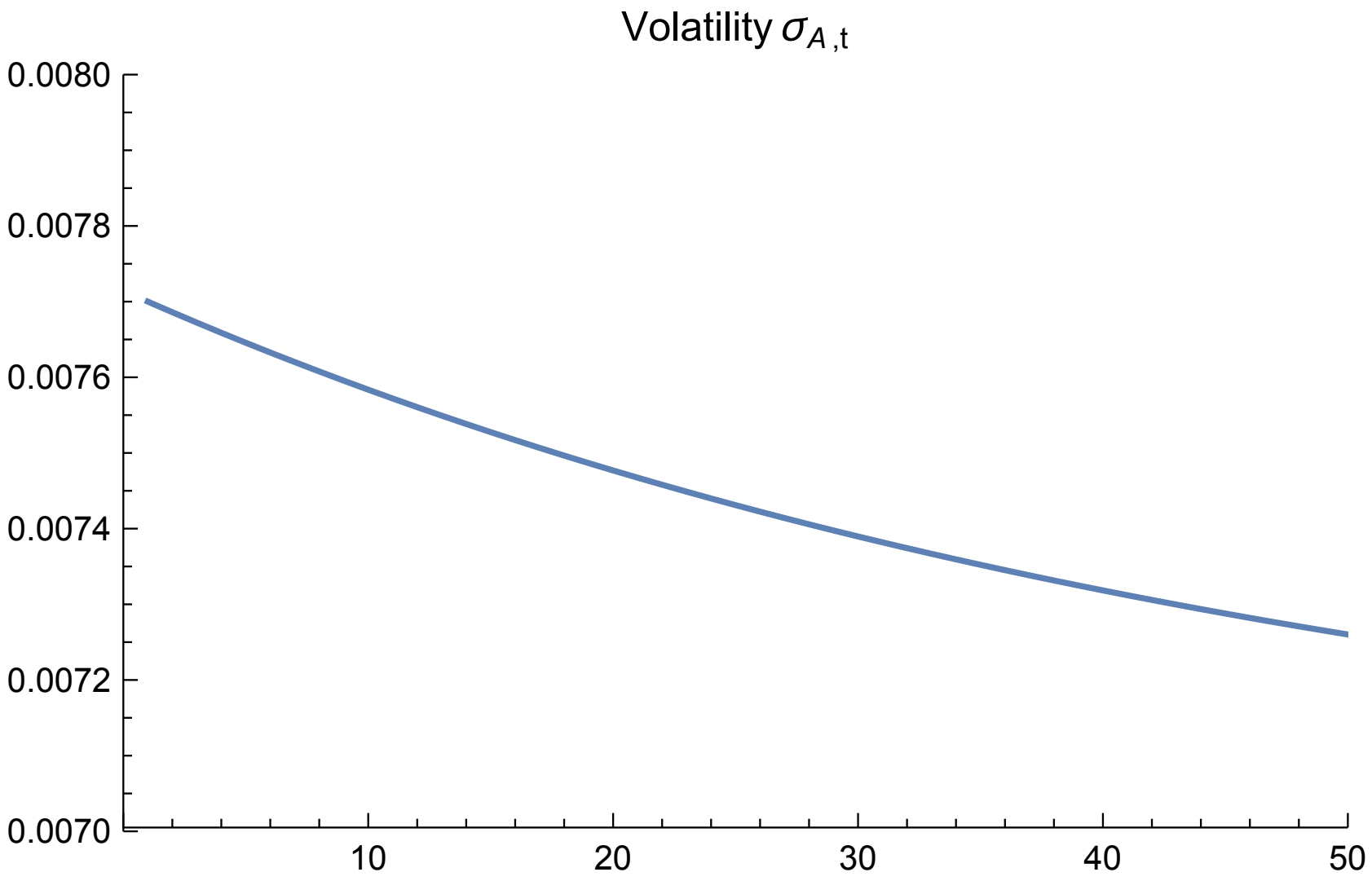

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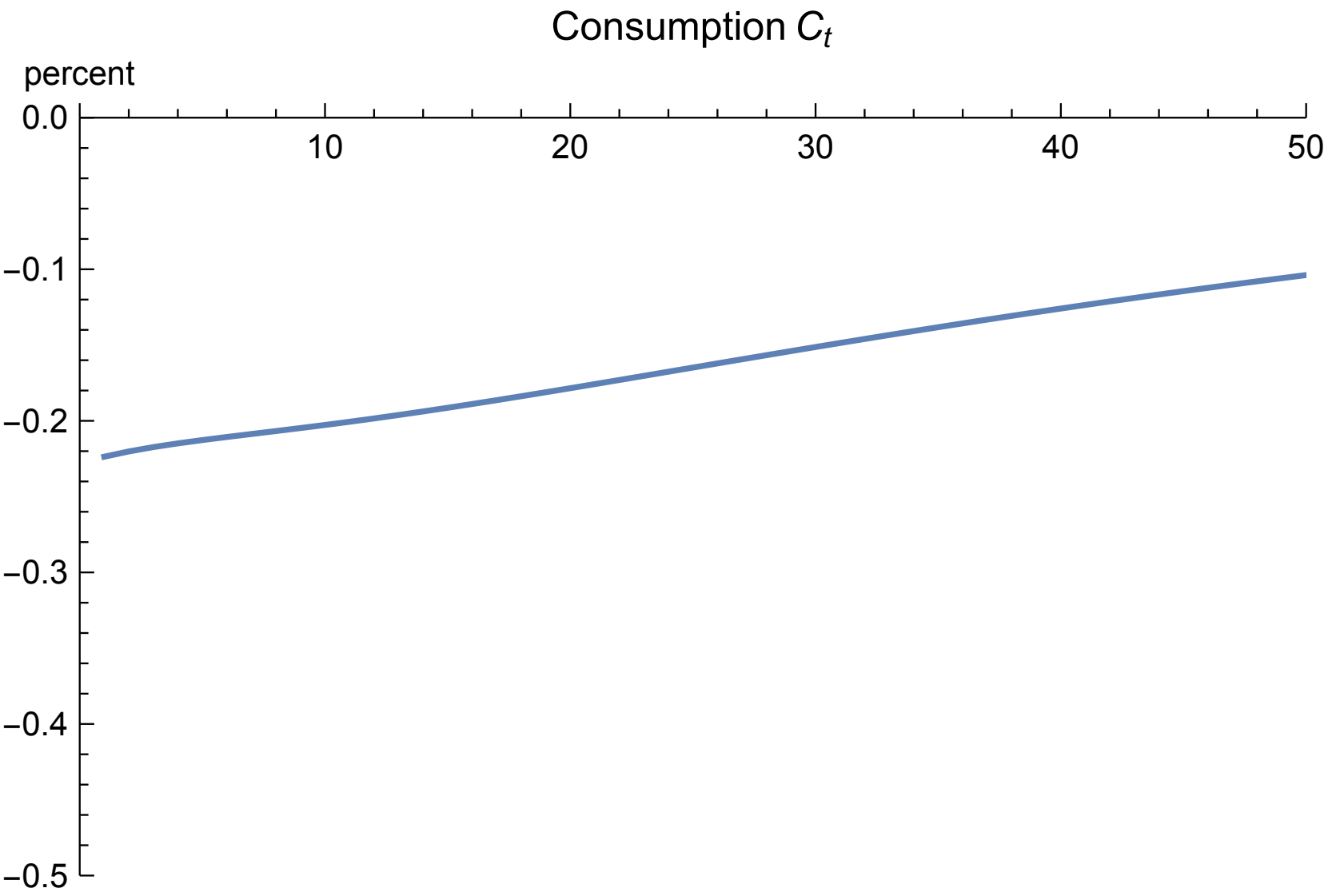

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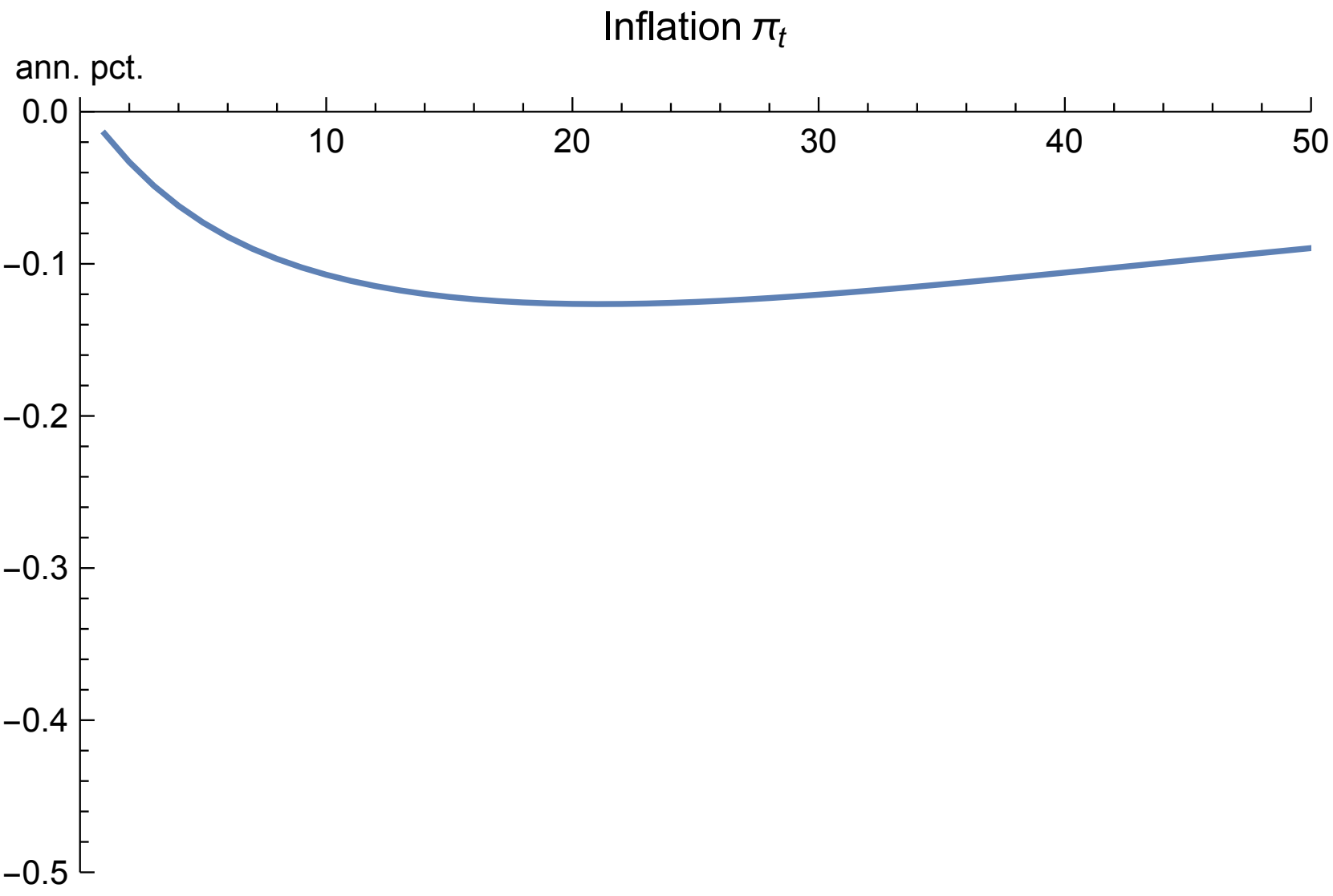

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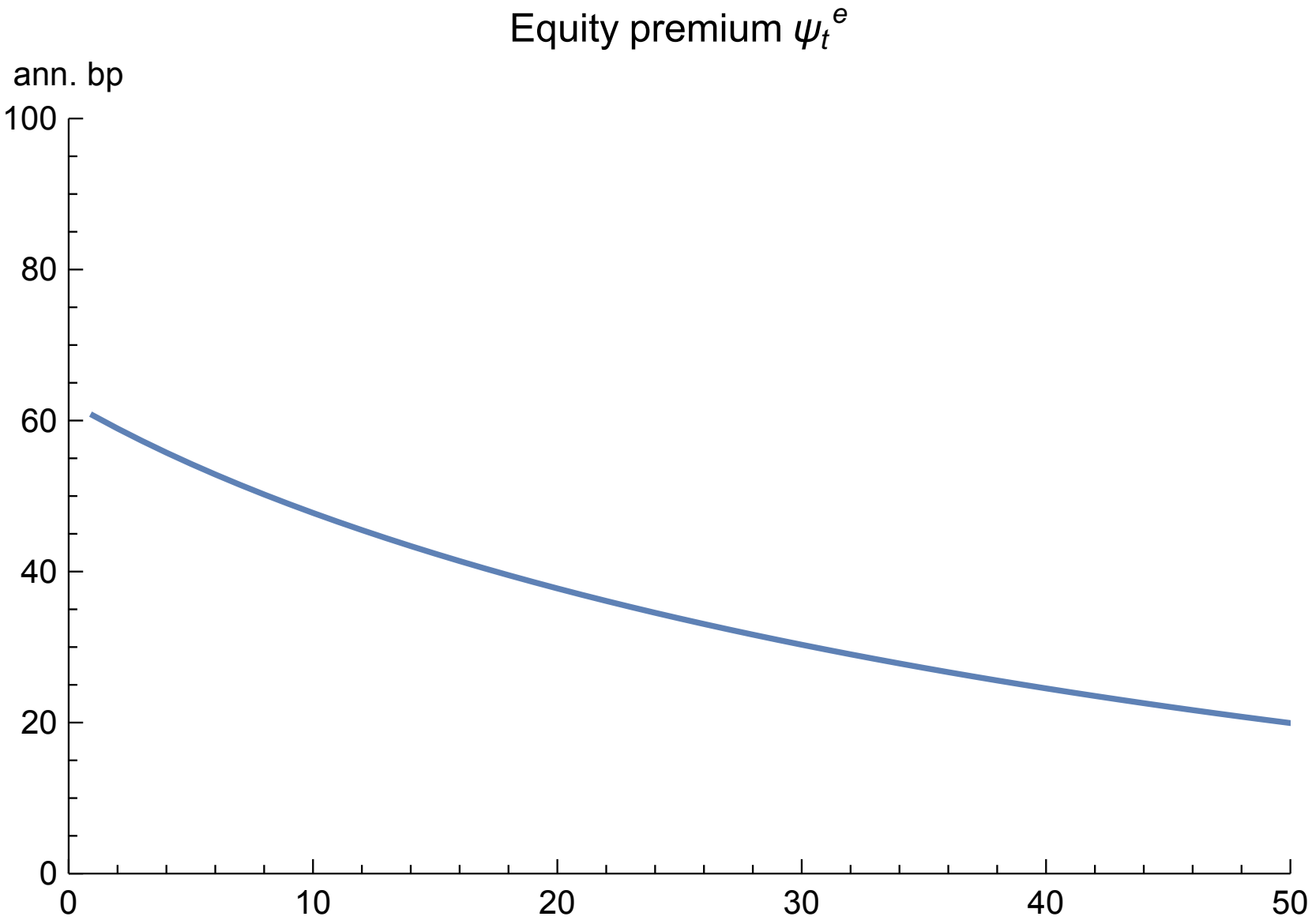

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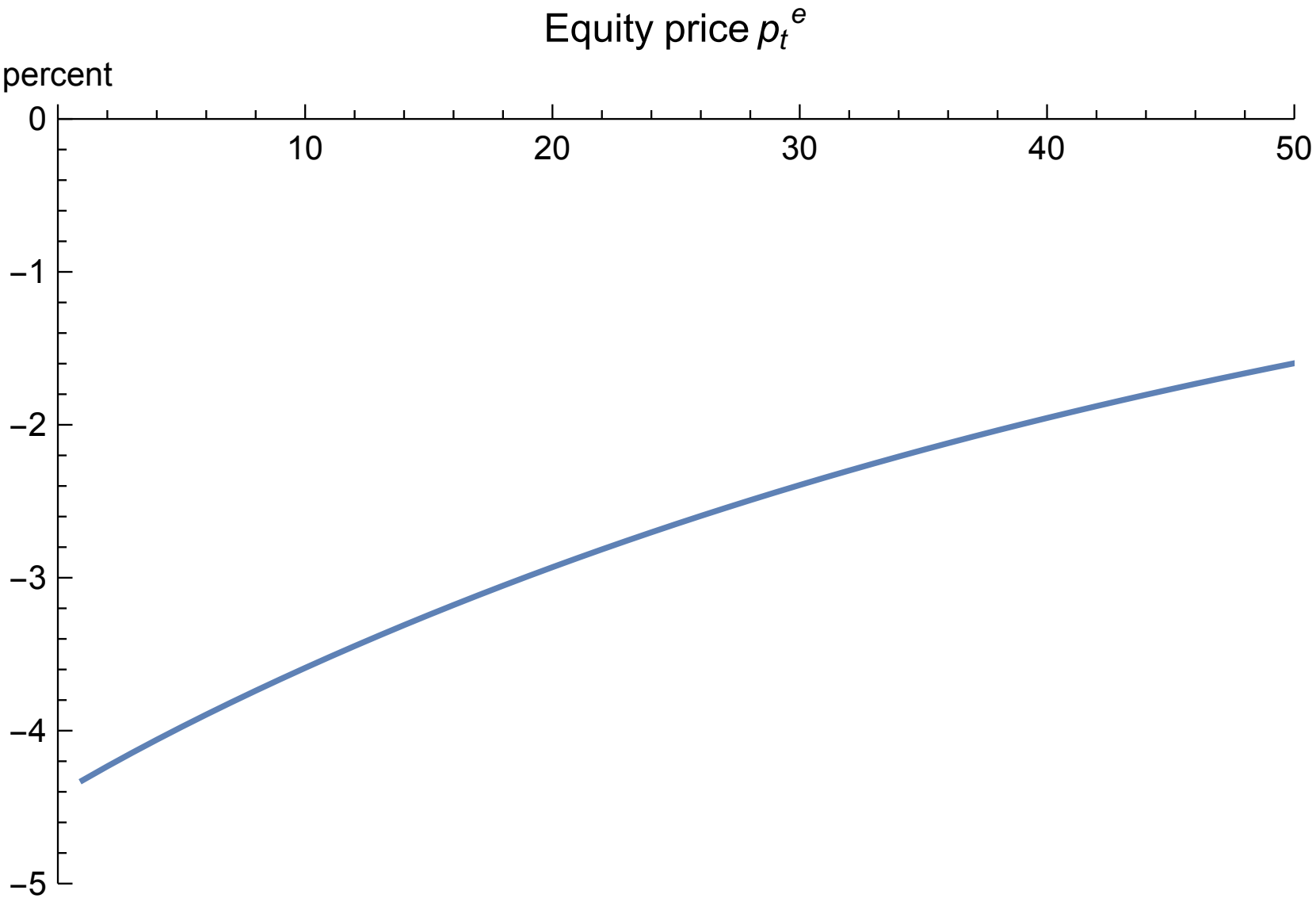

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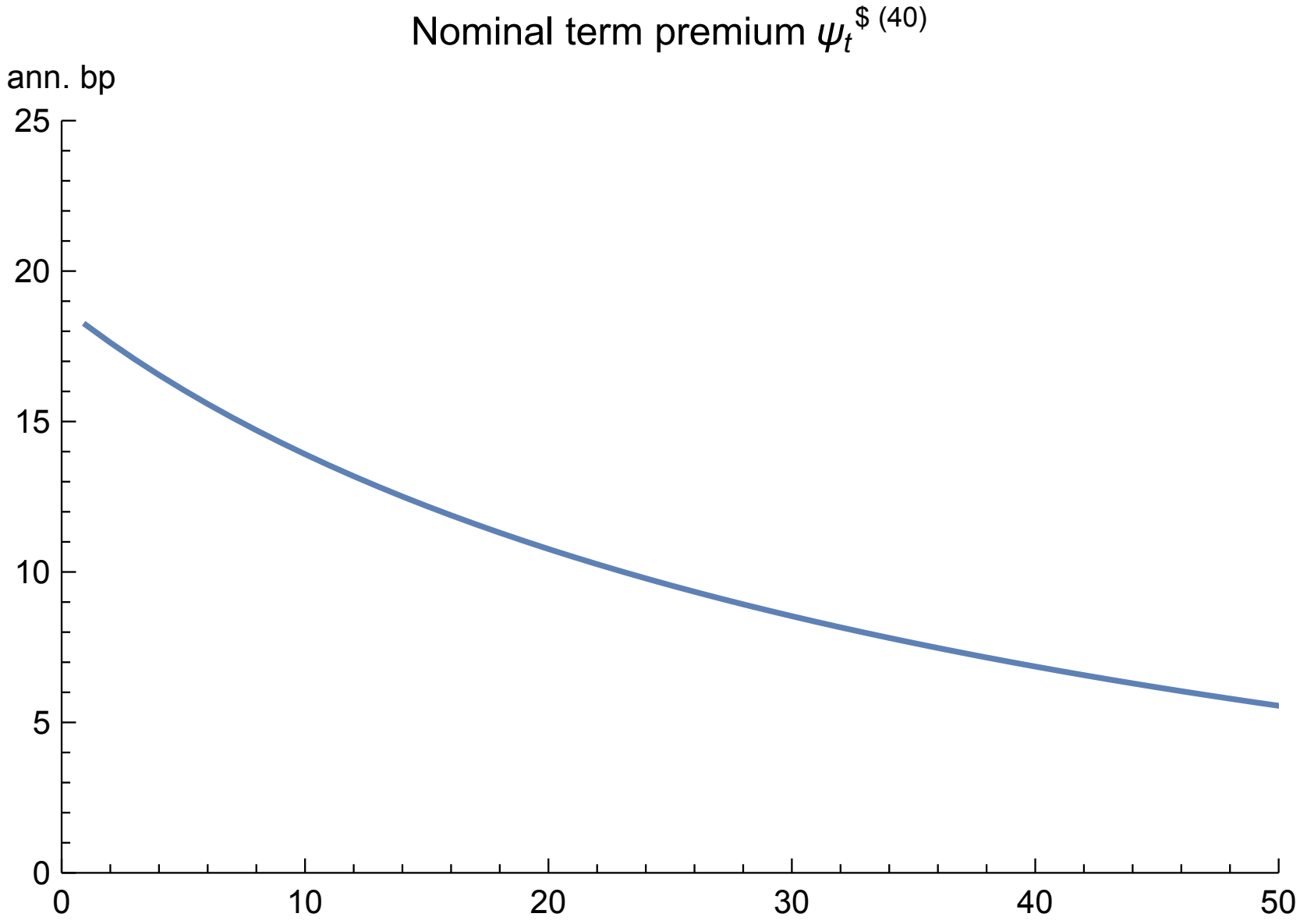

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\begin{aligned}
\psi_t^e &\equiv E_t R_{t+1}^e - e^{r_t} \\
&= \frac{E_t(C_{t+1}^\nu + p_{t+1}^e)}{p_t^e} - e^{r_t} \\
&= \frac{E_t(C_{t+1}^\nu + p_{t+1}^e)}{E_t m_{t+1}(C_{t+1}^\nu + p_{t+1}^e)} - \frac{1}{E_t m_{t+1}} \\
&= \frac{E_t m_{t+1}\, E_t(C_{t+1}^\nu + p_{t+1}^e) - E_t m_{t+1}(C_{t+1}^\nu + p_{t+1}^e)}{E_t m_{t+1}\, p_t^e} \\
&= \frac{-\mathrm{Cov}_t\left(m_{t+1}, R_{t+1}^e\right)}{E_t m_{t+1}} \\
&= -\mathrm{Cov}_t\left(\frac{m_{t+1}}{E_t m_{t+1}}, r_{t+1}^e\right)
\end{aligned}
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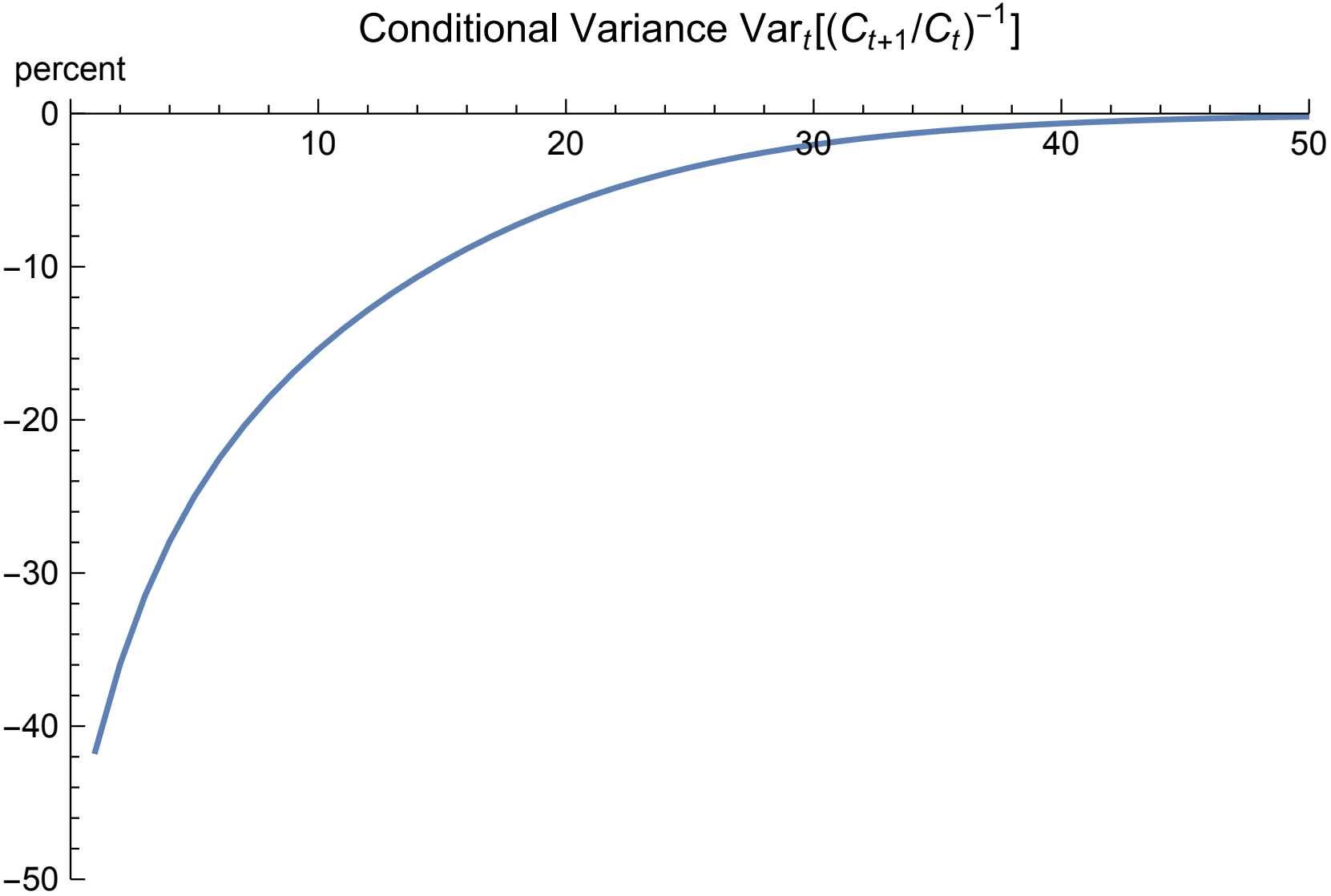
Nonlinear solution contains terms of form

$$x_t \varepsilon_{t+1}$$

so covariance Cov_t depends on state x_t

Impulse Responses for Conditional Variance



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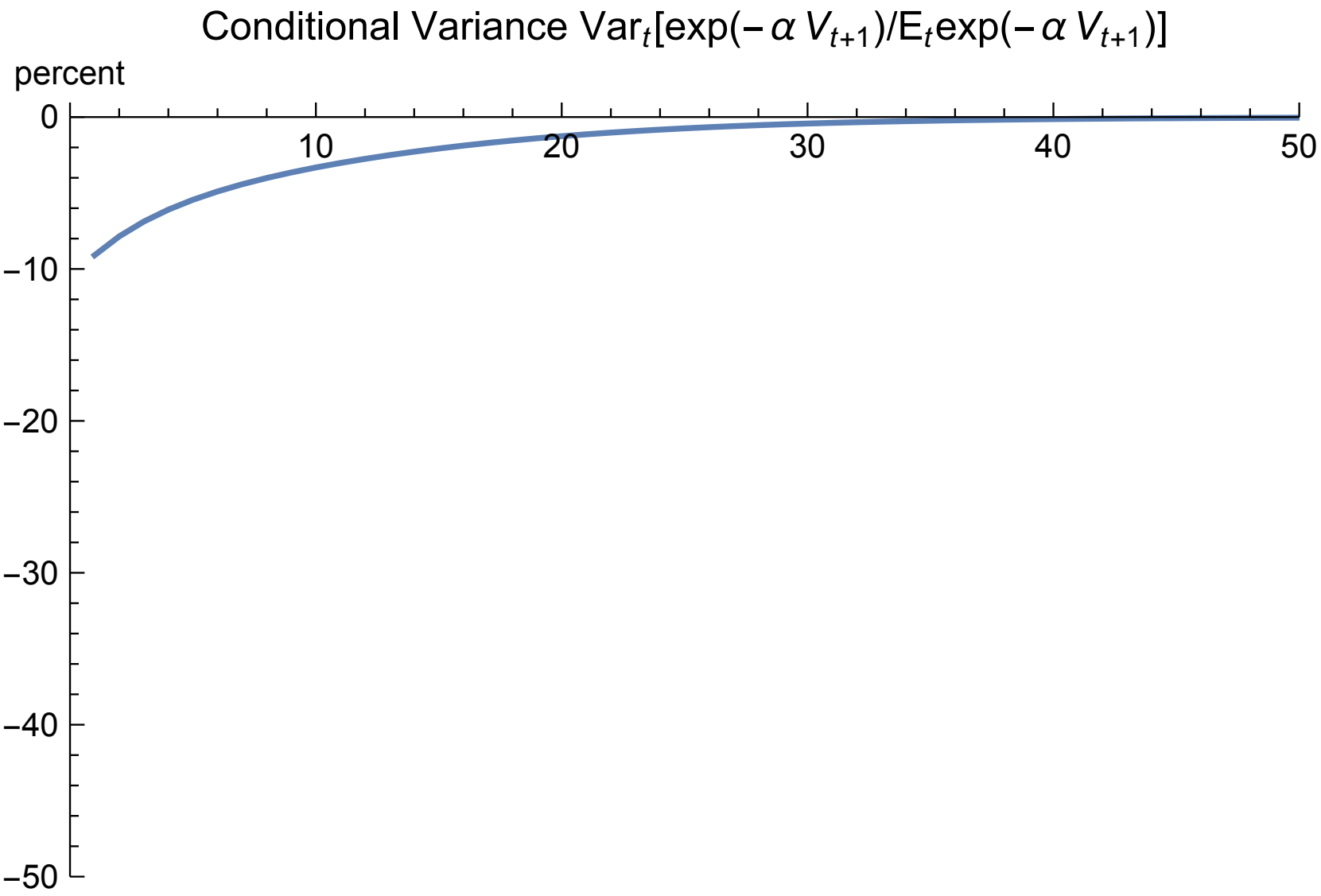
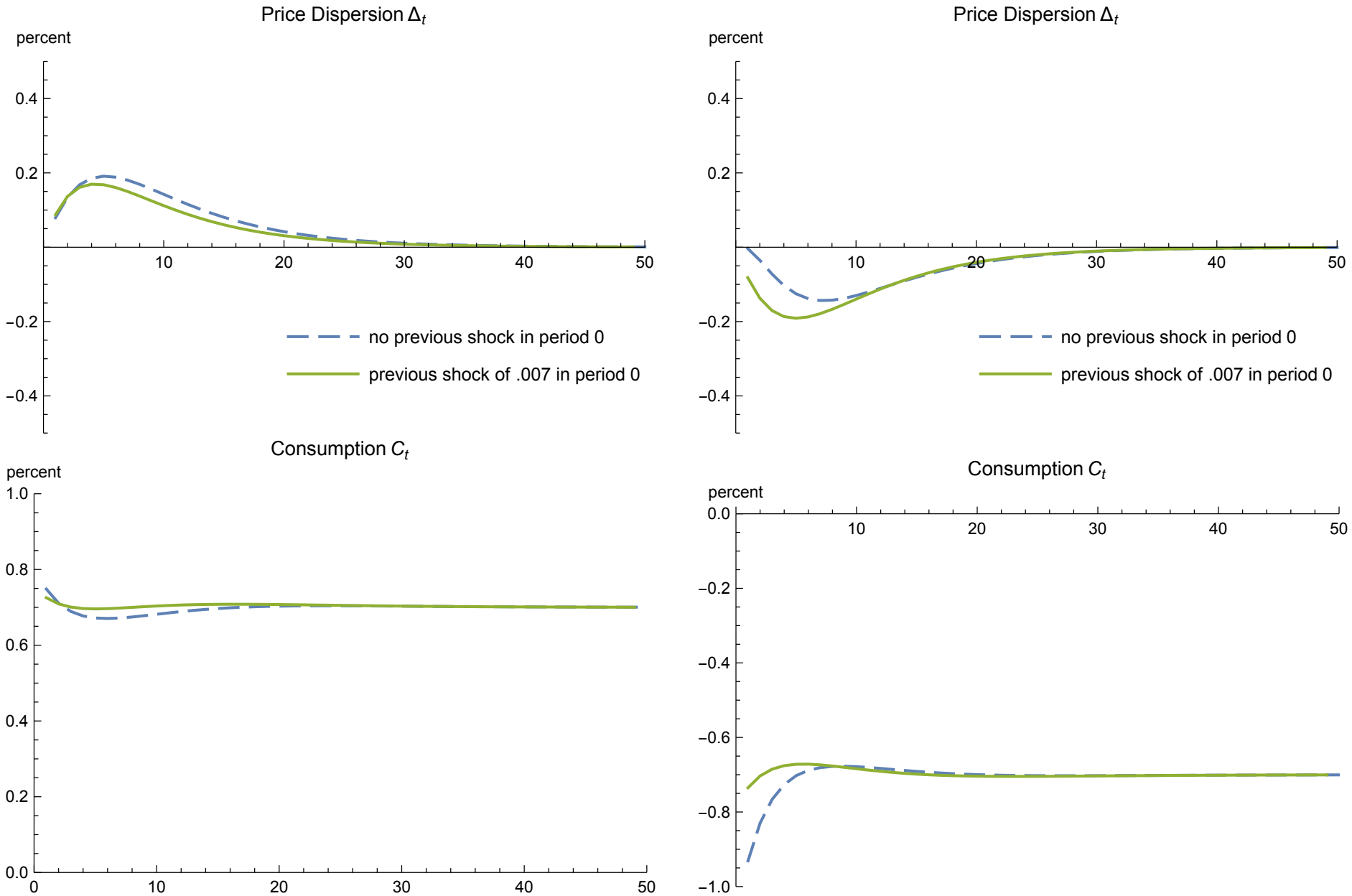
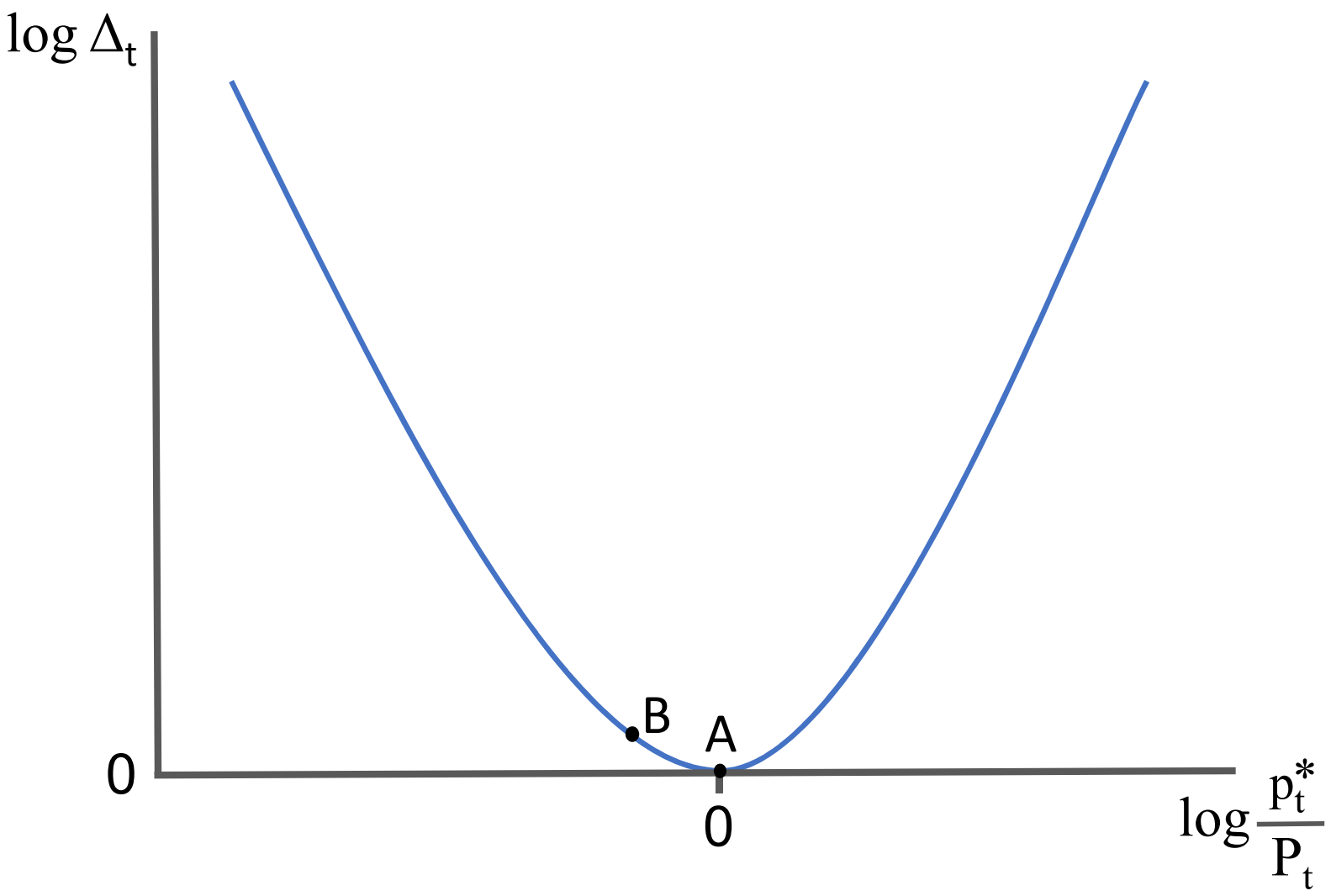


Impulse Responses to Pos. and Neg. Tech. Shocks



Price Dispersion



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But technology shock is most important (by far) for fitting asset prices:

- technology shock is more persistent
- technology shock makes nominal assets risky

No Financial Accelerator

With model-implied stochastic discount factor m_{t+1}, we can price any asset

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...but not in this paper

Conclusions

1. The standard textbook New Keynesian model (with Epstein-Zin preferences) is consistent with a wide variety of asset pricing facts/puzzles
2. Unifies asset pricing puzzles into a single puzzle—Why does risk aversion in macro models need to be so high?
   (Literature provides good answers to this question)
3. Provides a structural framework for intuition about risk premia
4. Suggests a way to model feedback from risk premia to macroeconomy