

Capital Accumulation, Sectoral Heterogeneity and the Taylor Principle

Tommy Sveen

BI Norwegian Business School

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How does capital accumulation change the determinacy properties of new Keynesian models?

There is a sizeable literature on determinacy properties of NK models (see, e.g., Clarida et al 1999):

- The Taylor principle: the central bank should change the nominal interest rate by more than one-for-one with changes in inflation.

The analysis has been extended to allow for capital accumulation:

- Carlstrom and Fuerst (2005): capital accumulation make it almost impossible for forward-looking rules to deliver determinacy.
- Sveen and Weinke (2005): firm-specific capital accumulation make the Taylor principle insufficient to guarantee determinacy.
- Other papers have followed up on the implications of endogenous capital accumulation for determinacy in the context of NK models.

Most analyses of determinacy in the existing literature have been conducted in the context of highly simplified models:

- The goal of the present paper is to analyze determinacy in the context of a model featuring two sectors:
 - One sector produces investment goods and the other sector consumer goods.
 - Introduces an endogenous relative price of investment goods.
- The starting point is a neo-classical two-sector model augmented with monopolistic competition and sticky prices and wages.

The aim of the analysis is twofold:

- Analyze determinacy properties in an interesting extension of the "baseline" model:
 - Recent interest in business cycle analysis in "investment specific shocks" and "relative price of investment goods" (e.g. Justiani et al 2010).
 - Compared to a one-sector set-up, a multiple-sector model (with heterogeneity in price stickiness) change how monetary policy propagates (e.g. Carvalho 2006).
- Use the two-sector set-up to reinterpret results of the "baseline" model.

Three types of agents

- Households
- Firms
 - Producers of consumer goods
 - Producers of investment goods
- Monetary authorities

- Infinitely lived families consisting of two types of family members:
 - One type working in the investment goods sector and the other in the consumer goods sector.
 - Consider also the case with integrated labor market across the two sectors.
- Household members maximize lifetime utility (separable in its two arguments):
 - CES consumption aggregate.
 - Leisure.
- Supply labor in monopolistically competitive labor markets. Nominal wages are changed in a staggered fashion.
- Perfect risk sharing.

The Model

Consumer (investment) goods firms

- Produce differentiated consumer (investment) goods using capital and labor.
- Invest and accumulates their own capital stock (firm-specific capital).
- Firms act under monopolistic competition and set prices in a staggered fashion.

The Model

Market Clearing and Monetary Policy

- Markets clear for all goods and for all types of labor.
- Monetary policy take the form of a simple interest rate rule.

The Model

Log-linearized model

- The household optimality problem gives rise to a standard consumer Euler equation for consumption, c_t :

$$c_t = E_t \{c_{t+1}\} - rr_t, \quad (1)$$

where:

- $rr_t \equiv r_t - E_t \pi_{c,t+1} - \rho$ is the consumption real interest rate.
- r_t and $\pi_{c,t}$ are the nominal interest rate and CPI inflation.

The Model

Log-linearized model

- Nominal wage inflation, ω_t , is given by:

$$\omega_{j,t} = \beta E_t \{ \omega_{j,t+1} \} + \kappa_w [mrs_{j,t} - w_{j,t}] \text{ for } j = c, i \quad (2)$$

- The the marginal rates of substitution, mrs_t , and the (consumer) real wages, w_t , are

$$\left. \begin{aligned} mrs_{j,t} &= c_t + \phi n_{j,t} \\ w_{j,t} &= w_{j,t-1} + \omega_{j,t} - \pi_{c,t} \end{aligned} \right\} \text{ for } j = c, i \quad (3)$$

where $n_{j,t}$ is average hours worked in sector j .

The Model

Log-linearized model

- Aggregate production in sector j , $y_{j,t}$, is:

$$y_{j,t} = (1 - \alpha_j) n_{j,t} + \alpha_j k_{j,t} \text{ for } j = c, i \quad (4)$$

where $k_{j,t}$ is the capital stock and α_j is the capital share in sector j .

- The law of motion of capital stocks

$$k_{j,t+1} = (1 - \delta) k_{j,t} + i_{j,t} \text{ for } j = c, i \quad (5)$$

where i_t is investment.

The Model

Log-linearized model

- Price setting implies familiar NK Phillips curves

$$\pi_{c,t} = \beta E_t \{ \pi_{c,t+1} \} + \kappa_{c,p} mc_{c,t}, \quad (6)$$

$$\pi_{i,t} = \beta E_t \{ \pi_{i,t+1} \} + \kappa_{i,p} (mc_{i,t} - \hat{p}_{l,t}), \quad (7)$$

where $\hat{p}_{l,t} = \hat{p}_{l,t-1} + \pi_{i,t} - \pi_{c,t}$ is the relative price of investment goods.

- Real marginal costs are

$$mc_{j,t} = w_{j,t} - (y_{j,t} - n_{j,t}) \text{ for } j = c, i \quad (8)$$

The Model

Log-linearized model

- The investment/capital ratios

$$i_{j,t} = k_{j,t} + \epsilon_{\psi} (q_{j,t} - \hat{p}_{l,t}) \quad (9)$$

- Tobin's Q in the two sectors

$$q_{j,t} = \beta E_t \{q_{j,t+1}\} + (1 - \beta(1 - \delta)) E_t \{ms_{j,t+1}\} - \delta \beta E_t \{\hat{p}_{l,t+1}\} \\ - (r_t - E_t \{\pi_{i,t+1}\}) \text{ for } j = c, i \quad (10)$$

- The real shadow rental prices of capital

$$ms_{j,t} = mc_{j,t} + (y_{j,t} - k_{j,t}) \text{ for } j = c, i \quad (11)$$

The Model

Log-linearized model

- Clearing in the consumer goods market:

$$c_t = y_{c,t} \quad (12)$$

- Clearing in the investment goods market:

$$y_{i,t} = \frac{I_C}{Y_I} i_{c,t} + \frac{I_I}{Y_I} i_{i,t} \quad (13)$$

- Monetary policy:

$$r_t = \tau_\pi E_t \pi_{c,t+k} \text{ for } k \in \{0, 1\} \quad (14)$$

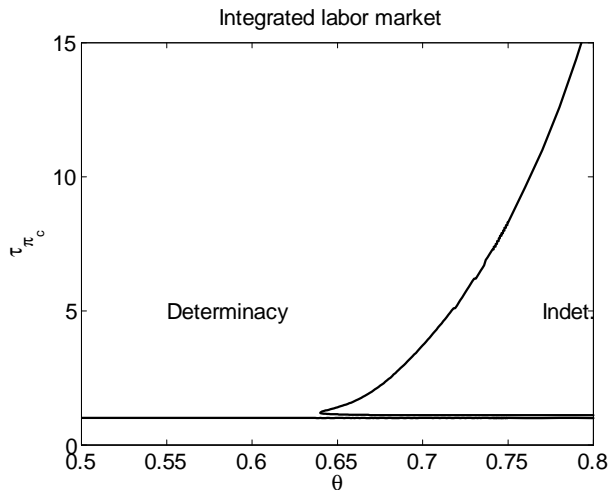
I choose standard parameter values:

Parameter	Value	Justification
β	0.99	Steady state annual real interest rate of 4%.
η	1	Labor supply elasticity of 1.
ϵ_N	6	Mark-up in wage setting of about 20%.
θ_w	0.75	Nominal wage stickiness of 4 quarters.
ϵ	11	10% mark-up on goods.
α	0.36	Capital share
δ	0.025	Annual depreciation of about 10%.
ϵ_ψ	3	Capital adjustment costs

Results

Current-looking monetary policy

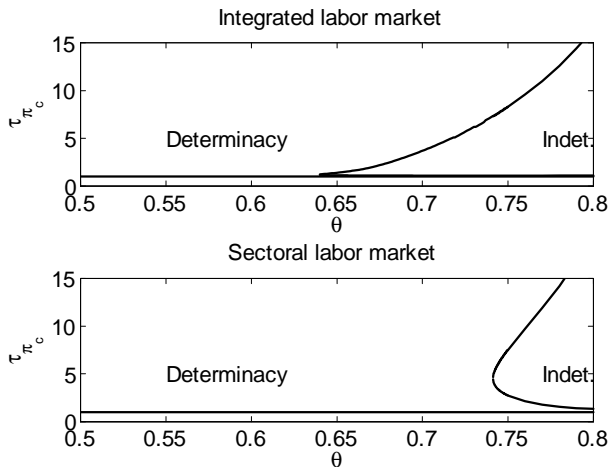
Integrated labor markets and common price stickiness



Results

Current-looking monetary policy

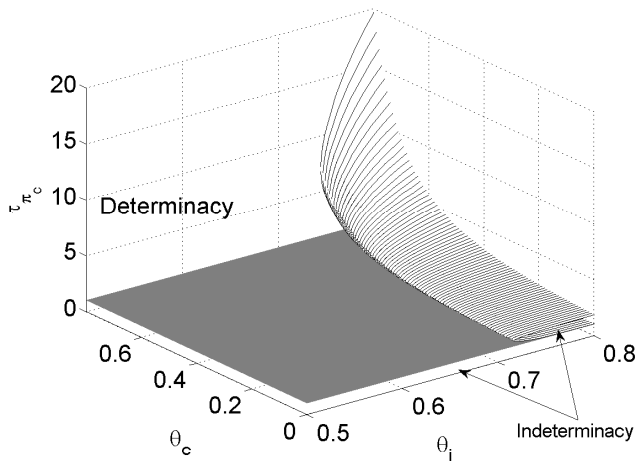
Integrated vs sectoral labor markets:



Results

Current-looking monetary policy

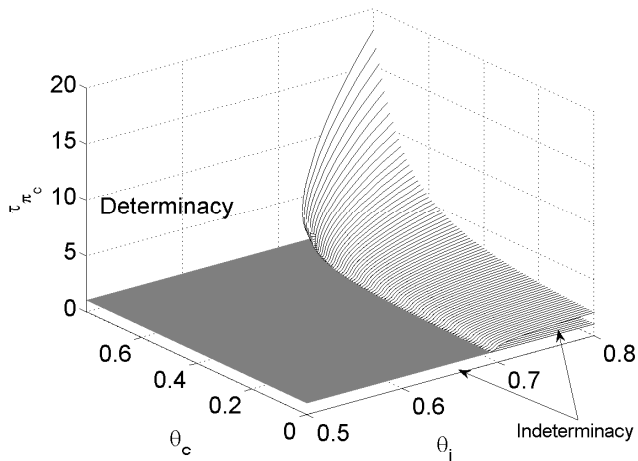
Adding heterogeneity in price stickiness:



Results

Current-looking monetary policy

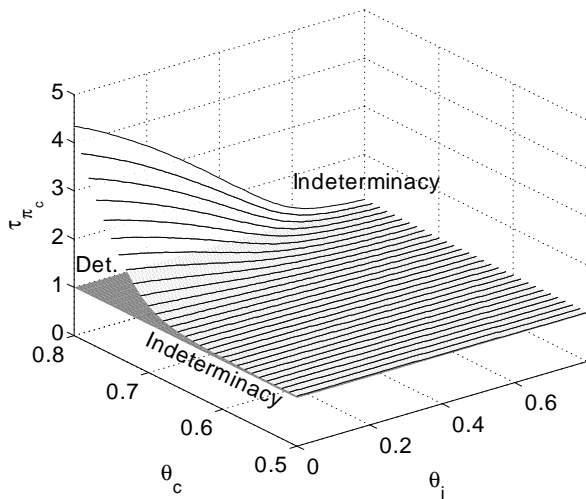
Adding more heterogeneity:



Results

Forward-looking monetary policy

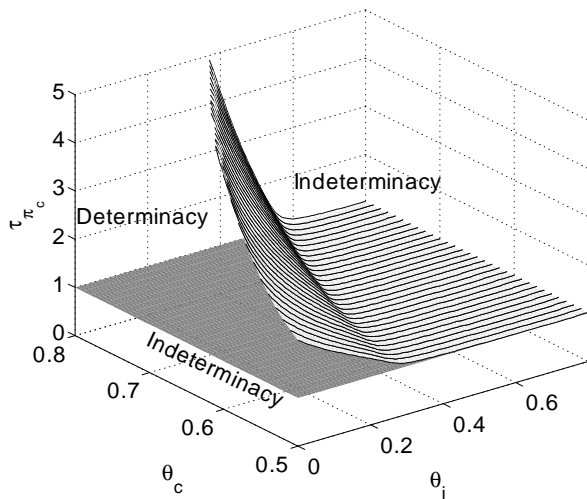
Forward-looking policy and heterogeneity in price stickiness:



Results

Current-looking monetary policy

Adding more heterogeneity:



- Related literature overstate the likelihood of indeterminacy in New Keynesian models with capital accumulation if the central bank follows the Taylor principle.
 - Key to the increased probability of determinacy is volatility of the real price of investment goods.
- In stark contrast to the existing literature, even forward-looking rules might give determinacy if there is sufficient heterogeneity (in price-setting and capital intensity) between the two sectors.