Pension Fund Restoration Policy in General Equilibrium

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Overview

1. Motivation
2. Model
3. Results
4. Conclusions

Research question

What are the business cycle effects and distributional consequences of pension fund restoration policy after the economy has been hit by a financial shock?

Motivation

Pension funds suffered large financial losses in 2008 ...

Country	2008
Turkey	19.00
Korea	4.09
Germany	1.60
Czech Republic	0.32
Greece	-0.89
Mexico	-2.03
Slovak Republic	-2.08
Italy	-6.30
Spain	-8.00
Norway	-8.70
Simple average	**-10.83**
Switzerland	-11.30
Austria	-12.94
Poland	-14.28
Luxembourg	-14.39
Chile	-14.58
Portugal	-14.66
Finland	-15.00
Netherlands	-15.70
Hungary	-17.64
Belgium	-19.89
Australia	-20.60
Weighted average	**-20.93**
United States	-24.00
Ireland	-35.00

Source: OECD (2011)

Figure: Pension funds' real investment rate of return in selected OECD countries in 2008 (Natali, 2011)

Motivation

... and as a result were heavily underfunded

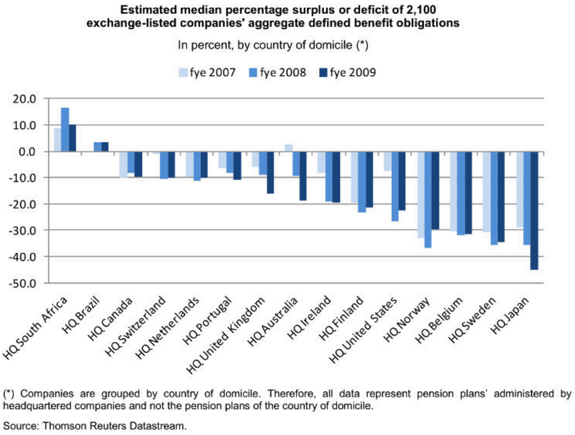


Figure: Median pension fund deficits of 2100 OECD companies in 2007, 2008, and 2009 (Laboul, 2010)

Motivation

How do pension funds typically function?

- Workers pay pension fund contributions (typically as a **share** of labour income)
- In return, workers accumulate pension benefits to be received upon retirement
- Pension fund invests paid contributions by workers

What does underfunded mean?

- Assets: value of managed assets (i.e. holding of capital stock)
- Liabilities: PDV of existing pension promises to fund participants
- No action entails pension fund exhausts assets

Motivation

Pension fund regulations prescribe speedy restoration of funding adequacy

- In e.g. Denmark, Finland, Germany, Iceland, Norway, Sweden (Pugh and Yermo, 2008)
- In The Netherlands through Financieel Toetsings Kader

However, undertaken measures differ widely (OECD, 2013)

- Less indexation of pension benefits
- Increased contribution payments
- Writing down of accumulated pension benefits (last resort)

Motivation

Theoretically, not just a matter of bring assets closer to liabilities:

- Δ distributional consequences
- Δ implications for macroeconomic aggregates

Writing down accumulated pension benefits:

- Liabilities $\downarrow$
- Mostly hurts retirees
- Retirees have higher MPCW $\rightarrow$ aggregate consumption drops

Increasing contribution payments:

- Assets $\uparrow$
- Mostly hurts workers
- Distorts labour supply and in turn aggregate supply

Model

Candidate model: Gertler (1999)

- Life-cycle behaviour in model calibrated at business cycle frequency
- Economy is populated by two groups of agents: workers and retirees
- Workers retire, retirees decease
- Agents take into account finiteness of life when optimising
- Government policy is non-Ricardian (and so is our pension fund)

Model

Our model:

- New-Keynesian, closed economy version of Gertler (1999) inspired by Kara and von Thadden (2016) and Fujiwara and Teranishi (2008)

Innovation:

- Introduce pension fund framework of Romp (2013) to flexibly embed various types of pension funds (DB, DC, etc.)
- Highlight how pension fund policy influences agent's incentives

Model

Discuss model elements with focus on own innovations:

1. Retiree and worker decision problem
2. Pension fund

Skip:

1. Production
2. Government

Retiree and worker decision problem

- Each period, agents choose consumption c_t^i, labour supply l_t^i, and real balances m_t^i, $i = \{r, w\}$
- Maximise expected lifetime utility with RINCE preferences (see e.g. Weil (1989) and Farmer (1990))
- Risk neutrality, but nontrivial preference for intertemporal consumption smoothing

Retiree and worker decision problem

How is the pension fund embedded in the decision problem of agents?

- Agents pay contribution 'tax' τ on labour income
- Agents accumulate ν share of labour income as additional per-period pension benefits to be received upon retirement (annuity)
- Pension fund can mark up or write down stock of per-period pension benefits with indexation instrument μ
- Pension fund announces τ, ν, and μ at the start of each period

Distorted labour supply decision

Effective retiree tax rate:

$$\tau_t^r = \tau_t - (R_t^r - 1)\nu_t$$
$$R_t^r = 1 + \mu_{t+1}\frac{\gamma}{1 + r_{t+1}}R_{t+1}^r$$

Effective worker tax rate:

$$\begin{aligned}
\tau_t^w =& \tau_t - R_t^w \nu_t \\
R_t^w =& \frac{\mu_{t+1}}{1 + r_{t+1}}\left(\frac{\omega}{\Omega_{t+1}}R_{t+1}^w + (1 - \frac{\omega}{\Omega_{t+1}})R_{t+1}^r\right) \\
\Omega_{t+1} =& \omega + (1-\omega)\left(\frac{1-\tau_{t+1}^w}{1-\tau_{t+1}^r}\frac{1}{\xi}\right)^{v_2}(\epsilon_{t+1})^{\frac{1}{1-\sigma}}
\end{aligned}$$

Pension Fund

Funding gap policy rule:

$$K_{t+1}^f - L_{t+1}^f = \upsilon(K_t^f - L_t^f)$$

- K_t^f = value of managed assets
- L_t^f = value of extended pension promises to current fund participants
- $\upsilon \in [0,1)$ denotes closure speed
- if $K_t^f < L_t^f \rightarrow$ either $\mu_t < 1$, or $\nu_t \downarrow$, or $\tau_t \uparrow$
- υ_μ denotes share of gap to be closed through indexation instrument μ
- fix $\nu_t = \nu$

Production and government

Production:

- Perfectly competitive final goods sector
- Imperfectly competitive intermediate goods sector with Calvo (1983) pricing
- Perfectly competitive capital goods sector subject to capital adjustment costs

Government:

- Central bank follows standard Taylor rule with interest rate smoothing

Results

1. Pension fund calibration
2. Restoration policy after unexpected capital stock shock
3. Impulse response functions
4. Welfare implications

Pension fund calibration

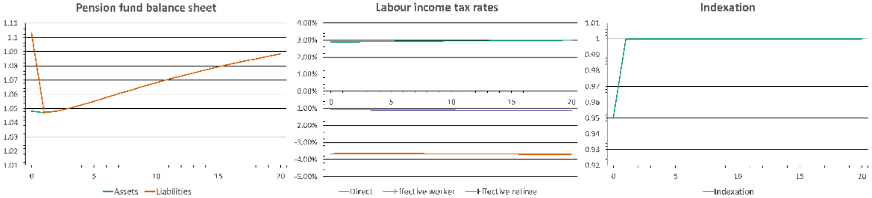
Table: Pension fund parameters and targeted pension fund variables

Accrual rate	ν	0.0055
Implied contribution rate	τ	0.022
Implied pension fund capital to output ratio	$\frac{K^f}{y}$	0.89
Implied retiree pension transfers to output ratio	$\frac{P^{r,f}}{y}$	0.049
Implied pension fund capital to aggregate capital ratio	$\frac{K^f}{k}$	0.274

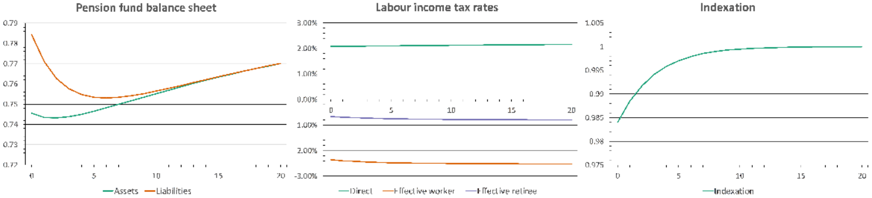
Capital stock shock

- As in Shimer (2012), suppose unexpected capital stock shock evaporates 10% of capital
- Pension fund now has $K_t^f < L_t^f \rightarrow$ conduct restoration policy

Pension fund restoration policy I

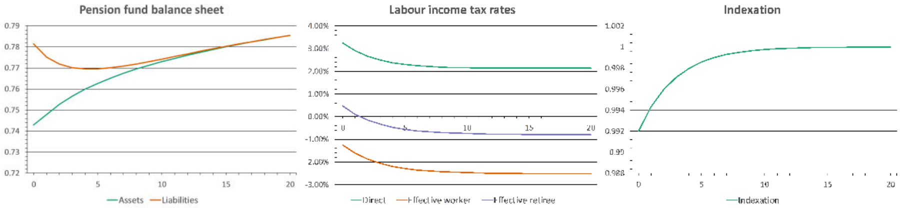


(a) Defined Contribution

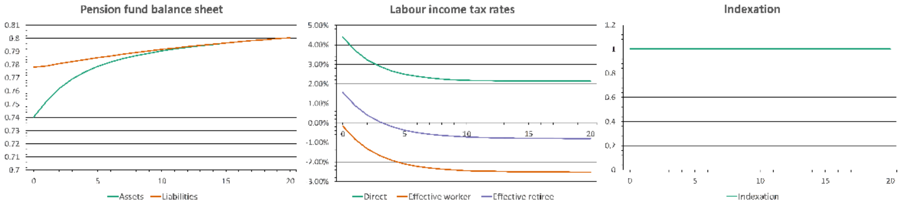


(b) Indexation

Pension fund restoration policy II

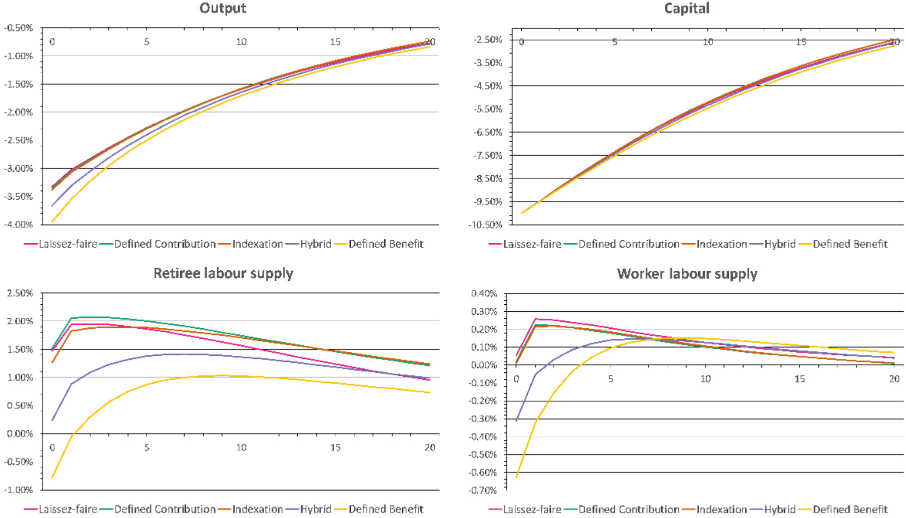


(c) Hybrid



(d) Defined Benefit

Impulse response diagrams I



Impulse response diagrams II

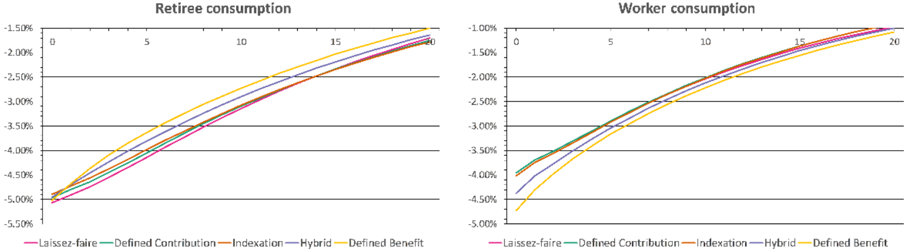


Figure: Impulse response diagrams for various variables after a 10% capital stock shock, compared over different pension systems. Values are in percentual deviation from the steady state.

Welfare implications

Table: First period equivalent variations (as a percentage of GDP) compared to Defined Contribution scenario after a 10% capital stock shock across different pension arrangements.

	Retirees EV	Workers EV
Indexation	0.19%	−0.42%
Hybrid	0.49%	−1.68%
Defined Benefit	0.78%	−3.04%

- Only compute welfare of current groups of workers and retirees (income effects in labour supply)
- When pension funding gap is closed over time, part of welfare gains come at expense of future generations

Sensitivity analyses

- Low retiree productivity $\rightarrow$ welfare improving scope of DB fund $\uparrow$
- Large DB pension fund $\rightarrow$ shelter retirees from shocks $\uparrow$
- Increased life-expectancy $\rightarrow$ retirees better equipped against shocks
- Trade-off between slow and fast recovery

Concluding remarks

Major take-aways:

- Economies with DC-type pension funds behave similarly to economies without pension funds
- Significant deviations when pension funds use τ to fill funding gaps
- DB pension funds distort labour supply, but can shelter retirees from shocks
- Retiree self-sufficiency, size of pension funds, and speed of recovery are key determinants

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Retiree decision problem

$$V_t^{r,i}(\frac{1+r_t}{\gamma}a_{t-1}^{r,i}, \mu_t P_t^{r,i}) = \max_{c_t^{r,i}, a_t^{r,i}, l_t^{r,i}, m_t^{r,i}} \Bigg[[(c_t^{r,i})^{v_1}(1-l_t^{r,i})^{v_2}(m_t^{r,i})^{v_3}]^{\rho} + \beta\gamma[V_{t+1}^{r,i}(\frac{1+r_{t+1}}{\gamma}a_t^{r,i}, \mu_{t+1}P_{t+1}^{r,i})]^{\rho}\Bigg]^{\frac{1}{\rho}}$$

subject to:

$$c_t^{r,i} + a_t^{r,i} + \frac{i_t}{1+i_t}m_t^{r,i} = \frac{1+r_t}{\gamma}a_{t-1}^{r,i} + (1-\tau_t)\xi w_t l_t^{r,i} + \mu_t P_t^{r,i} - \tau_t^g$$

$$P_{t+1}^{r,i} = \mu_t P_t^{r,i} + \nu_t \xi w_t l_t^{r,i}$$

Retiree decision problem

Special attention to labour supply decision:

$$1 - l_t^{r,i} = \frac{v_2}{v_1} \frac{c_t^{r,i}}{(1 - \tau_t^r)\xi w_t},$$

where $\tau_t^r = \tau_t - (R_t^r - 1)\nu_t$ and $R_t^r = 1 + \mu_{t+1} \frac{\gamma}{1+r_{t+1}} R_{t+1}^r$

Optimisation gives:

- Retiree consumes fraction $\epsilon_t \pi_t$ of total lifetime wealth in period t
- Total lifetime wealth: PDV of disposable income

Retiree decision problem

Optimisation gives:

$$c_{t+1}^{r,i} = \left[\beta(1+r_{t+1})\left(\frac{(1-\tau_t^r)w_t}{(1-\tau_{t+1}^r)w_{t+1}}\right)^{v_2\rho}\left(\frac{1+i_{t+1}}{i_{t+1}}\frac{i_t}{1+i_t}\right)^{v_3\rho}\right]^{\sigma} c_t^{r,i}$$

$$1-l_t^{r,i} = \frac{v_2}{v_1}\frac{c_t^{r,i}}{(1-\tau_t^r)\xi w_t}$$

$$m_t^{r,i} = \frac{v_3}{v_1}\frac{1+i_t}{i_t}c_t^{r,i},$$

where $\tau_t^r = \tau_t - (R_t^r - 1)\nu_t$ and $R_t^r = 1 + \mu_{t+1}\frac{\gamma}{1+r_{t+1}}R_{t+1}^r$

Worker decision problem

$$V_t^{w,j}((1+r_t)a_{t-1}^{w,j}, \mu_t P_t^{w,j}) = \max_{c_t^{w,j}, a_t^{w,j}, l_t^{w,j}, m_t^{w,j}} \Bigg[[(c_t^{w,j})^{v_1}(1-l_t^{w,j})^{v_2}(m_t^{w,j})^{v_3}]^{\rho} + \beta \Big[\omega V_{t+1}^{w,j}((1+r_{t+1})a_t^{w,j}, \mu_{t+1}P_{t+1}^{w,j}) + (1-\omega)V_{t+1}^{r,j}((1+r_{t+1})a_t^{r,j}, \mu_{t+1}P_{t+1}^{r,j}) \Big]^{\rho} \Bigg]^{\frac{1}{\rho}}$$

subject to the constraints that become operative once he retires and:

$$c_t^{w,j} + a_t^{w,j} + \frac{i_t}{1+i_t} m_t^{w,j} = (1+r_t)a_{t-1}^{w,j} + (1-\tau_t)w_t l_t^{w,j} + f_t - \tau_t^g$$

$$P_{t+1}^{w,j} = \mu_t P_t^{w,j} + \nu_t w_t l_t^{w,j}$$

Worker decision problem

$$\omega c_{t+1}^{w,j} + (1-\omega) c_{t+1}^{r,j} \Lambda_{t+1} \chi_{t+1} = c_t^{w,j} \left[\beta(1+r_{t+1}) \Omega_{t+1} \left(\frac{(1-\tau_t^w) w_t}{(1-\tau_{t+1}^w) w_{t+1}} \right)^{v_2 \rho} \left(\frac{1+i_{t+1}}{i_{t+1}} \frac{i_t}{1+i_t} \right)^{v_3 \rho} \right]^{\sigma}$$

$$1 - l_t^{w,j} = \frac{v_2}{v_1} \frac{c_t^{w,j}}{(1-\tau_t^w) w_t}$$

$$m_t^{r,j} = \frac{v_3}{v_1} \frac{1+i_t}{i_t} c_t^{w,j},$$

with:

$$\Lambda_{t+1} = (\epsilon_{t+1})^{\frac{\sigma}{1-\sigma}}$$

$$\chi_{t+1} = \left(\frac{1-\tau_{t+1}^w}{1-\tau_{t+1}^r} \frac{1}{\xi} \right)^{v_2}$$

$$\Omega_{t+1} = \omega + (1-\omega) \chi_{t+1} (\epsilon_{t+1})^{\frac{1}{1-\sigma}}$$

Aggregation

Aggregation is straight-forward due to:

- Linearity of l_t^z and m_t^z in c_t^z
- π_t and $\epsilon_t \pi_t$ the same for all workers and retirees, respectively

Example:

$$l_t^r = \sum^i (1 - \frac{v_2}{v_1} \frac{c_t^{r,i}}{(1-\tau_t^r)\xi w_t}) = N^r - \frac{v_2}{v_1} \frac{c_t^r}{(1-\tau_t^r)\xi w_t}$$

$$c_t^r = \sum^i \left(\epsilon_t \pi_t \left(\frac{(1+r_t)}{\gamma} a_{t-1}^{r,i} + h_t^{r,i} \right) \right) = \epsilon_t \pi_t \left((1+r_t) a_{t-1}^r + h_t^r \right)$$

Aggregation I

$$l_t^r = \sum^i (1 - \frac{v_2}{v_1} \frac{c_t^{r,i}}{(1-\tau_t^r)\xi w_t}) = N^r - \frac{v_2}{v_1} \frac{c_t^r}{(1-\tau_t^r)\xi w_t}$$

$$l_t^w = \sum^j (1 - \frac{v_2}{v_1} \frac{c_t^{w,j}}{(1-\tau_t^w) w_t}) = N^w - \frac{v_2}{v_1} \frac{c_t^w}{(1-\tau_t^w) w_t}$$

$$l_t = l_t^w + \xi l_t^r,$$

$$d_t^r = \sum^i \left((1-\tau_t)\xi w_t l_t^{r,i} + \mu_t P_t^{r,i} - \tau_t^g \right) = (1-\tau_t)\xi w_t l_t^r + \mu_t P_t^{r,f} - \tau_t^g N^r$$

$$d_t^w = \sum^j \left((1-\tau_t) w_t l_t^{w,j} + f_t - \tau_t^g \right) = (1-\tau_t) w_t l_t^w + f_t N^w - \tau_t^g N^w,$$

Aggregation II

$$h_t^r = \sum^i (d_t^{r,i} + \frac{\gamma}{1+r_{t+1}} h_{t+1}^{r,i}) = d_t^r + \frac{\gamma}{1+r_{t+1}} h_{t+1}^r$$

$$\begin{aligned} h_t^w &= \sum^j \left(d_t^{w,j} + \frac{1}{1+r_{t+1}} \left(\frac{\omega}{\Omega_{t+1}} h_{t+1}^{w,j} + (1 - \frac{\omega}{\Omega_{t+1}}) h_{t+1}^{r,j} \right) \right) \\ &= d_t^w + \frac{1}{1+r_{t+1}} \left(\frac{\omega}{\Omega_{t+1}} h_{t+1}^w + (1 - \frac{\omega}{\Omega_{t+1}}) \frac{1}{\psi} h_{t+1}^r \right), \end{aligned}$$

$$\begin{aligned} a_t^r =& (1+r_t) a_{t-1}^r + d_t^r - c_t^r - \frac{i_t}{1+i_t} m_t^r + \\ & (1-\omega) \left((1+r_t) a_{t-1}^w + d_t^w - c_t^w - \frac{i_t}{1+i_t} m_t^w \right) \\ a_t^w &= \omega \left((1+r_t) a_{t-1}^w + d_t^w - c_t^w - \frac{i_t}{1+i_t} m_t^w \right) \\ a_t &= a_t^w + a_t^r, \end{aligned}$$

Aggregation III

$$c_t^r = \sum^i \left(\epsilon_t \pi_t \left(\frac{(1+r_t)}{\gamma} a_{t-1}^{r,i} + h_t^{r,i} \right) \right) = \epsilon_t \pi_t \left((1+r_t) a_{t-1}^r + h_t^r \right)$$

$$c_t^w = \sum^j \left(\pi_t \left((1+r_t) a_{t-1}^{w,j} + h_t^{w,j} \right) \right) = \pi_t \left((1+r_t) a_{t-1}^w + h_t^w \right)$$

$$c_t = c_t^r + c_t^w,$$

$$m_t^r = \sum^i \left(\frac{v_2}{v_1} \frac{1+i_t}{i_t} c_t^{r,i} \right) = \frac{v_2}{v_1} \frac{1+i_t}{i_t} c_t^r$$

$$m_t^w = \sum^j \left(\frac{v_2}{v_1} \frac{1+i_t}{i_t} c_t^{w,j} \right) = \frac{v_2}{v_1} \frac{1+i_t}{i_t} c_t^w$$

$$m_t = m_t^w + m_t^r$$

Pension Fund

Liabilities:

$$L_t^f = R_t^{r,f} P_t^{r,f} + R_t^{w,f} P_t^{w,f}$$

Counterparts of $P_t^{r,i}$ and $P_t^{w,j}$:

- $P_t^{r,f}$ = aggregate stock of per-period pension benefits of currently retired
- $P_t^{w,f}$ = aggregate stock of per-period pension benefits of currently working

Counterparts of R_t^r and R_t^w:

$$R_t^{r,f} = 1 + \frac{\gamma}{1 + r_{t+1}} R_{t+1}^{r,f}$$
$$R_t^{w,f} = \frac{1}{1 + r_{t+1}} (\omega R_{t+1}^{w,f} + (1-\omega) R_{t+1}^{r,f})$$

Production I

Back to (**??**)

$$y_t = \left[\int_0^1 (y_{z,t})^{\frac{\theta-1}{\theta}} \, dz \right]^{\frac{\theta}{\theta-1}}$$

$$y_{z,t} = y_t \left[\frac{P_{z,t}}{P_t} \right]^{-\theta}$$

$$P_t = \left[\int_0^1 (P_{z,t})^{1-\theta} \, dz \right]^{\frac{1}{1-\theta}}$$

$$y_{z,t} = (A_t^{lap} l_{z,t})^{\alpha} (k_{z,t})^{1-\alpha}$$

Production II

$$w_t = mc_t[\alpha \left(\frac{k_{z,t}}{A_t^{lap} l_{z,t}} \right)^{1-\alpha} A_t^{lap}] \rightarrow mc_t = \frac{w_t l_{z,t}}{\alpha y_{z,t}}$$

$$r_t^k = mc_t[(1-\alpha) \left(\frac{A_t^{lap} l_{z,t}}{k_{z,t}} \right)^{\alpha}] \rightarrow mc_t = \frac{r_t^k k_{z,t}}{(1-\alpha) y_{z,t}}$$

$$\begin{aligned} f_{z,t} &= \frac{P_{z,t}}{P_t} y_{z,t} - w_t l_{z,t} - r_t^k k_{z,t} \\ &= y_{z,t} \left(\frac{P_{z,t}}{P_t} - mc_t \right) \end{aligned}$$

$$\frac{k_{z,t}}{l_{z,t}} = \frac{1-\alpha}{\alpha} \frac{w_t}{r_t^k}$$

$$mc_t = \left(\frac{w_t}{\alpha A_t^{lap}} \right)^{\alpha} \left(\frac{r_t^k}{1-\alpha} \right)^{1-\alpha}$$

Production III

$$\frac{P_t^*}{P_t} = \frac{\theta}{\theta - 1} \frac{\sum_{i=0}^{\infty} (\zeta\beta)^i \Delta_{t+i} \left(\frac{1}{P_{t+i}}\right)^{1-\theta} y_{t+i} mc_{t+i} \frac{P_{t+i}}{P_t}}{\sum_{i=0}^{\infty} (\zeta\beta)^i \Delta_{t+i} \left(\frac{1}{P_{t+i}}\right)^{1-\theta} y_{t+i}}$$

$$P_t = \left[\zeta (P_{t-1})^{1-\theta} + (1-\zeta)(P_t^*)^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

$$k_t = (1-\delta) k_{t-1} + \left(1 - S[\frac{i_t^k}{i_{t-1}^k}]\right) i_t^k$$

$$1 + r_t = \frac{P_t^k (1-\delta) + r_t^k}{P_{t-1}^k}$$

$$1 = P_t^k \left(1 - S[\frac{i_t^k}{i_{t-1}^k}] - S'[\frac{i_t^k}{i_{t-1}^k}] \frac{i_t^k}{i_{t-1}^k}\right) + \frac{P_{t+1}^k}{1 + r_{t+1}} S'[\frac{i_{t+1}^k}{i_t^k}] (\frac{i_{t+1}^k}{i_t^k})^2$$

Production IV

$$l_t = \int_0^1 l_{z,t} dz$$

$$k_{t-1} = \int_0^1 k_{z,t} dz$$

$$y_t = \left[\int_0^1 (y_{z,t})^{\frac{\theta-1}{\theta}} dz\right]^{\frac{\theta}{\theta-1}}, \text{ with } y_{z,t} = (A_t^{lap} l_{z,t})^{\alpha}(k_{z,t})^{1-\alpha}$$

$$f_t N^w = \int_0^1 f_{z,t} dz = \int_0^1 \left(\frac{P_{z,t}}{P_t} - mc_t\right) y_{z,t} dz, \text{ with } y_{z,t} = (A_t^{lap} l_{z,t})^{\alpha}(k_{z,t})^{1-\alpha}$$

$$a_t + K_t^f + \tau_t w_t l_t - \mu_t P_t^{r,f} = P_t^k k_t + \frac{m_t}{1+i_t}$$

$$y_t = c_t + i_t^k$$

$$i_t = \eta i_{t-1} + (1-\eta)[r_{t+1} + \gamma_\pi \pi_t^p + \gamma_y \tilde{y}_t]$$

Production V

$$\tau_t^g = m_{t-1}\frac{P_{t-1}}{P_t} - m_t$$