Inflation and speculation in a dynamic macroeconomic model

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George Boole Mathematical Sciences Conference
University College Cork, August 27, 2015

What's happening in China?

OPEN	DAY RANGE	PREVIOUS CLOSE
3,092.812	3,028.398 - 3,206.724	3,025.692
52WK RANGE	**1 YR RETURN**	**YTD RETURN**
2,309.639 - 5,380.426	39.83%	-7.95%

Figure: Shanghai Shenzhen CSI 300 Index (Source: Bloomberg)

Not for the first time...

Could anyone see it coming?

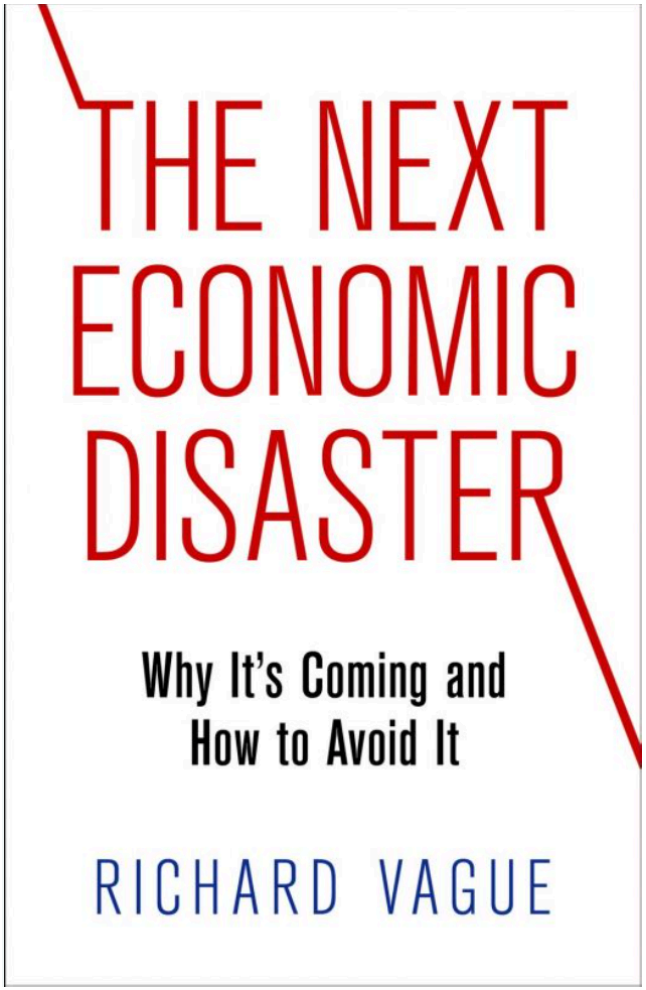
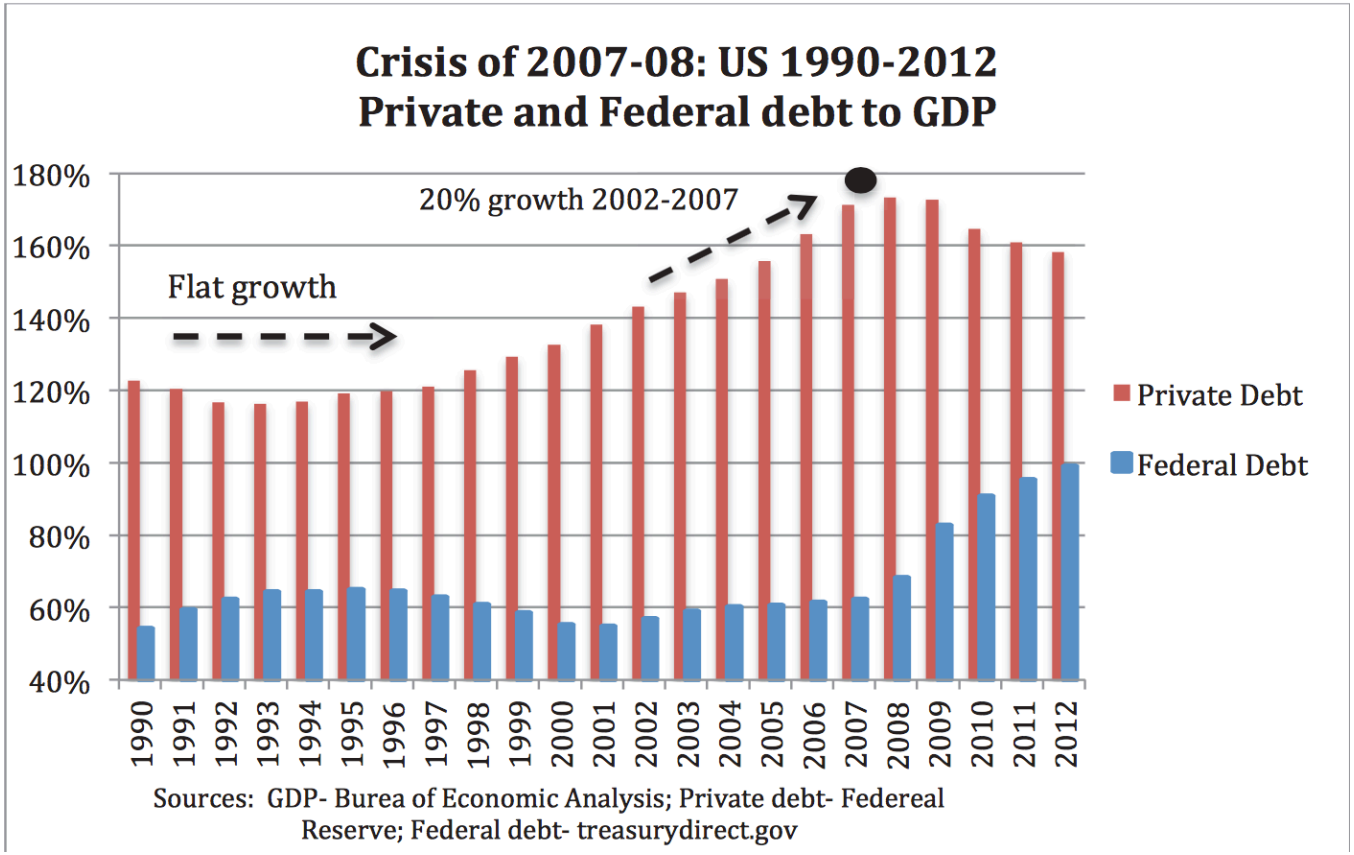


Figure: Published July 15, 2014

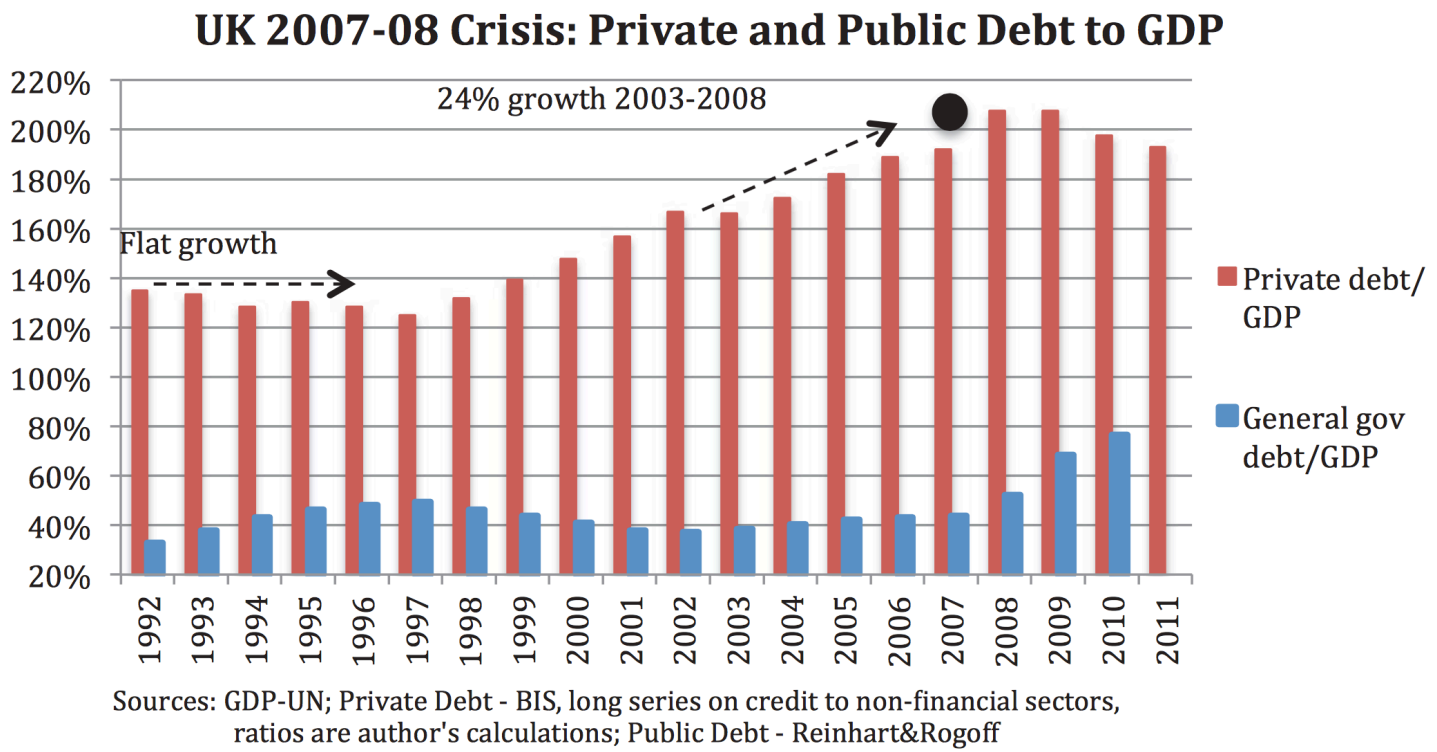
Vague's Crisis Indicator

- Indicator: 5-year increase in Private Debt/GDP of 18% or more + Private Debt/GDP greater than 150%
- Data: 22 countries, 27 crises (1997-2014)
- 5 crises with no private debt data
- 19 crises signalled by indicator (true positives)
- 3 crises not signalled by indicator (misses)
- 2 signals followed by no crises (false positives)
- Country at risk: China!

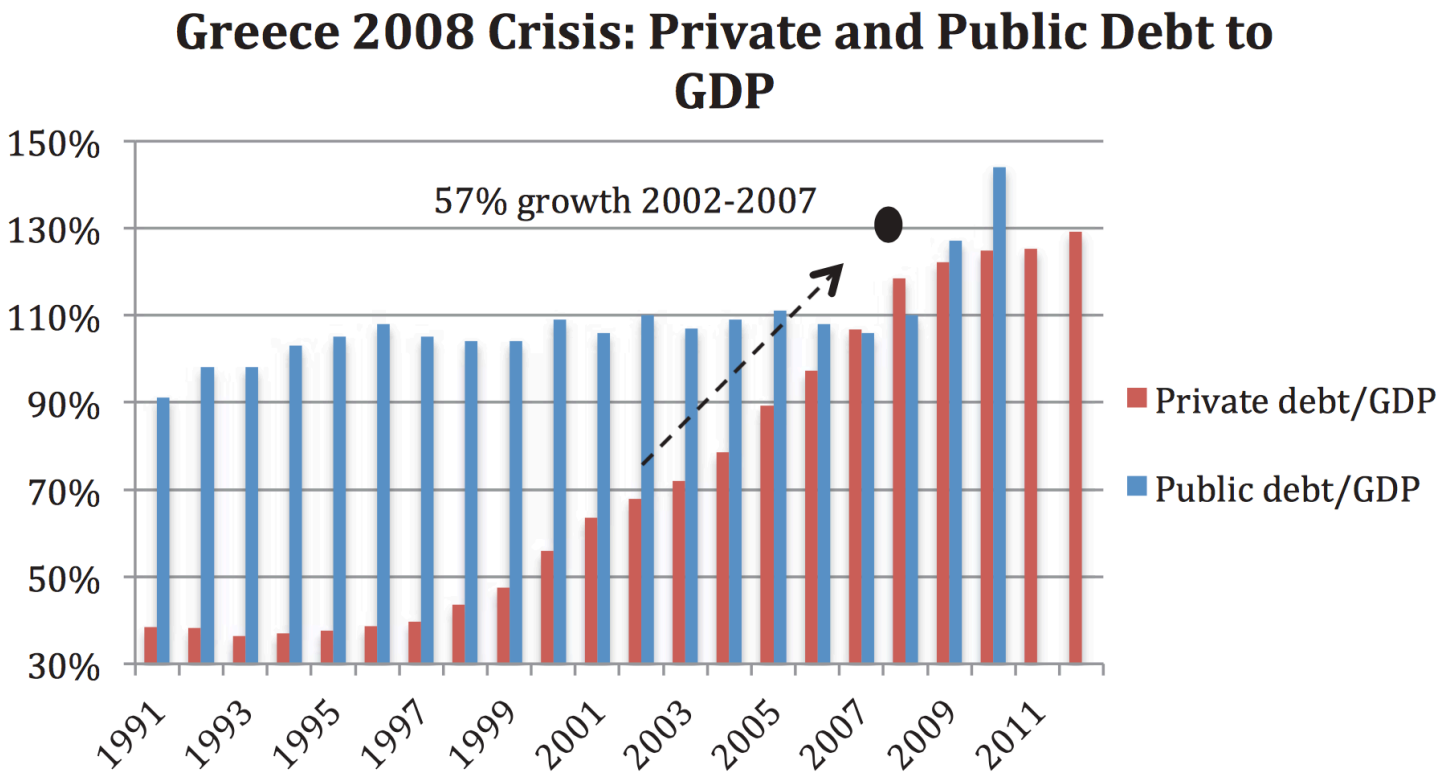
Vague's example 1: United States 2007-08 crisis



Vague's example 2: UK 2007-08 crisis

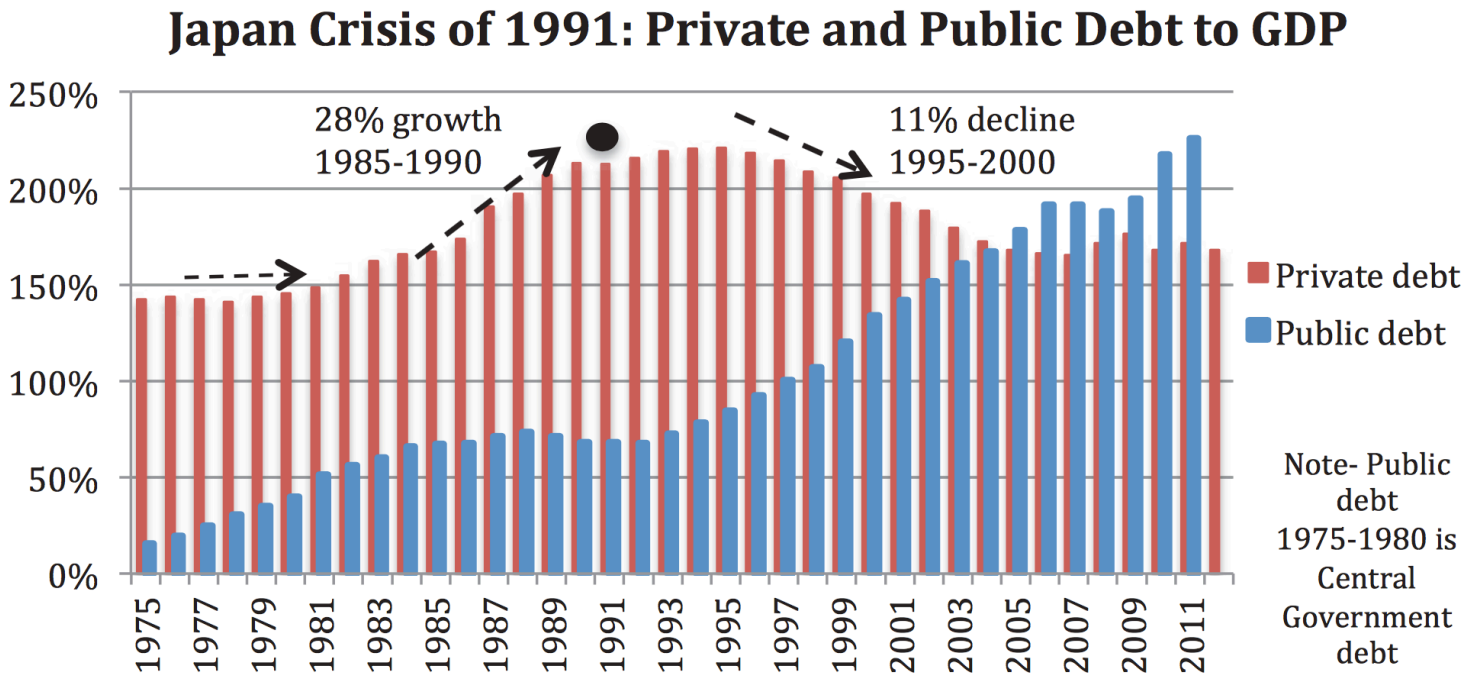


Vague's example 3: Greece 2008-09 crisis



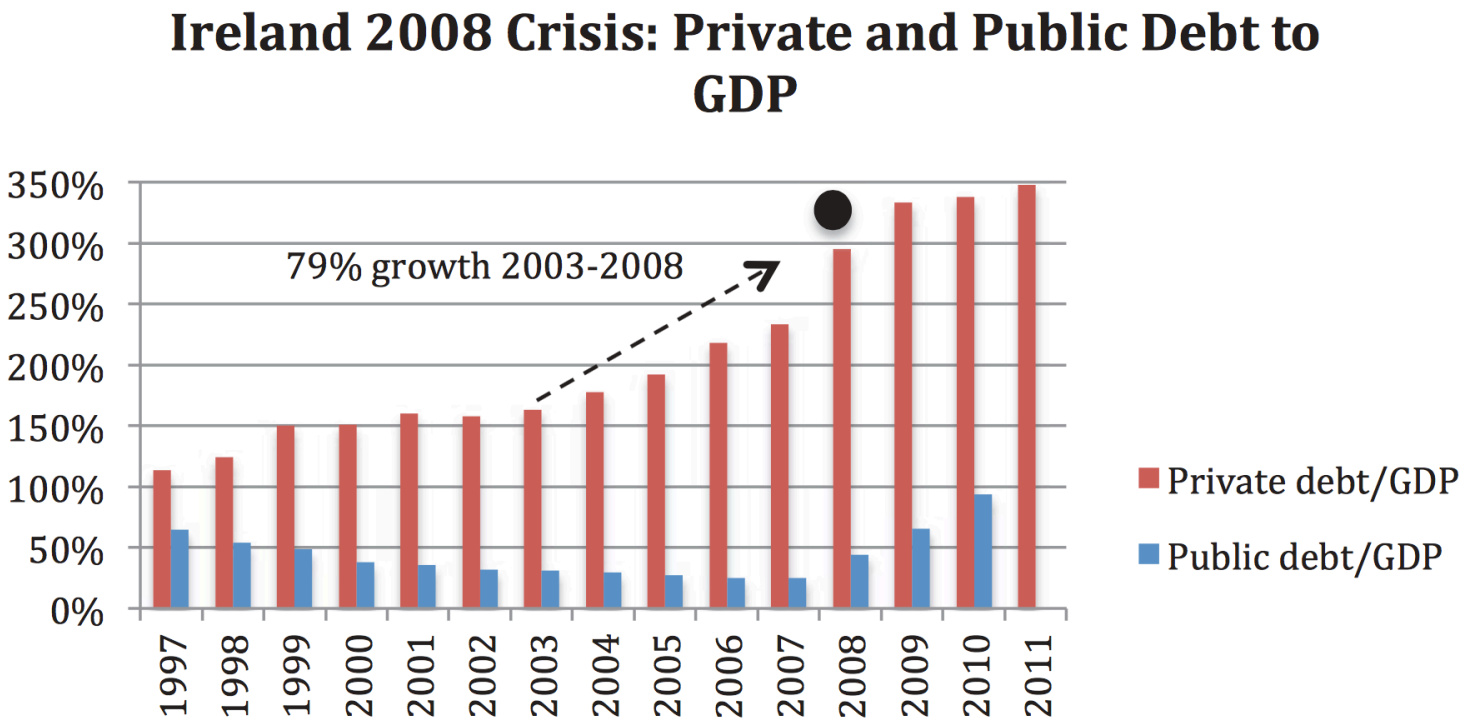
Sources- GDP- UN; Private debt- BIS, long series on credit to private non-financial sectors, ratios are author's calculations; Public debt- Reinhart&Rogoff

Vague's example 4: Japan 1991 crisis



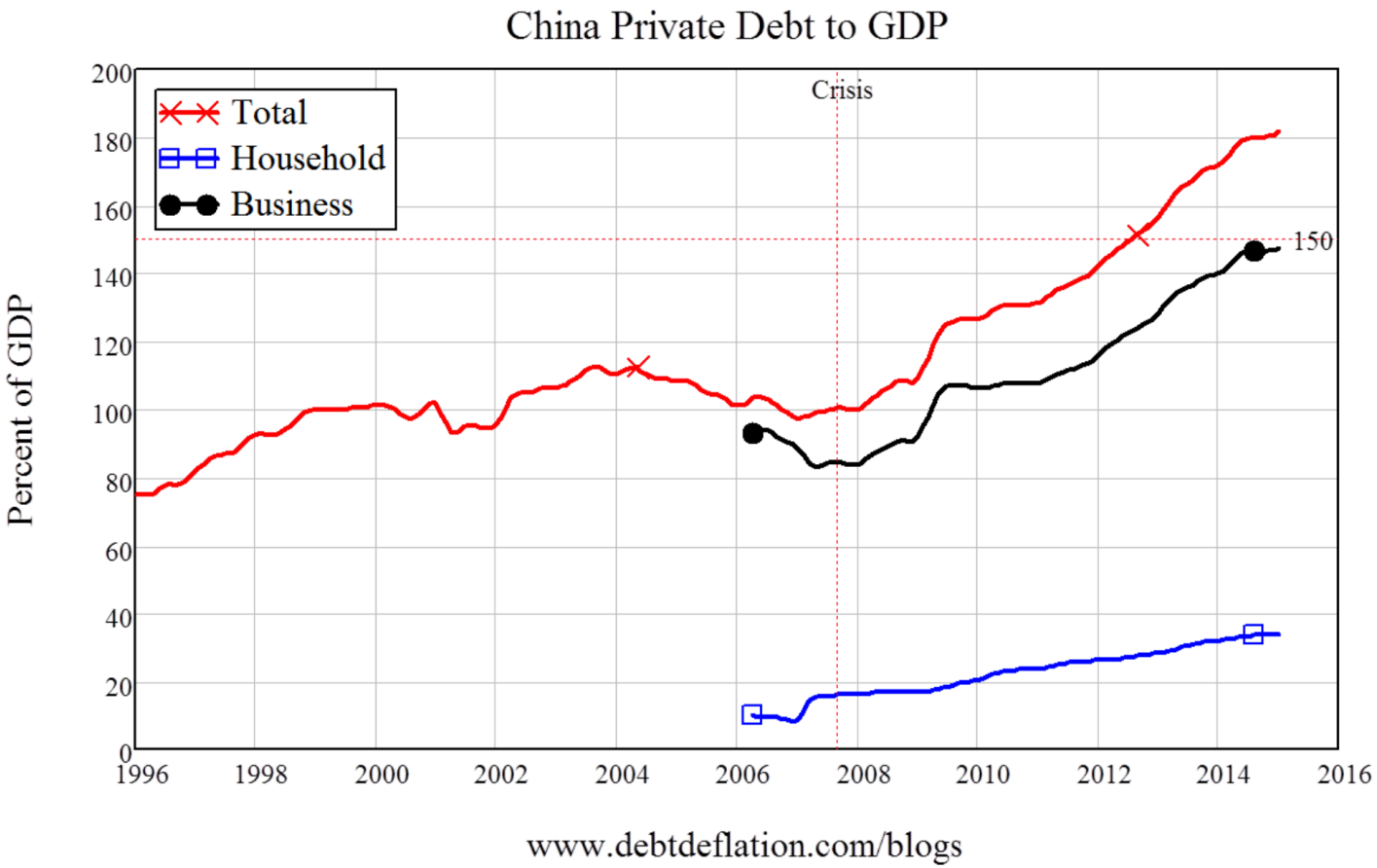
Sources: GDP -UN; Private Debt - BIS, long series on credit to private non-fianancial sectors, ratio's are author's calculations; Public Debt - Reinhart&Rogoff

Vague's example 5: Ireland 2008-09 crisis

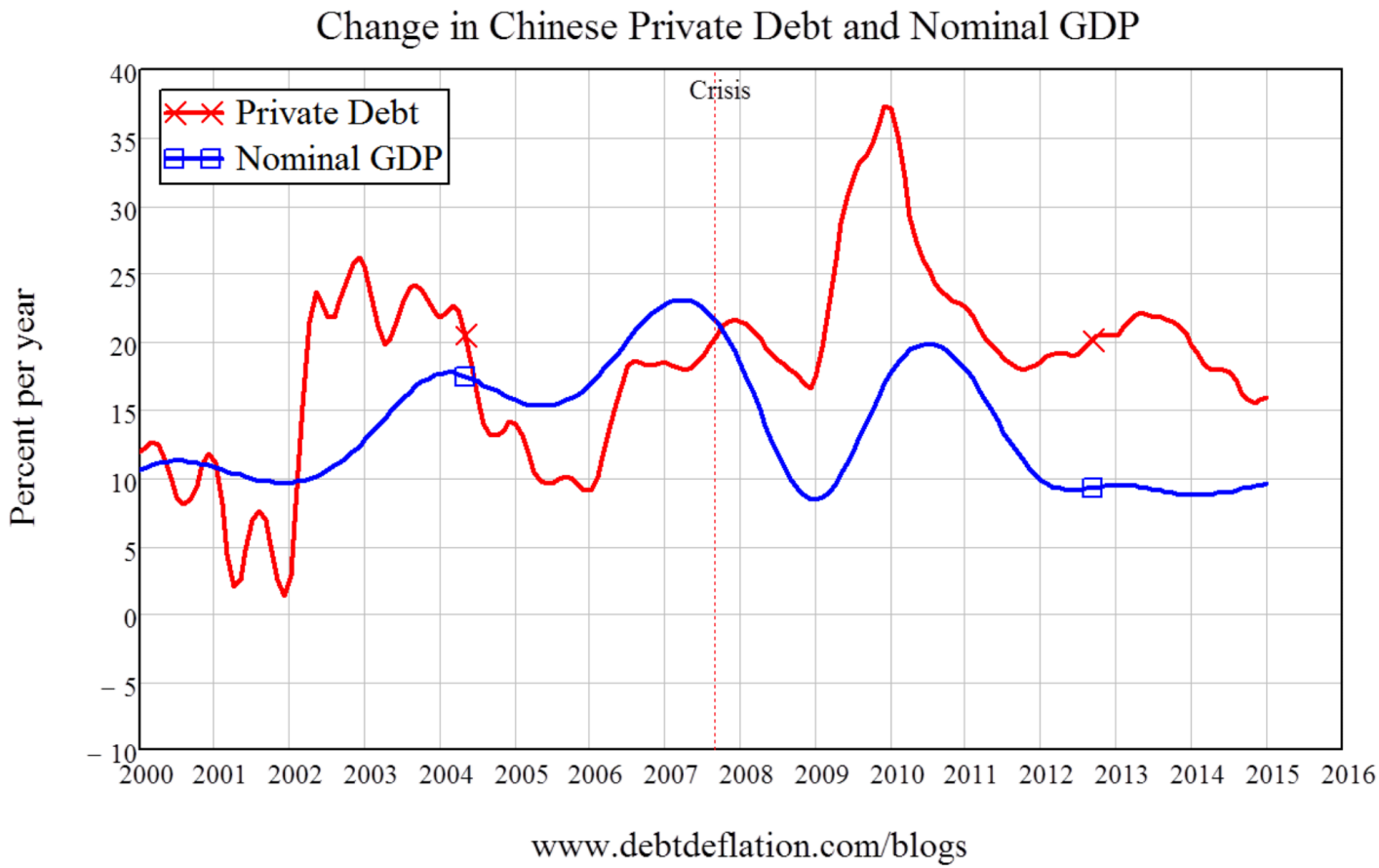


Sources: GDP-UN; Private Debt - BIS, long series on credit to private non-financial sectors, author's calculations; Public Debt - Reinhart&Rogoff

Back to China - why is this time different?



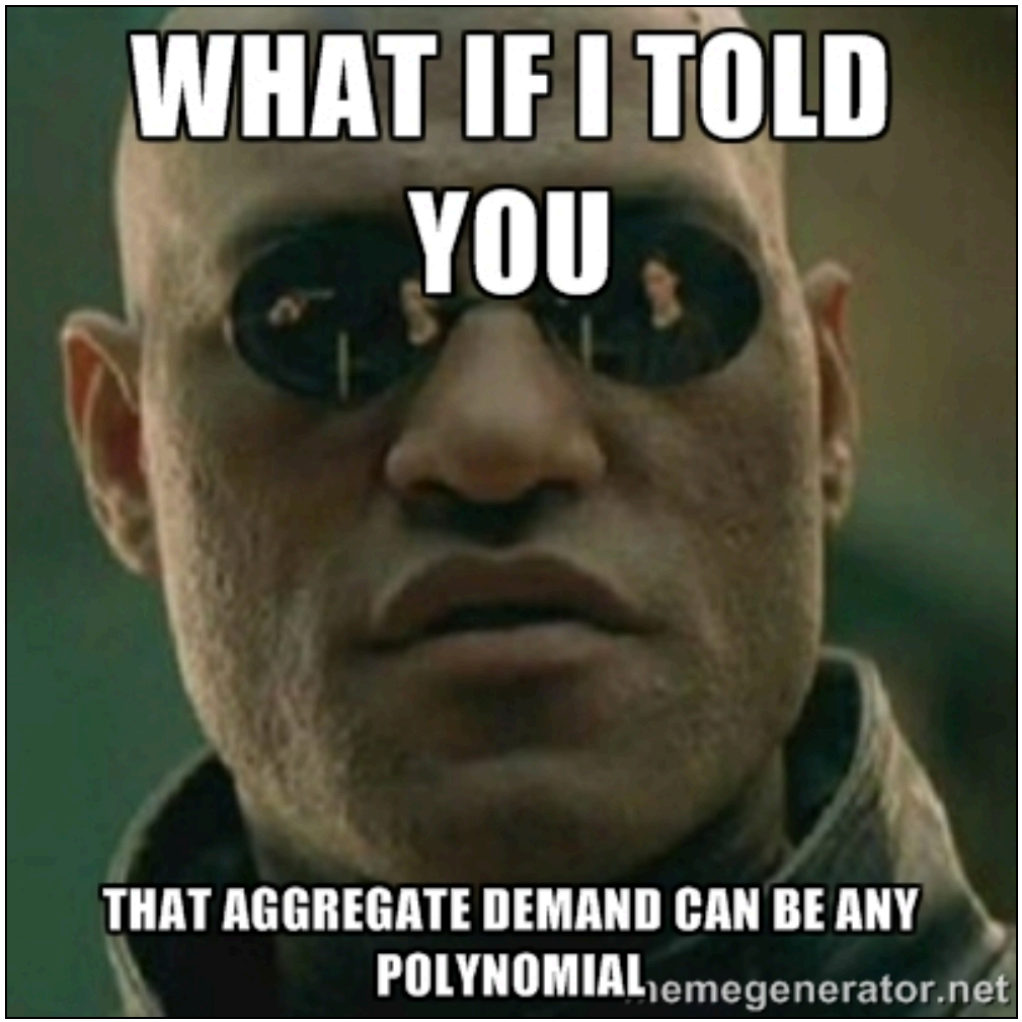
Private debt: the missing link (holy grail?) in macroeconomics



Dynamic Stochastic General Equilibrium (DSGE)

- Seeks to explain the aggregate economy using theories based on strong microeconomic foundations.
- Collective decisions of rational individuals over a range of variables for both present and future.
- All variables are assumed to be simultaneously in equilibrium.
- Equilibrium is only disrupted by exogenous shocks.
- The only way the economy can be in disequilibrium at any point in time is through decisions based on wrong information.
- Money is neutral in its effect on real variables.
- Finance exists to address frictions.
- Private debt only matters in extreme conditions (e.g liquidity trap).

SMD theorem: something is rotten in GE land



Stock-Flow Consistent models

- Stock-flow consistent models emerged in the last decade as a common language for many heterodox schools of thought in economics.
- They consider both real and monetary factors simultaneously.
- Specify the balance sheet and transactions between sectors.
- Accommodate a number of behavioural assumptions in a way that is consistent with the underlying accounting structure.
- Reject the RARE individual (representative agent with rational expectations) in favour of SAFE (sectoral average with flexible expectations) modelling.
- See Godley and Lavoie (2007) for the full framework.

Goodwin Model - SFC matrix

Balance Sheet	Households	Firms		Sum
		current	capital	
Capital			$+pK$	pK
Sum (net worth)	0	0	V_f	pK
Transactions				
Consumption	$-pC$	$+pC$		0
Investment		$+pI$	$-pI$	0
Acct memo [GDP]		$[pY]$		
Wages	$+W$	$-W$		0
Profits		$-\Pi$	$+\Pi_u$	0
Sum	0	0	0	0
Flow of Funds				
Capital			$+pI$	pI
Sum	0	0	Π_u	pI
Change in Net Worth	0	$pI + \dot{p}K - p\delta K$		$\dot{p}K + p\dot{K}$

Table: SFC table for the Goodwin model.

Goodwin Model - Differential equations

- Define

$$\omega = \frac{\mathrm{w}\ell}{pY} = \frac{\mathrm{w}}{pa} \quad \text{(wage share)}$$

$$\lambda = \frac{\ell}{N} = \frac{Y}{aN} \quad \text{(employment rate)}$$

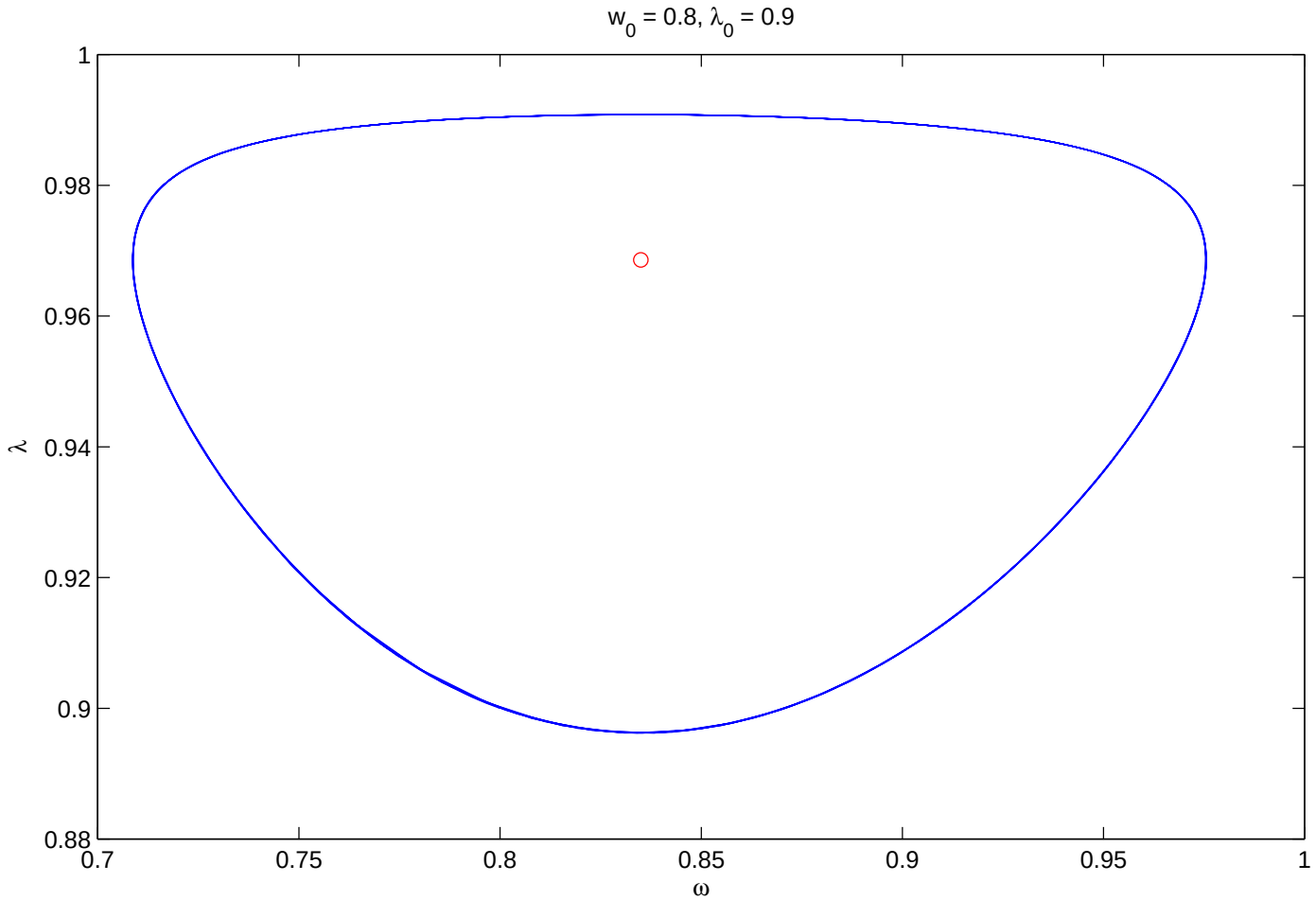
- It then follows that

$$\frac{\dot{\omega}}{\omega} = \frac{\dot{\mathrm{w}}}{\mathrm{w}} - \frac{\dot{p}}{p} - \frac{\dot{a}}{a} = \Phi(\lambda, i, i^e) - i - \alpha$$

$$\frac{\dot{\lambda}}{\lambda} = \frac{1-\omega}{\nu} - \alpha - \beta - \delta$$

- In the original model, all quantities were real (i.e divided by p), which is equivalent to setting $i = i^e = 0$.

Example 1: Goodwin model



Testing Goodwin on OECD countries

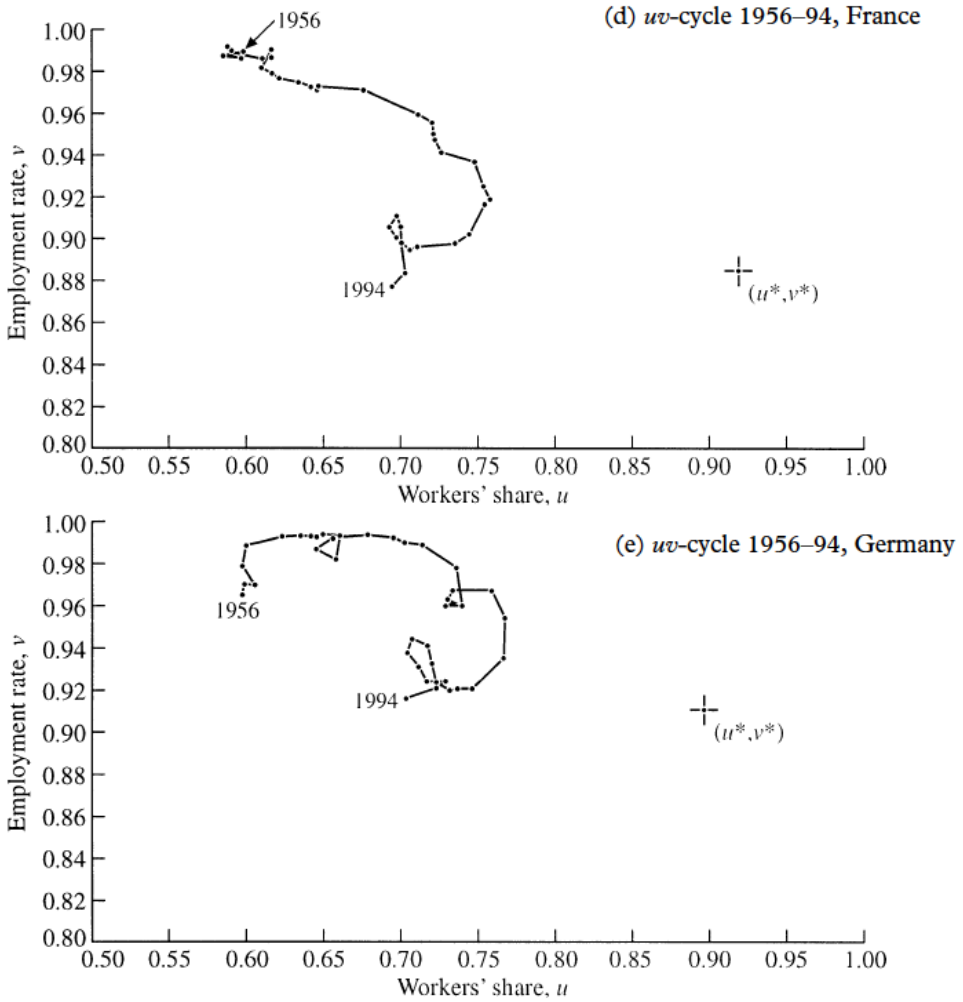


Figure: Harvie (2000)

Where does Φ come from?

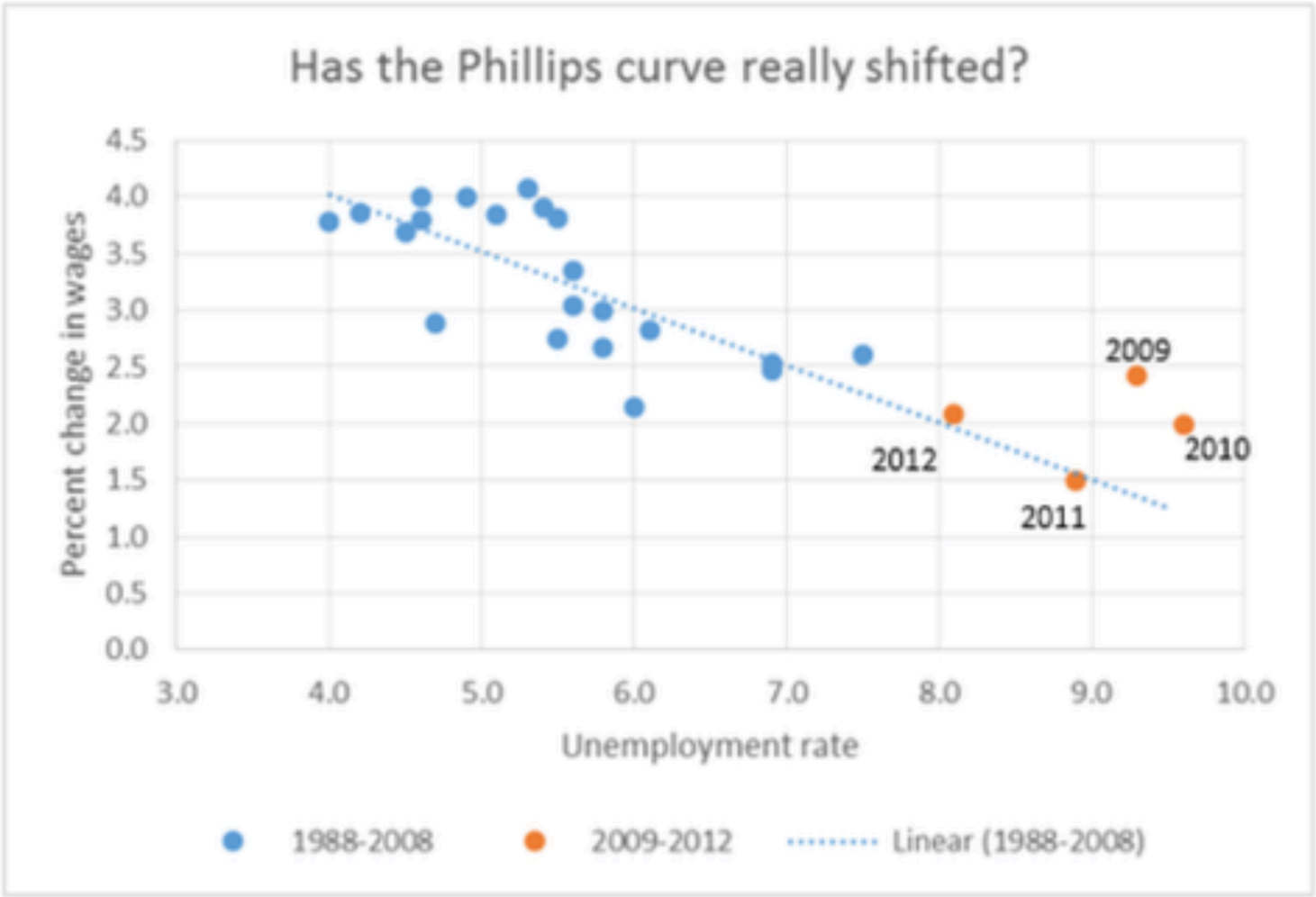


Figure: Krugman - July 15, 2014

Correcting and Extending Harvie (1970 to 2009)

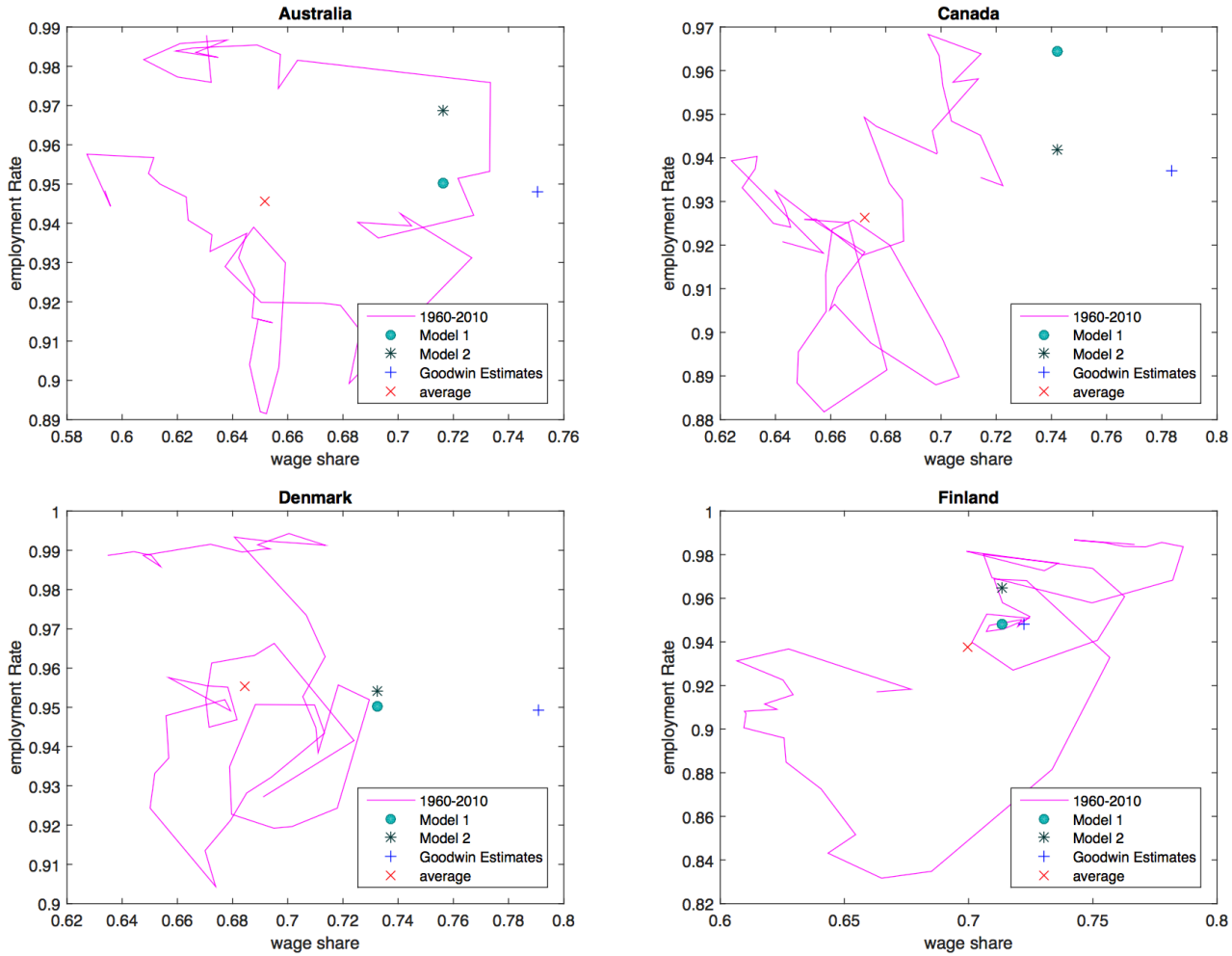


Figure: Grasselli and Maheshwari (2015, in progress)

What about shocks?

- Nguyen Huu and Costa Lima (2014) introduce stochastic productivity of the form

$$da_t := a_t d\alpha_t = a_t[\alpha dt - \sigma(\lambda_t) dW_t]$$

leading to a modified model of the form

$$\frac{\dot{\omega}}{\omega} = \Phi(\lambda) - \alpha + \sigma^2(\lambda_t)dt + \sigma(\lambda_t)dW_t$$
$$\frac{\dot{\lambda}}{\lambda} = \frac{1-\omega}{\nu} - \alpha - \beta - \delta + \sigma^2(\lambda_t)dt + \sigma(\lambda_t)dW_t$$

- They then prove the existence of stochastic orbits generalizing the original Goodwin cycles.

Example 2: stochastic orbits of a Goodwin model with productivity shocks

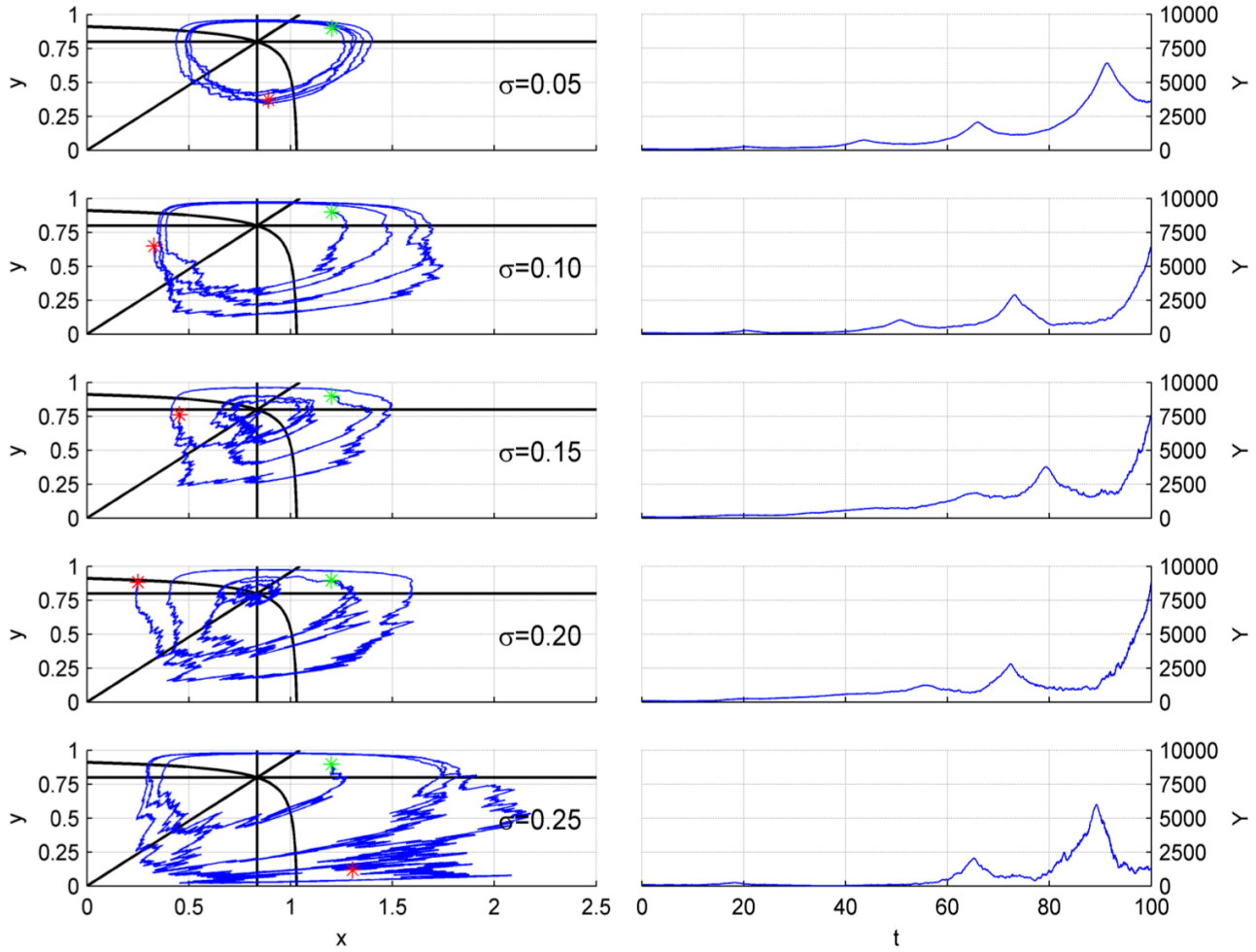


Figure: Figure 3 in Nguyen Huu and Costa Lima (2014)

SFC table for Keen model

	Households	**Firms**		**Banks**	**Sum**
Balance Sheet					
Capital stock		$+pK$			$+pK$
Deposits	D_h	$+D_f$		$-D$	0
Loans		$-L$		$+L$	0
Sum (net worth)	X_h	X_f		X_b	X
Transactions		current	capital		
Consumption	$-pC_h$	$+pC$		$-pC_b$	0
Investment		$+pI$	$-pI$		0
Accounting memo [GDP]		$[pY]$			
Wages	$+W$	$-W$			0
Interest on deposits	$+r_h D_h$	$+r_f D_f$		$-r_h D_h - r_f D_f$	0
Interest on loans		$-r_L L$		$+r_L L$	0
Financial Balances	S_h	Π	$-pI$	S_b	0
Flow of Funds					
Change in Capital Stock		$+pI$			$+pI$
Change in Deposits	$+\dot{D}_h$	$+\dot{D}_f$		$-\dot{D}$	0
Change in Loans		$-\dot{L}$		$+\dot{L}$	0
Column sum	S_h	Π		S_b	pI
Change in net worth	$\dot{X}_h = S_h$	$\dot{X}_f = \Pi + (\dot{p} - \delta p)K$		$\dot{X}_b = S_b$	$\dot{X}$

Figure: Table 1 in Grasselli and Nguyen Huu (2015)

Keen model - Investment function

- Assume now that new investment is given by

$$\dot{K} = \kappa(\pi) Y - \delta K$$

where $\kappa(\cdot)$ is a nonlinear increasing function of profits $\pi = 1 - \omega - rd$.

- This leads to external financing through debt evolving according to

$$\dot{L} - \dot{D}_f = pI - \Pi$$

- The economy grows at a rate

$$g(\pi) := \frac{\dot{Y}}{Y} = \frac{\kappa(\pi)}{\nu} - \delta.$$

Keen model with inflation - Differential Equations

Consider a wage-price dynamics of the form

$$\frac{\dot{\mathrm{w}}}{\mathrm{w}} = \Phi(\lambda) + \gamma i \,, \tag{1}$$

$$i = \frac{\dot{p}}{p} = -\eta_p \left[1 - \xi \frac{\mathrm{w}}{ap}\right] = \eta_p(\xi\omega - 1) \tag{2}$$

Denoting the firm sector net borrowing ratio by $b = /Y$, the model can now be described by the following system

$$\begin{cases} \dot{\omega} &= \omega\left[\Phi(\lambda) - \alpha - (1-\gamma)i(\omega)\right] \\ \dot{\lambda} &= \lambda\left[g(\pi) - \alpha - \beta\right] \\ \dot{b} &= \kappa(\pi) - \pi - b\left[i(\omega) + g(\pi)\right] \end{cases} \tag{3}$$

where $\pi = 1 - \omega - rb$ and $i(\omega) = \eta_p(\xi\omega - 1)$.

Example 3: convergence to the good equilibrium

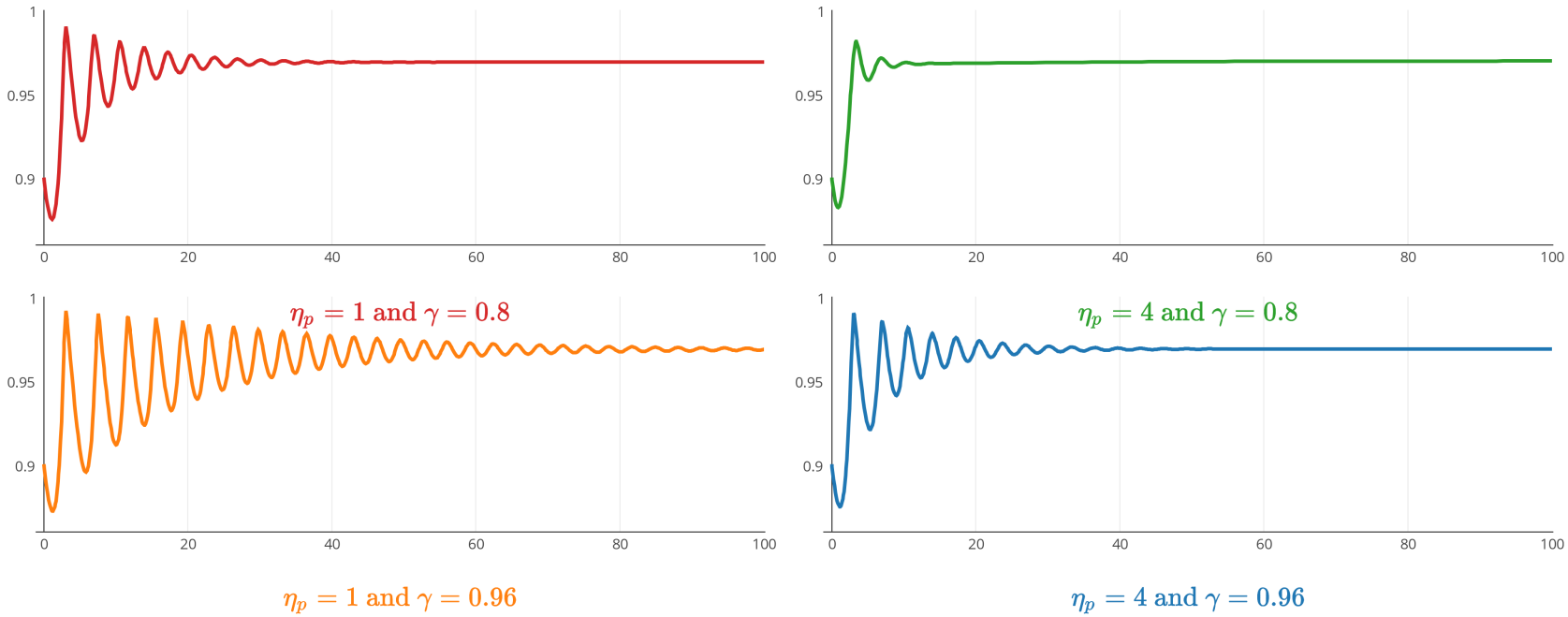


Figure: Trajectories for λ for different values of price adjustment η_p and money illusion $(1-\gamma)$, Grasselli and Nguyen Huu (2015)

Example 4: convergence to (new) bad equilibrium

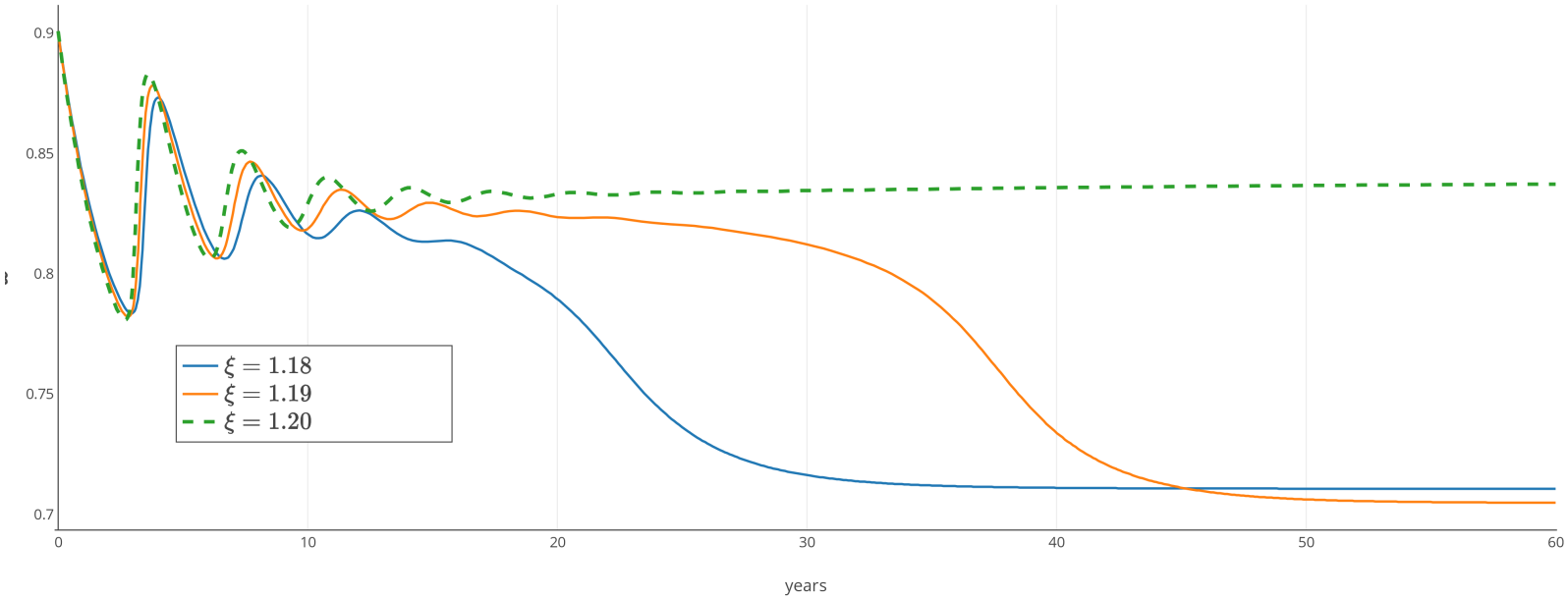
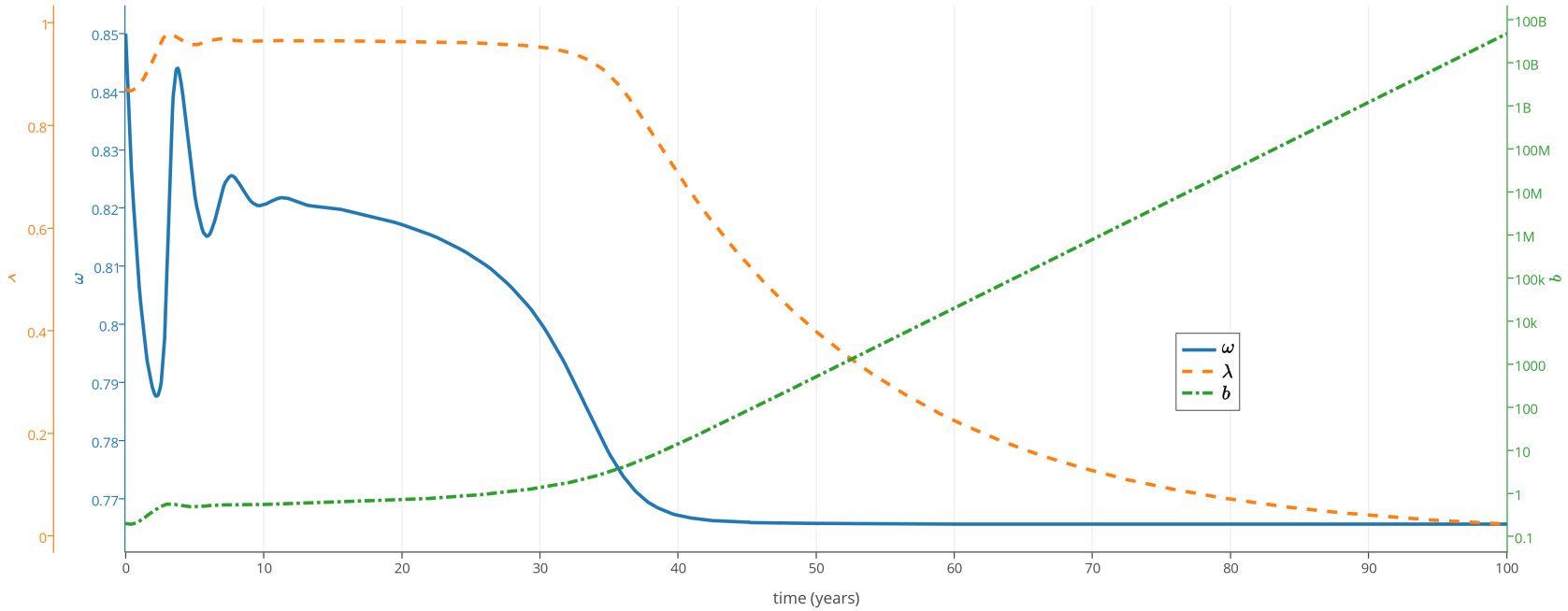


Figure: Trajectories for ω for different values of mark-up ξ, Grasselli and Nguyen Huu (2015)

Example 5: explosive debt and 'great moderation'



Speculative flow

To introduce the destabilizing effect of purely speculative investment, we consider a modified version of the previous model with

$$\dot{L} = pI + r_L L - \kappa_L L + F$$
$$\dot{D}_f = pY - W + r_f D_f - \kappa_L L + F$$

where F denotes a speculative flow modelled by

$$\dot{F} = \Psi(g(\pi) + i(\omega))pY,$$

where $\Psi(\dot{})$ is an increasing function of the nominal growth rate in the economy. Notice that this still satisfies

$$\dot{L} - \dot{D}_f = pI - \Pi.$$

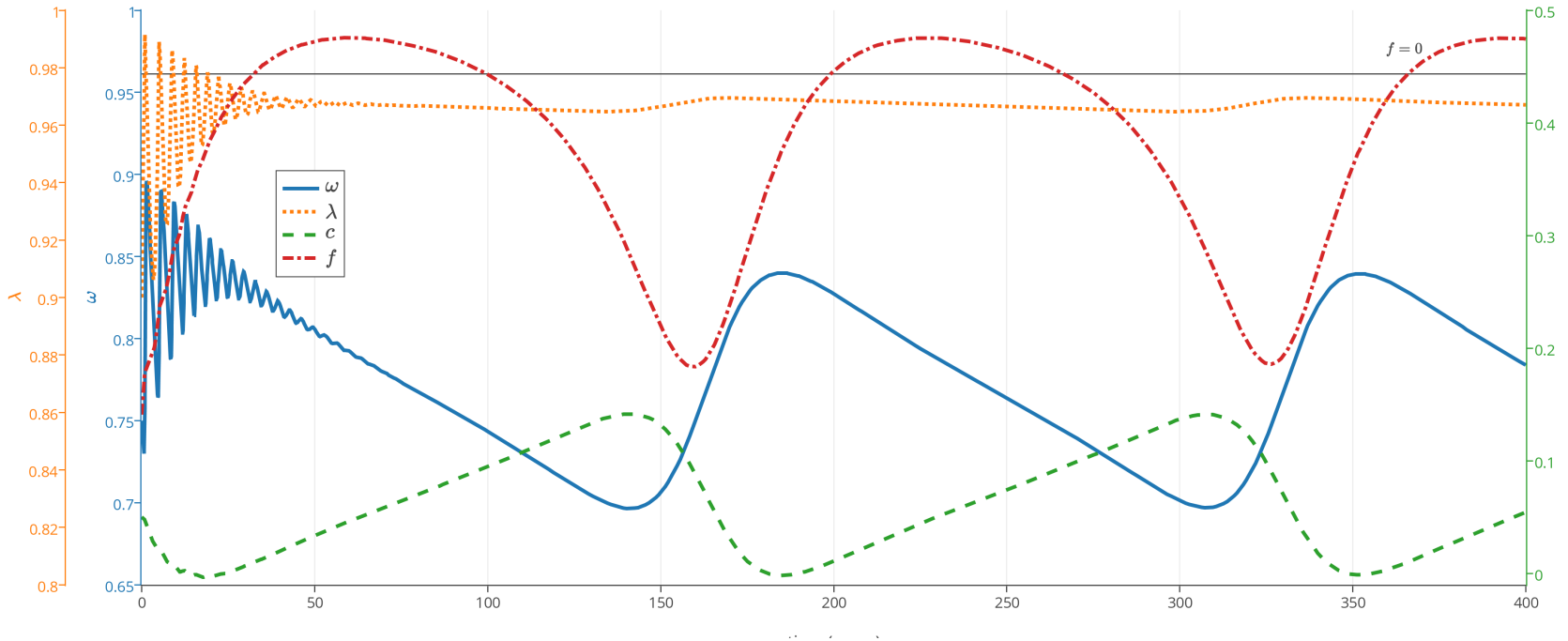
Speculation - Differential equations

Assuming for simplicity that $\kappa_L = r_L$ and considering the state variables $c = r_L b + (r_L - r_f) d_f$ and $f = F/(pY)$, where $d_f = D_f/(pY)$, leads to

$$\begin{cases} \dot{\omega} &= \omega \left[\Phi(\lambda) - \alpha - (1-\gamma) i(\omega) \right] \\ \dot{\lambda} &= \lambda \left[g(\pi) - \alpha - \beta \right] \\ \dot{c} &= r_L \kappa(\pi) - r_f \pi - c \left[g(\pi) + i(\omega) \right] + (r_L - r_f) f \\ \dot{f} &= \Psi(g(\pi) + i(\omega)) - f \left[g(\pi) + i(\omega) \right] \end{cases}$$

with $\pi = 1 - \omega - c$.

Example 6: effect of speculation



Stock price dynamics

- We consider a stock price process of the form

$$\frac{dS_t}{S_{t-}} = r_b dt + \sigma dW_t + j\mu_t dt - dJ_t$$

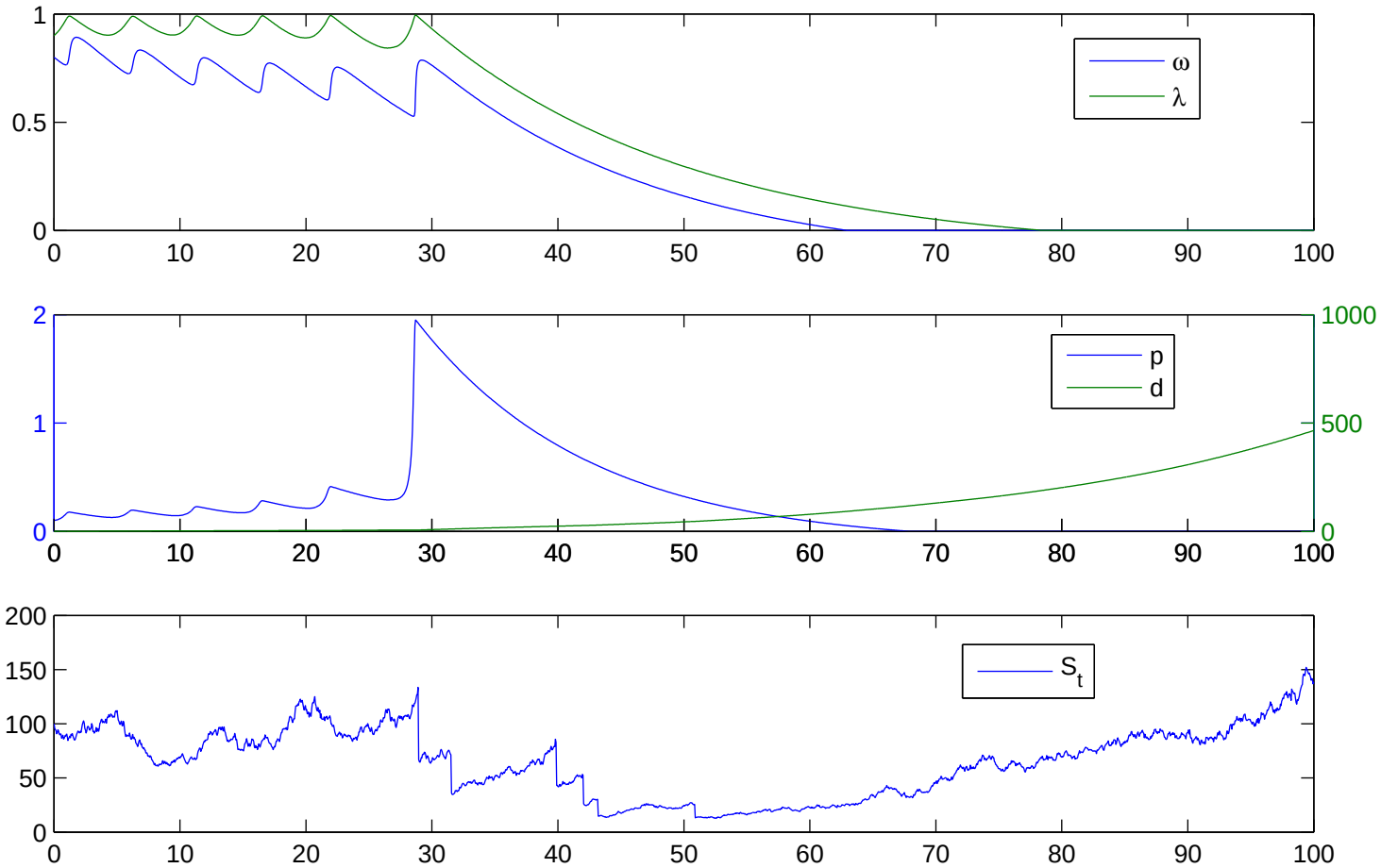
where J_t is an inhomogenous Poisson process with intensity $\mu_t = M(f(t))$ and jump sizes distributed on $(0,1)$ with mean j.

- The interest rate for private debt is modelled as $r_t = r_b + r_p(t)$ where

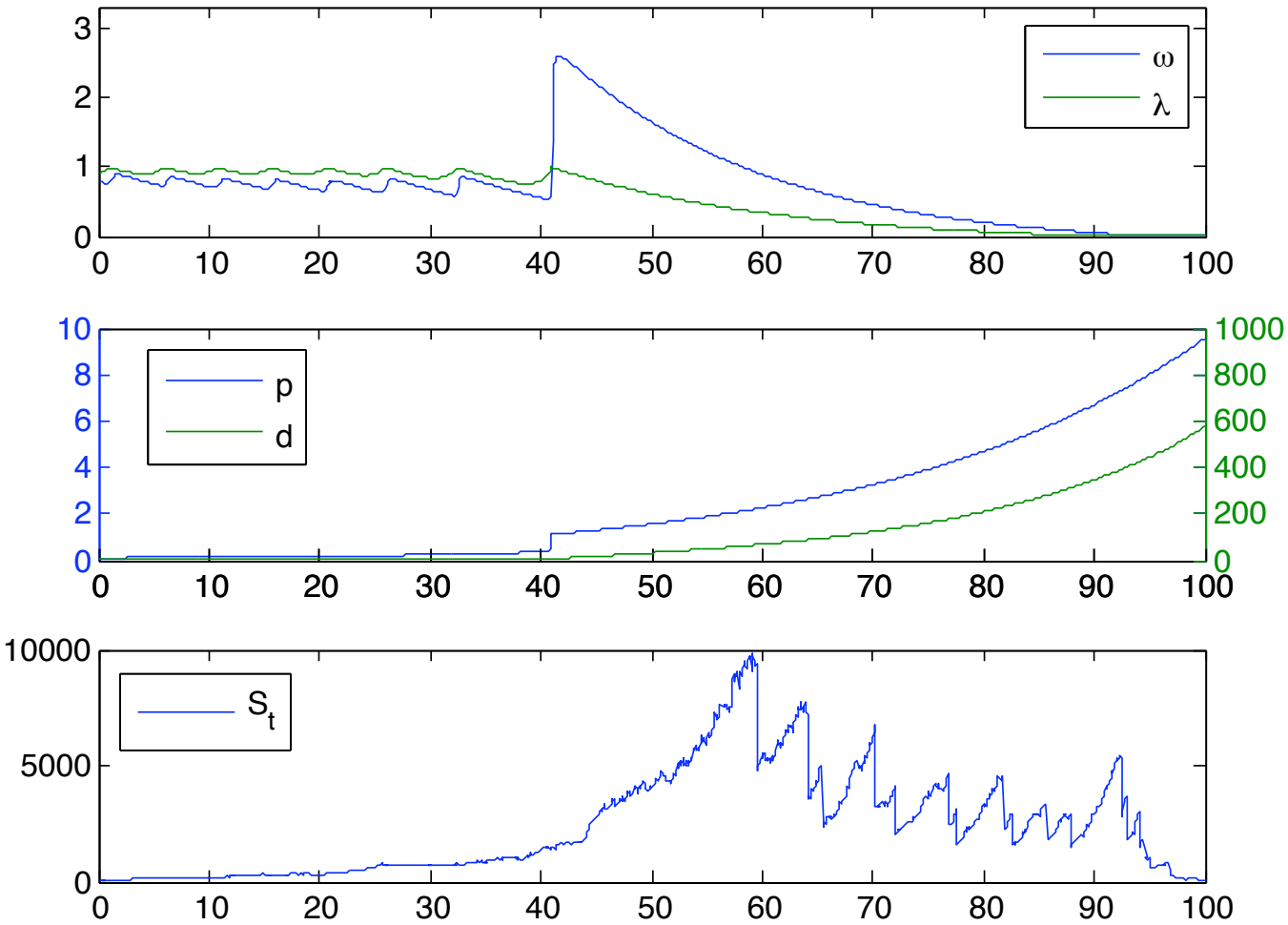
$$r_p(t) = \frac{\rho_1}{(S_t + \rho_2)^{\rho_3}}$$

for positive constants ρ_1, ρ_2, ρ_3.

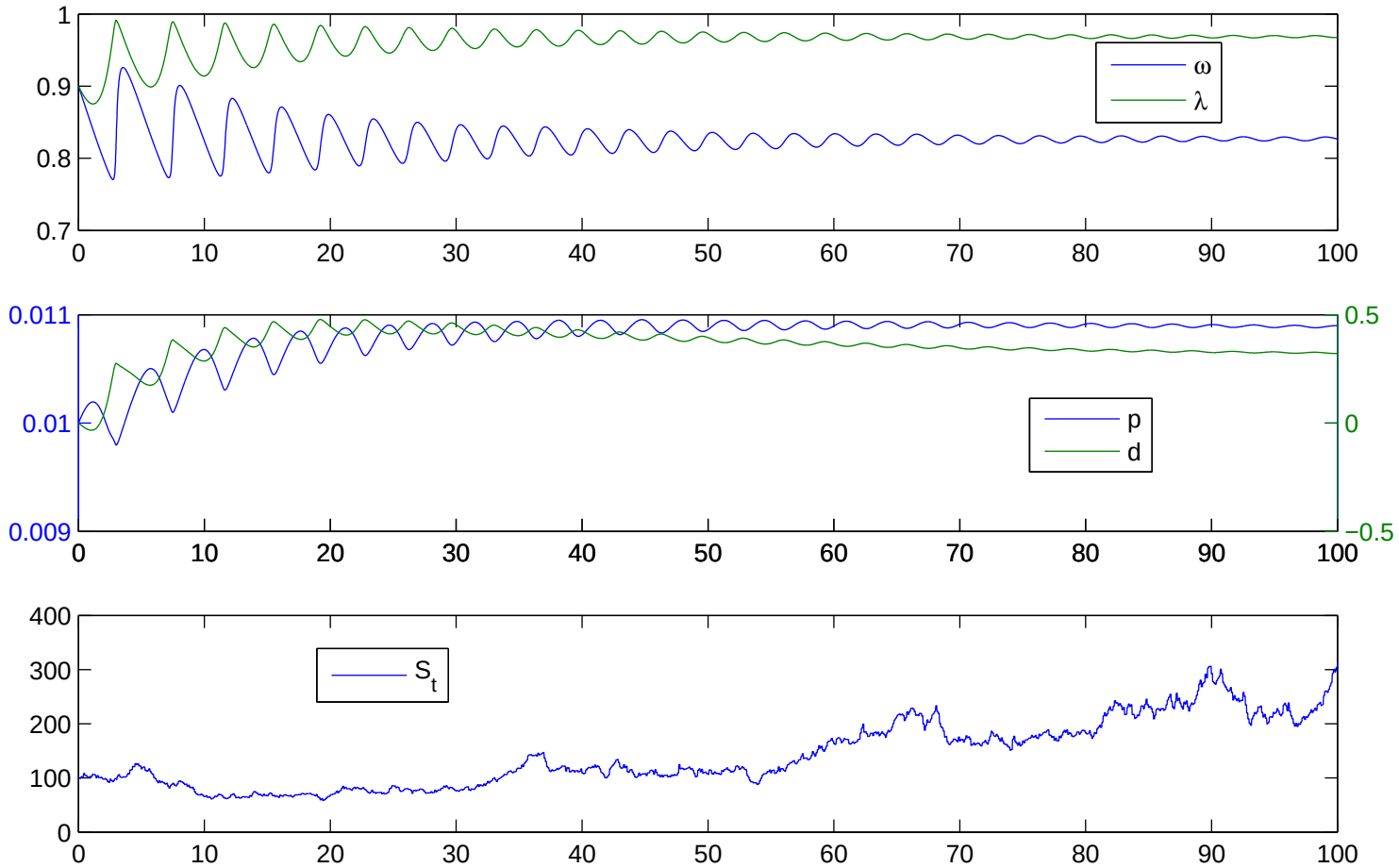
Example 7: stock prices, explosive debt, zero speculation



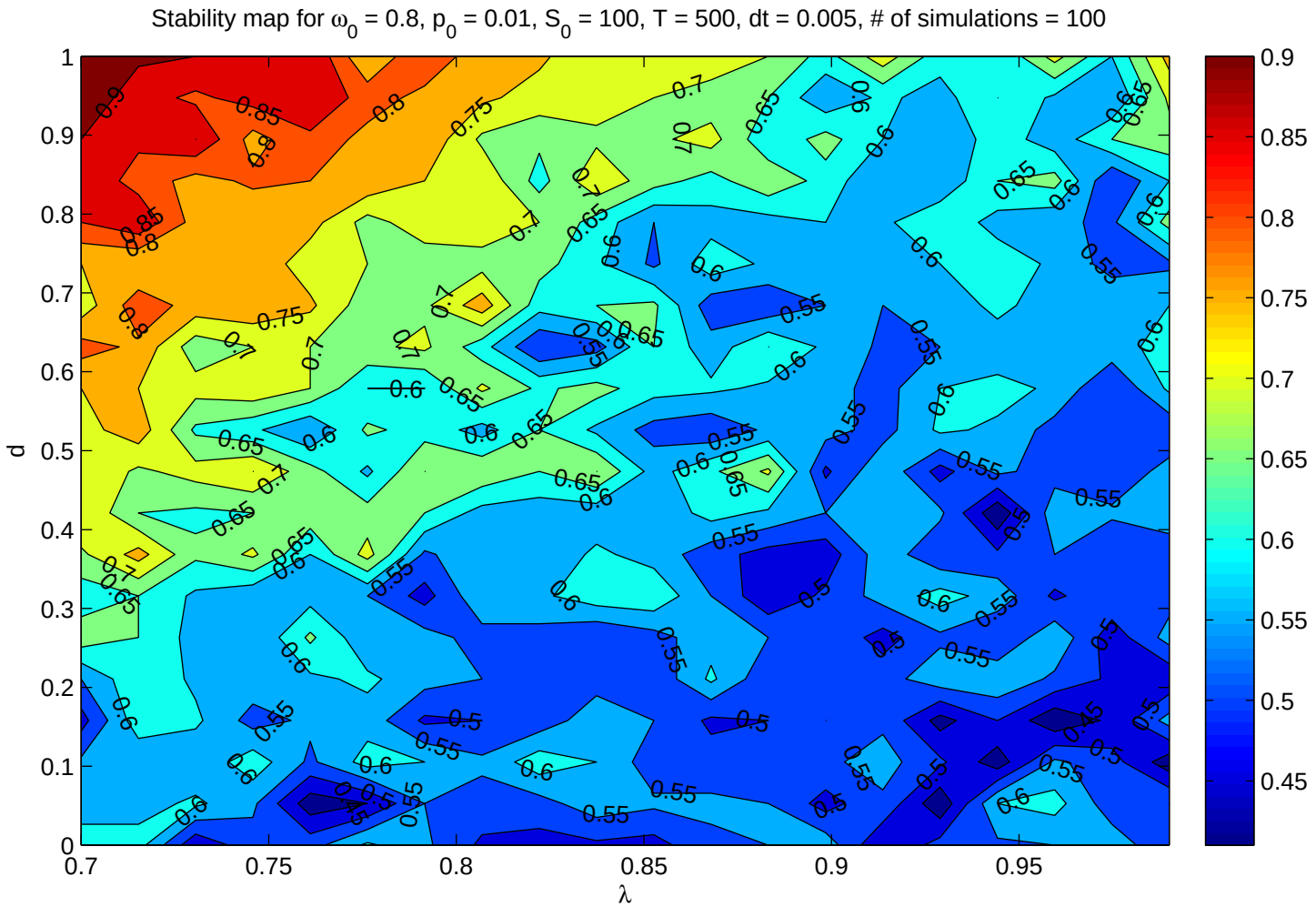
Example 8: stock prices, explosive debt, explosive speculation



Example 9: stock prices, finite debt, finite speculation



Stability map



Concluding remarks

- We provided a stock-flow consistent model for real-financial interactions as an extension of the Goodwin-Keen labour, investment, and debt dynamics.
- The modelling framework is an alternative to the dominant microfounded DSGE paradigm in macroeconomics.
- It incorporates insights from endogenous money theory, sectoral balances, and Minskian financial instability.
- Opens up new avenues for the application of modern dynamical systems techniques to economics.
- Work has just begun . . .

Go raibh maith agat!