Inflation, Debt, and Default

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Motivation

- The majority of sovereign debt in advanced economies is held domestically.

- In these countries, the co-movement between inflation and domestic consumption growth also varies considerably over time.

Domestic Share of Government Debt

Country	Year 2004	2008	2012	Mean
Australia	83.3	85.6	61.9	76.9
Belgium	50.7	41.0	58.9	50.2
Canada	77.6	83.8	72.1	77.8
Denmark	74.5	75.2	70.9	73.5
Finland	23.1	38.1	25.9	29.0
France	57.9	57.8	51.5	55.7
Germany	68.6	53.5	41.4	54.5
Greece	40.8	41.2	22.2	34.7
Italy	59.9	60.9	66.1	62.3
Japan	95.7	91.9	92.1	93.3
Korea*	92.2	90.8	83.9	89.0
Netherlands	44.4	45.2	55.8	48.5
Norway	43.5	50.6	71.5	55.2
Portugal	24.0	27.3	35.9	29.0
Spain	55.7	62.6	78.1	65.5
Sweden	64.4	75.5	61.4	67.1
United Kingdom	81.9	78.1	72.4	77.5
United States	80.8	78.0	73.3	77.3
Mean	63.3	63.9	60.4	62.5

Sources: BIS, Haver

Motivation

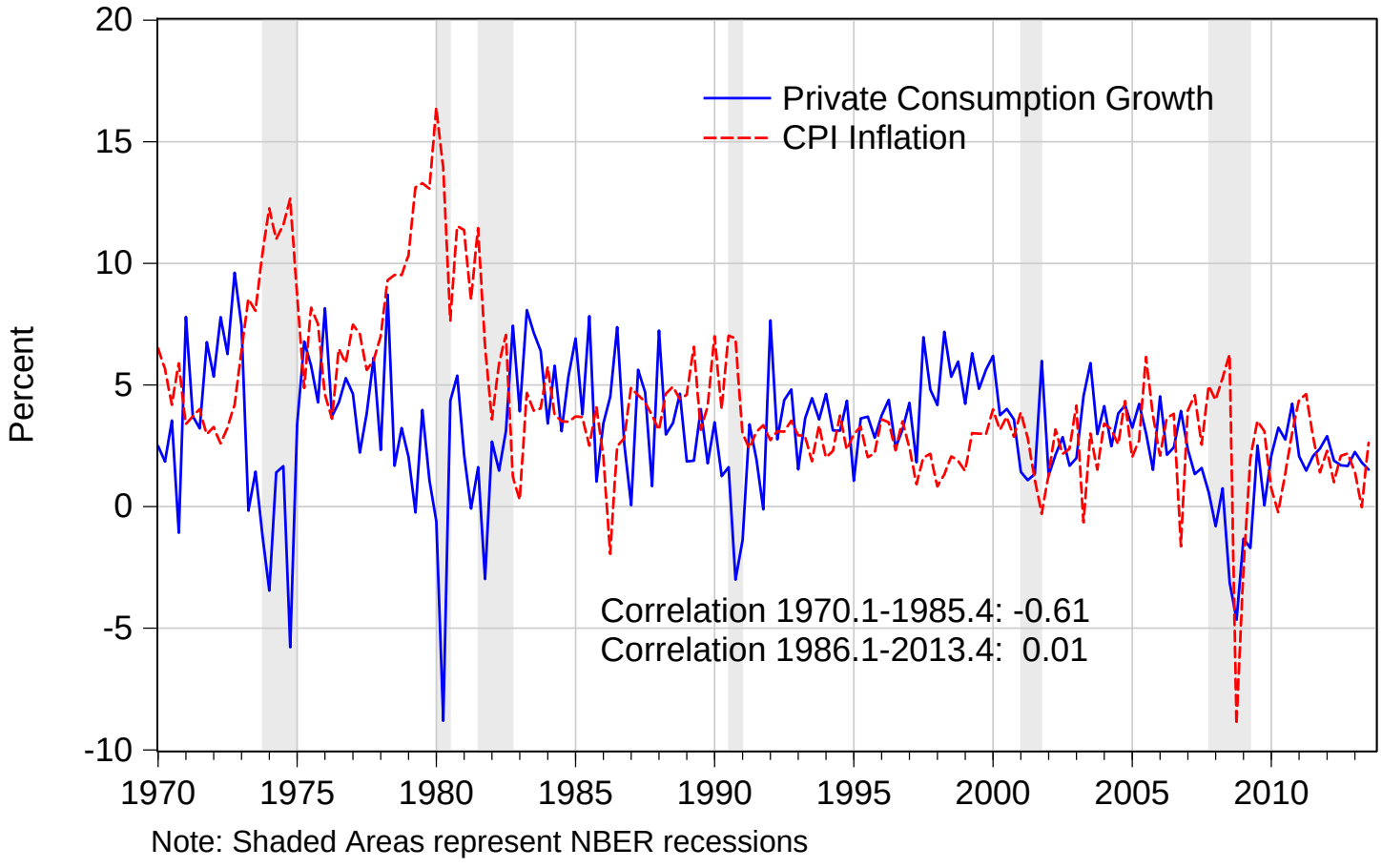

Figure: Inflation and consumption growth co-movement in the U.S.

The question

How does the inflation process - in particular the co-movement of inflation and consumption growth - jointly affect interest rates, debt dynamics, and debt crises?

Why does inflation matter?

- The co-movement of inflation and consumption growth affects the risk of nominal debt

$\Rightarrow$ Pro-cyclical inflation makes nominal debt
  - $+$ less risky to lender: receives more in bad times
  - $-$ more risky to borrower: pays out more bad times

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- Inflation affects debt pricing
- Debt pricing $\rightarrow$ debt dynamics $\rightarrow$ debt crises $\rightarrow$ ...

Related literature

- Sovereign default

  Eaton and Gersovitz (1981), Arellano (2008), Aguiar and Gopinath (2007), Chatterjee and Eyigungor (2012), Hatchondo and Martinez (2009)
- Domestic/Selective default

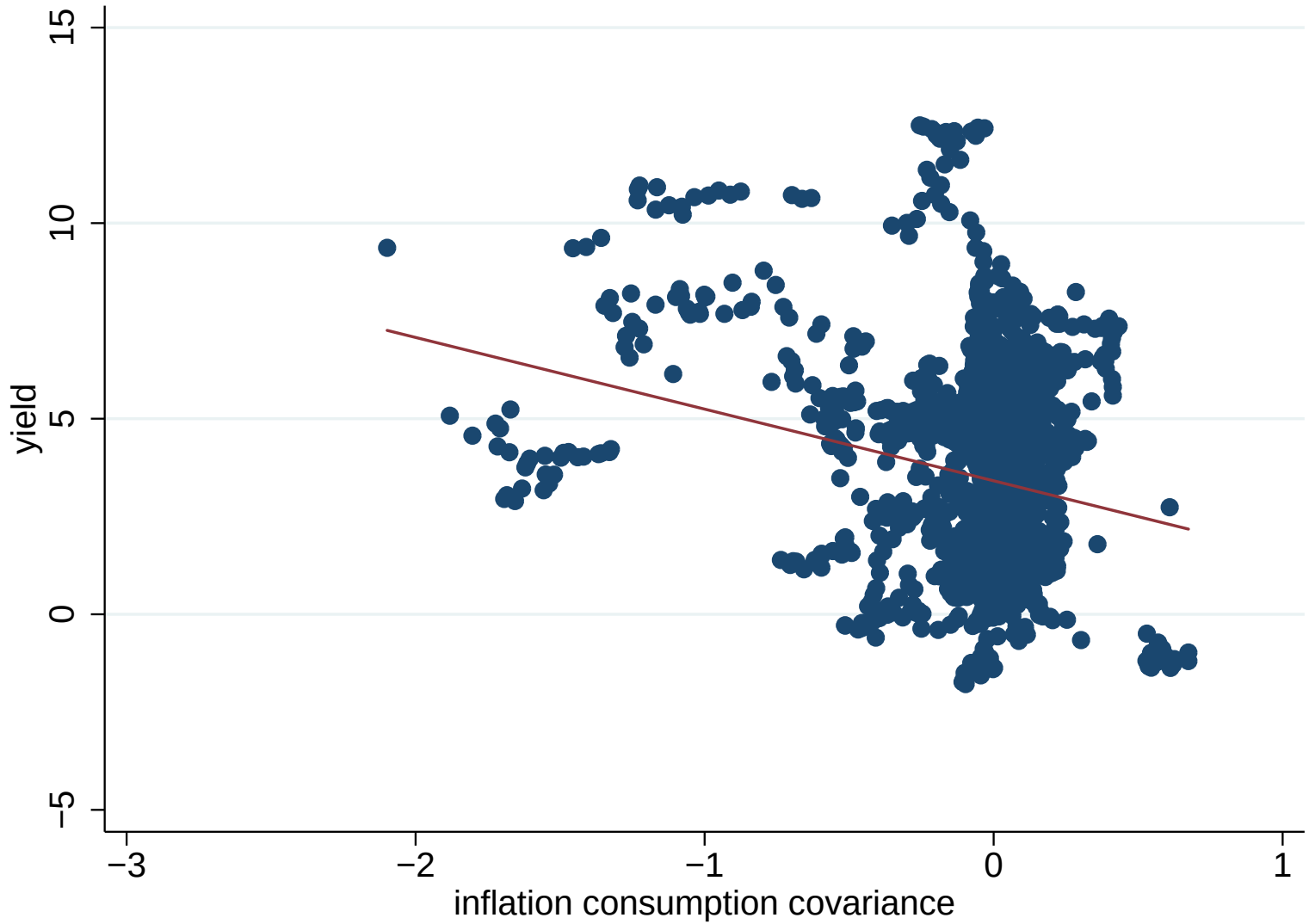
  Reinhart and Rogoff (2011), D'Erasmo and Mendoza (2013), Mallucci (2015)
- Default and inflation

  Aguiar, Amador, Farhi and Gopinath (2012), Sunder-Plassman (2013)
- Cyclicality of inflation

  Boudoukh (1993), Ang, Bekaert, and Wei (2008), Campbell, Pflueger, and Viceira (2014), Song (2014)
- Monetary unions

  Neumeyer (1998), Aguiar et al. (2013), Corsetti and Dedola (2013)

Inflation Consumption Covariance and Real Interest Rates



Evidence

- Inflation and connection to real yields on government debt
- Compute co-movement of innovations to inflation and to consumption growth
- OECD 1970-2012 using overlapping windows
- Less pro-cyclical inflation is associated with higher yield

Conditional co-movement between inflation and consumption growth

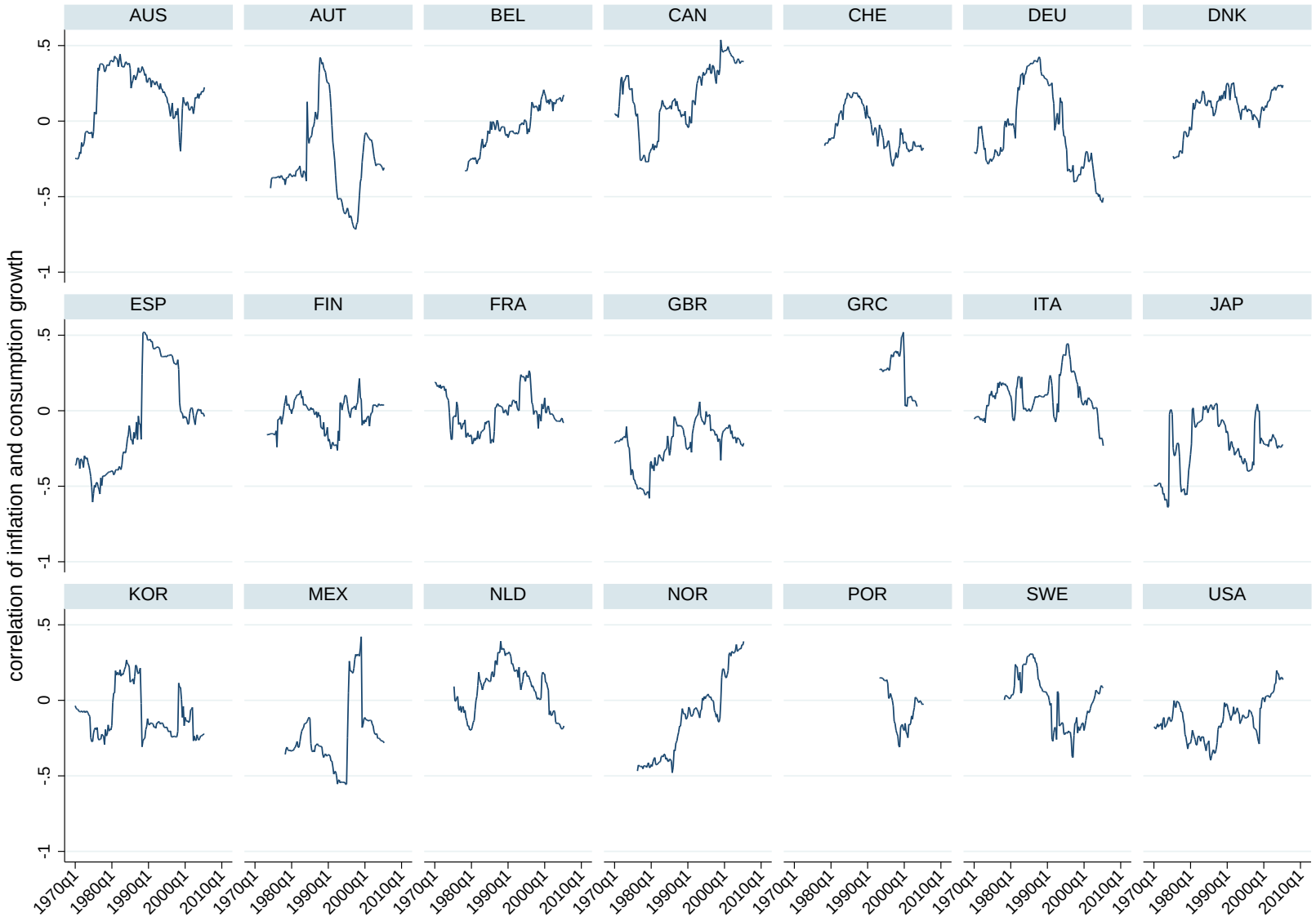
- Follow Boudoukh (1993)
- VAR country by country on quarterly data

$$\begin{bmatrix} \pi_{it} \\ g^c_{it} \end{bmatrix} = A_i \begin{bmatrix} \pi_{i,t-1} \\ g^c_{i,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{\pi it} \\ \varepsilon_{git} \end{bmatrix}$$

- Compute conditional co-movement between $\varepsilon_{\pi it}$ and ε_{git} using overlapping five-year windows

Graph

Conditional correlation between inflation and consumption growth



Inflation cyclicality and real interest rates

	Real yield on government debt		
	(1)	(2)	(3)
Inflation consumption covariance	-2.518***	-2.636***	-2.357***
	(0.484)	(0.518)	(0.405)
Inflation		0.080	-0.089
		(0.409)	(0.431)
Consumption growth		-0.018	-0.042
		(0.726)	(0.704)
Lagged government debt		-0.006	-0.005
		(0.008)	(0.009)
Inflation Variance			0.310
			(0.180)
Consumption Variance			0.008
			(0.185)
adj. R^2	0.769	0.782	0.787
N	2772	2682	2682

Standard errors in parentheses. All regressions include country and time fixed effects.

Inflation cyclicality and debt accumulation

	Change in government debt		
	(1)	(2)	(3)
Inflation consumption covariance	0.027	0.477***	0.494***
	(0.091)	(0.136)	(0.121)
Inflation	0.013	0.025	0.002
	(0.029)	(0.155)	(0.145)
Consumption growth	-1.366***	-1.347***	-1.370***
	(0.209)	(0.219)	(0.262)
Lagged government debt	-0.000	0.002	0.002
	(0.003)	(0.003)	(0.003)
Inflation Variance			0.046
			(0.067)
Consumption Variance			-0.021
			(0.077)
Real yield on government debt		0.127**	0.124**
		(0.047)	(0.051)
adj. R^2	0.492	0.571	0.572
N	2870	2682	2682

Standard errors in parentheses. All regressions include country and time fixed effects.

Additional evidence

- Less pro-cyclical inflation is associated with lower CDS spreads suggesting reduced default probability
- Less pro-cyclical inflation is associated with higher volatility of spreads

This paper

- Understand effects of the inflation process on borrowing costs, debt dynamics and debt crises
- Model of sovereign debt, builds on standard model (Arellano 2008)
- New ingredients:
  - Inflation, exogenous
    (e.g. changes monetary independence, changes in nature of shocks supply/demand in the economy)
  - risk-averse, domestic lenders
- Long term debt

Model

- Builds on standard sovereign debt model (Arellano 2008)
- Both lenders and borrowers are *risk-averse*

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- Both lenders and borrowers are *risk-averse*
- Nominal bonds have stochastic return (exogenous *inflation* process)

Model

- Closed economy, discrete time $t = 0, 1, 2, ...$, one good
- Endowments y and inflation π follow a joint Markov Process
- Agents
  - unit measure of hand-to-mouth households (poor, impatient)
  - μ measure of lenders (rich, patient)
  - government
- Government
  - borrows from and defaults on lenders, on behalf of poor households, using nominal bonds
  - maximizes welfare of poor households

Households

- Household types:
  - hand-mouth households (poor, impatient)
  - rich, patient lenders
- Both households have preferences given by

$$E_0 \sum_{t=0}^{\infty} \beta_i^t u(c_{it})$$

  where $0 < \beta_h < \beta_\ell < 1$
- Lenders receive αy

Long-term debt

- We follow Hatchondo and Martinez (2009) in modeling long-term debt
- A bond issued in period t promises an infinite stream of coupons, decreasing at rate δ
- Law of motion for coupon payment obligations:

$$B' = (1 - \delta)B - x$$

where x is new issuance

Government

- Given the option to default, the government chooses

$$V^o(B,s) \quad = \quad \max_{c,d} \left\{ V^c(B,s), V^d(B,s) \right\}$$

where B is incoming assets and $s = (\pi, y)$

Value of default

- The value of default is given by

$$V^d(B,s) = u(y - \phi^d(y)) + \beta_h \mathbf{E}_{s|s'} \left[\theta V^o \left(\frac{\lambda B}{1+\pi'}, s' \right) + (1-\theta) V^d \left(\frac{\lambda B}{1+\pi'}, s' \right) \right]$$

  where $0 < \theta < 1$ is the probability of regaining access to credit markets, $0 < \lambda < 1$ is the recovery rate, and

$$\phi^d(y) = \max \left\{ 0, \frac{d_1}{d_0} y + \left(d_1 - \frac{d_1}{d_0} \right) y^2 \right\}$$

- The default cost at mean is $\phi^d(1) = d_1$
- Default costs matter when $\phi^d(y) > 0$, when $y < 1 + d_0$

Value of repayment

- The value, conditional on not defaulting is given by

$$V^c(B,s) = \max_{B'} \left\{ u\left(y - q(B,s,B')(B' - (1-\delta)B) + B\right) + \beta_h \mathbf{E}_{s'|s}\left[V^o\left(\frac{B'}{1+\pi'}, s'\right)\right] \right\}$$

  where $q(B,s,B')$ is the bond price

- Real return on government debt is stochastic (even in absence of default)

Bond price

In this environment, the bond price satisfies

$$
\begin{aligned}
q(B,s,B') \quad = \quad & \beta_\ell \mathbf{E}_{s'|s} \left[\frac{1 - d^* \left(\frac{B'}{1+\pi'}, s' \right)}{1+\pi'} \times \right. \\
& \left. \left(1 + (1-\delta) q^* \left(\frac{B'}{1+\pi'}, s' \right) \right) \frac{u'\left(c'_\ell\right)}{u'\left(c_\ell\right)} \right] \\
& + \beta_\ell \mathbf{E}_{s'|s} \left[\frac{d^* \left(\frac{B'}{1+\pi'}, s' \right)}{1+\pi'} q^d \left(\frac{B'}{1+\pi'}, s' \right) \frac{u'\left(\alpha y^d(y')\right)}{u'\left(c_\ell\right)} \right]
\end{aligned}
$$

where q^d is the price of a bond in default

Bond price in default

The price of a bond in default satisfies

$$
\begin{aligned}
q^d(B,s) \quad = \quad & \beta_\ell \lambda \theta \mathbf{E}_{s'|s} \left[\frac{1 - d^* \left(\frac{\lambda B}{1+\pi'}, s' \right)}{1+\pi'} \times \right. \\
& \left. \left(1 + (1-\delta) q^* \left(\frac{\lambda B}{1+\pi'}, s' \right) \right) \frac{u'\left(c'_\ell\right)}{u'\left(\alpha y^d(y)\right)} \right] \\
& + \beta_\ell \lambda \mathbf{E}_{s'|s} \left[\frac{1 - \theta + \theta d^* \left(\frac{B'}{1+\pi'}, s' \right)}{1+\pi'} q^d \left(\frac{\lambda B}{1+\pi'}, s' \right) \frac{u'\left(\alpha y^d(y')\right)}{u'\left(\alpha y^d(y)\right)} \right]
\end{aligned}
$$

Cyclicality of inflation and borrowing costs

- When $\delta = 1$ and $\lambda = 0$, the bond price can be written as

$$q(B,s,B') = \beta_\ell \mathbf{E}_{s'|s}\left[\frac{1-d^*\left(\frac{B'}{1+\pi'},s'\right)}{1+\pi'}\right]\mathbf{E}_{s'|s}\left[\frac{u'(c'_\ell)}{u'(c_\ell)}\right]$$
$$+\beta_\ell \,\mathbf{cov}_s\left[\frac{1-d^*\left(\frac{B'}{1+\pi'},s'\right)}{1+\pi'},\frac{u'(c'_\ell)}{u'(c_\ell)}\right]$$

- Default and inflation increase borrowing costs; so does countercyclical default (standard effects)
- Pro-cyclical inflation *reduces* borrowing costs (new channel).

Key mechanisms

Co-movement of inflation and consumption growth affects

- Interest rates on debt
  significant and uniform across states
- Debt dynamics
  especially during crisis times
  $\Rightarrow$ risky debt and precautionary motives
- Default incentives
  especially during bad times

Quantitative experiment

- Calibrate the model to match default frequency, mean and volatility of spreads in advanced economies
- Assess impact of different inflation processes on interest rates, debt dynamics, and crises

Functional forms

- Preferences

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}$$

- Stochastic Process

$$\begin{bmatrix} \log y' \\ \pi' \end{bmatrix} = \begin{bmatrix} \rho_y & \rho_{\pi,y} \\ \rho_{y,\pi} & \rho_\pi \end{bmatrix} \begin{bmatrix} \log y \\ \pi \end{bmatrix} + \begin{bmatrix} \varepsilon_y \\ \varepsilon_\pi \end{bmatrix}$$

where

$$\begin{bmatrix} \varepsilon_y \\ \varepsilon_\pi \end{bmatrix} = N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_y^2 & \sigma_{\pi,y} \\ \sigma_{\pi,y} & \sigma_\pi^2 \end{bmatrix} \right)$$

Parameters

Parameters	Values	Targets
Gov't discount factor β_h	0.80	annual default probability: 1.8 percent*
default penalty d_0	-0.082	average spread: 2.5 percent
d_1	0.095	st dev of spread: 3.0 percent
Lender discount factor β_ℓ	0.99	risk-free rate: 1 percent
Risk aversion γ	2	
Stochastic process		VAR estimates
$\rho_y = \rho_\pi$	0.90	
$\rho_{\pi,y} = \rho_{y,\pi}$	0.00	
σ_y	0.010	
σ_π	0.015	
$\sigma_{\pi,y}$	$\{0, \pm 0.000034\}$	
Probability of re-entry θ	0.10	average exclusion: 10 quarters†
Recovery parameter λ	0.96	average recovery rate, discounted to period of default: 50 percent‡
Relative lender endowment α	7	income of top 43 percent / income of bottom 57 percent (US)
Measure of lenders μ	0.75	0.43/0.57
Debt maturity δ	$\{1, 0.04\}$	short-term debt and 5-year maturity

* :Reinhart and Rogoff (2009), †: Richmond and Dias (2008), ‡: Benjamin and Wright (2009)

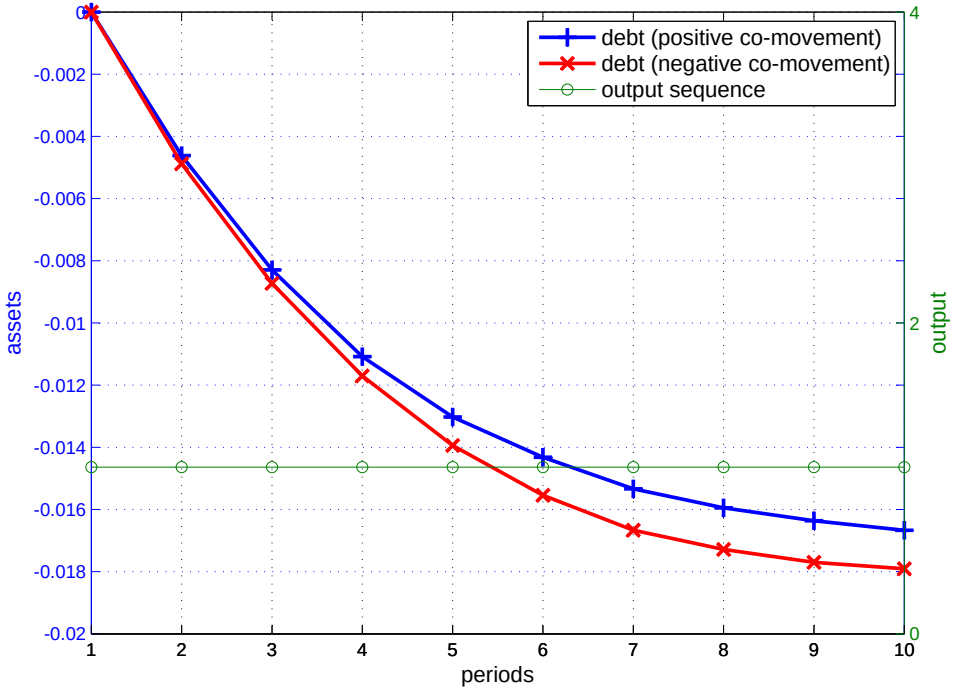
Model with default

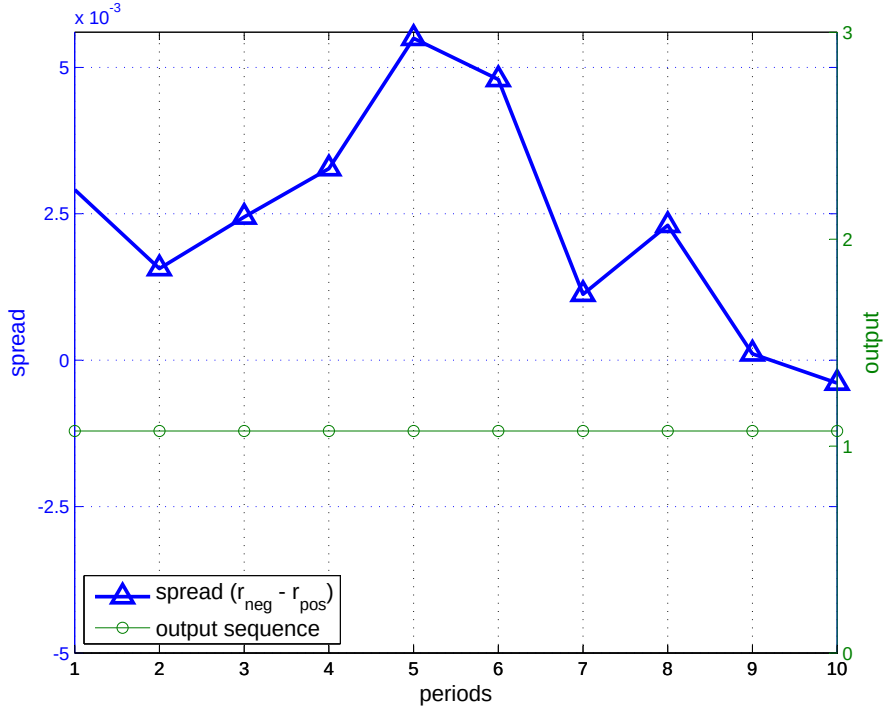
- Borrowing costs are lower with pro-cyclical inflation
- Yet, debt is also lower with pro-cyclical inflation
- So are default rates

Table: Debt and Default

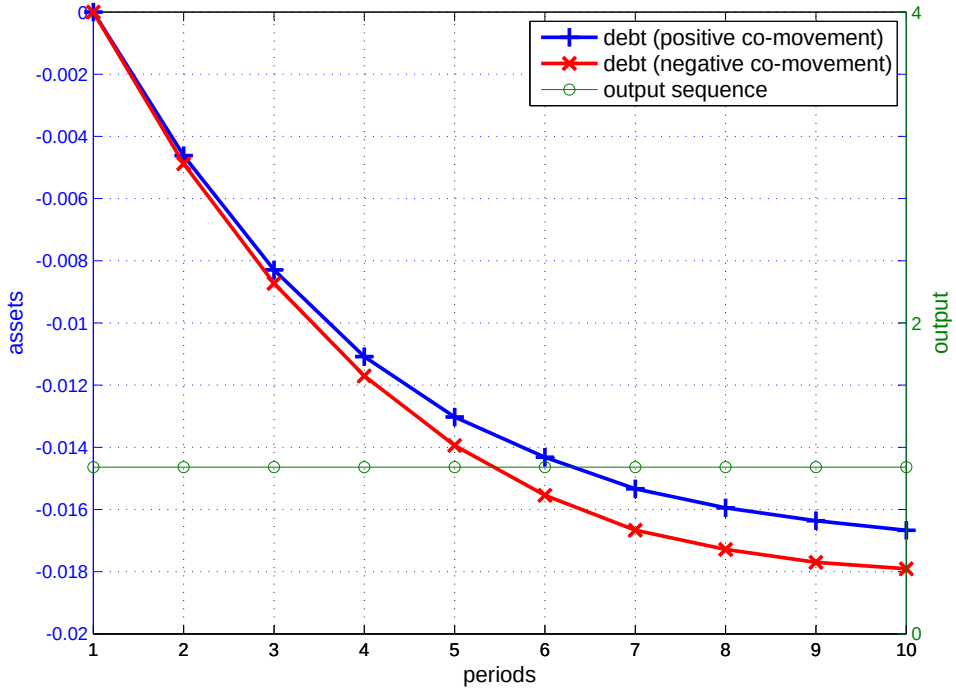
	Positive co-movement	Negative co-movement
Default prob. (percent)	2.15	1.84
Spreads (percent)	0.86	0.91
Debt (percent)	24.41	22.88

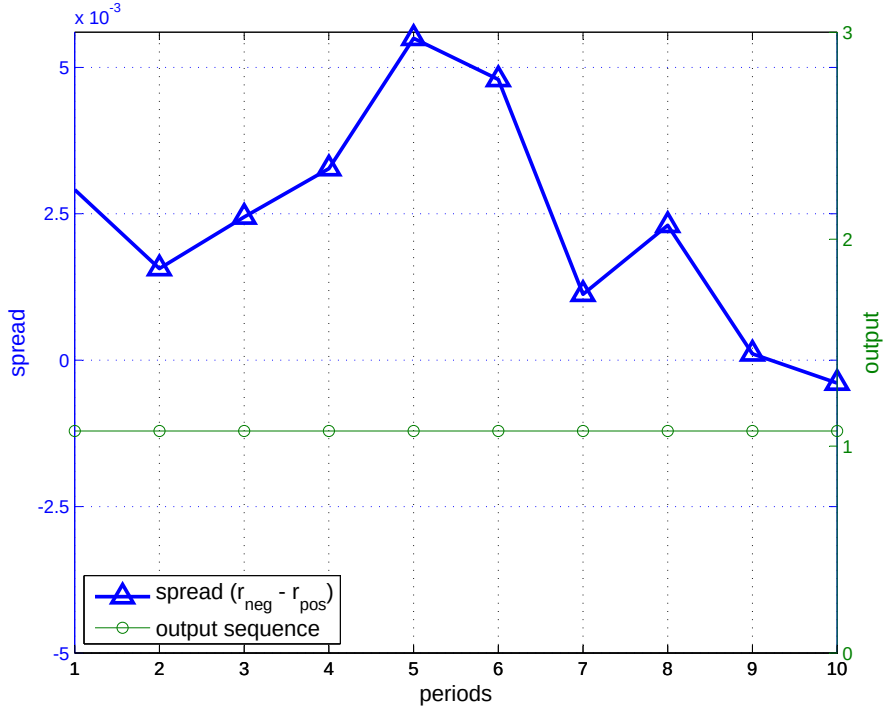
Inflation and debt dynamics: precautionary motives





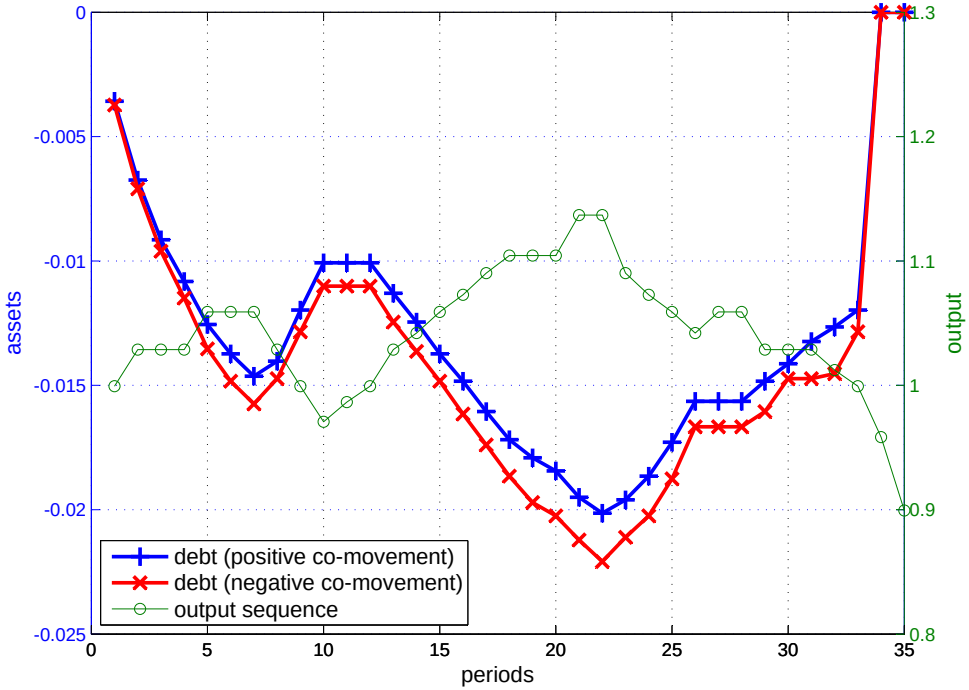
Inflation and debt dynamics: precautionary motives

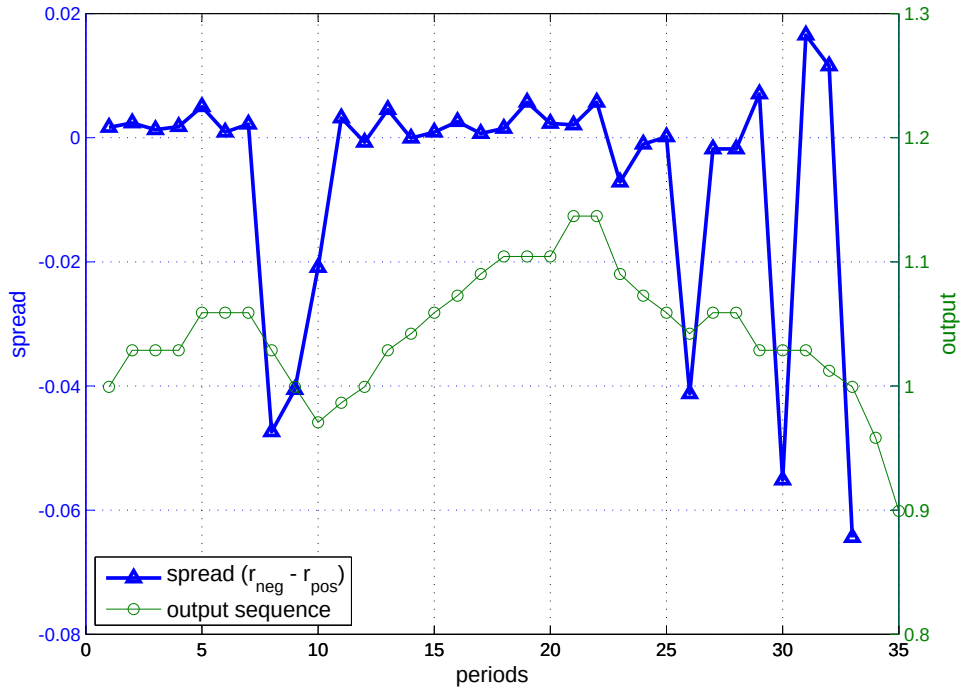




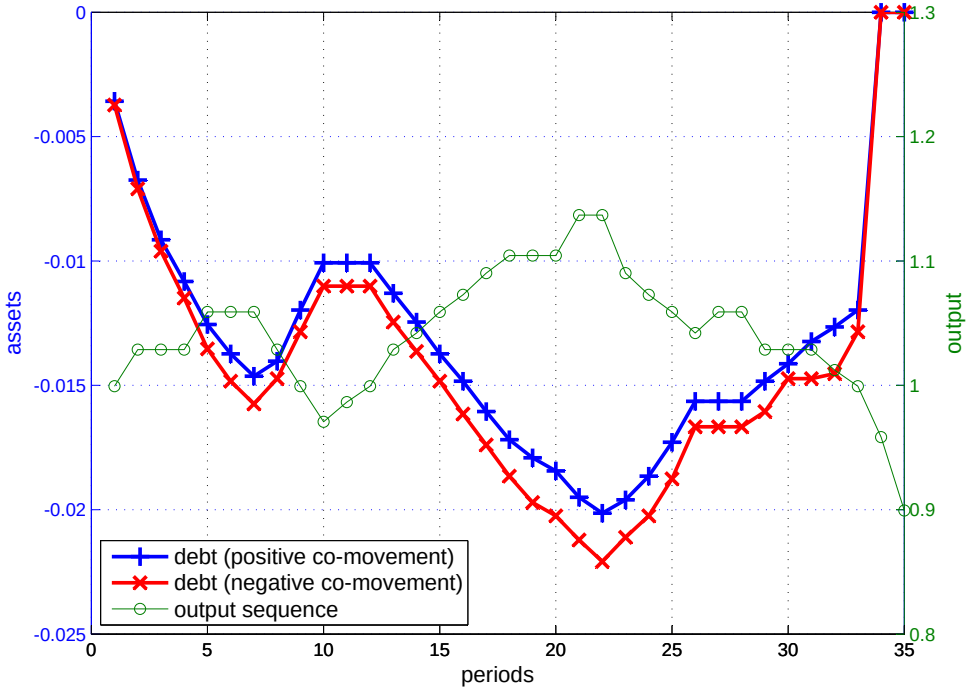
- Precautionary motives from pro-cyclical inflation increase with debt (i.e. as the borrower gets poorer)
- Meanwhile, lenders demand lower yield

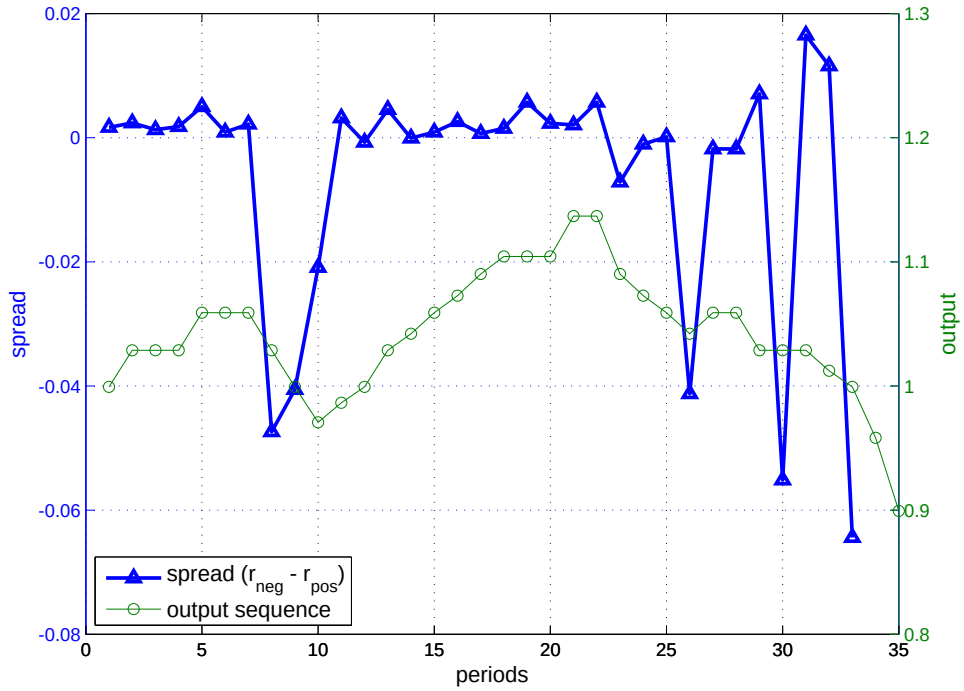
Inflation and debt dynamics





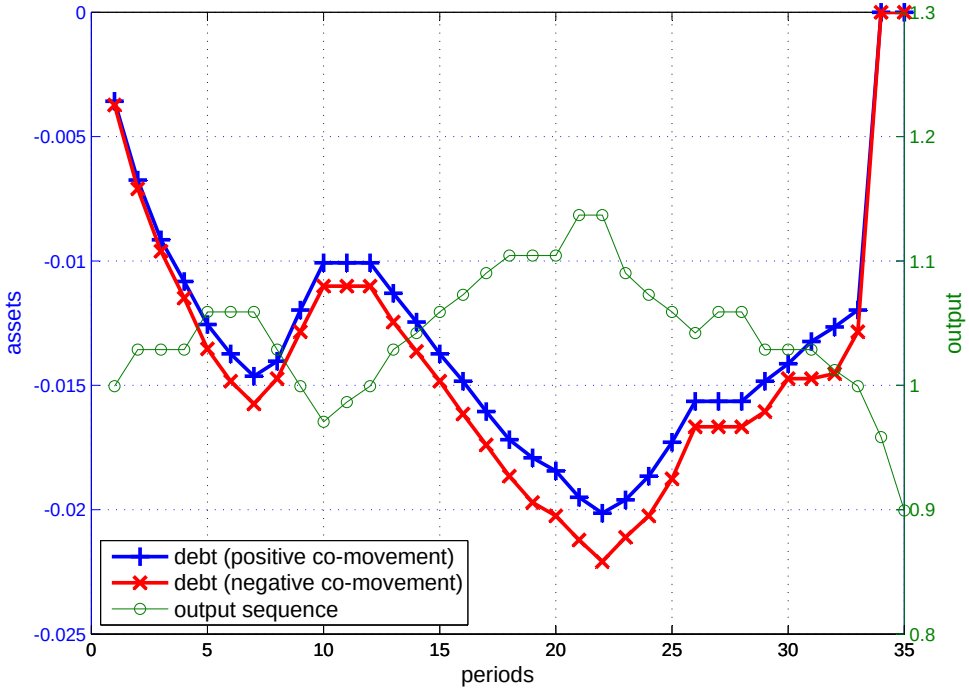
Inflation and debt dynamics

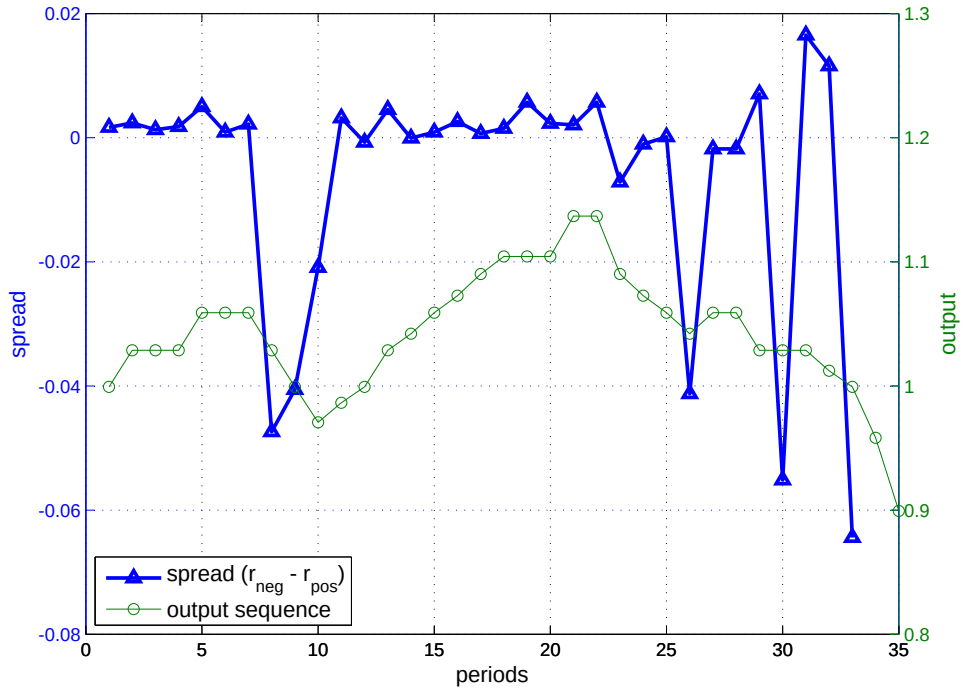




- On average lower rates and debt with pro-cyclicality
- But more volatile rates: riskier debt precisely in bad times

Inflation and debt dynamics





- On average lower rates and debt with pro-cyclicality
- But more volatile rates: riskier debt precisely in bad times

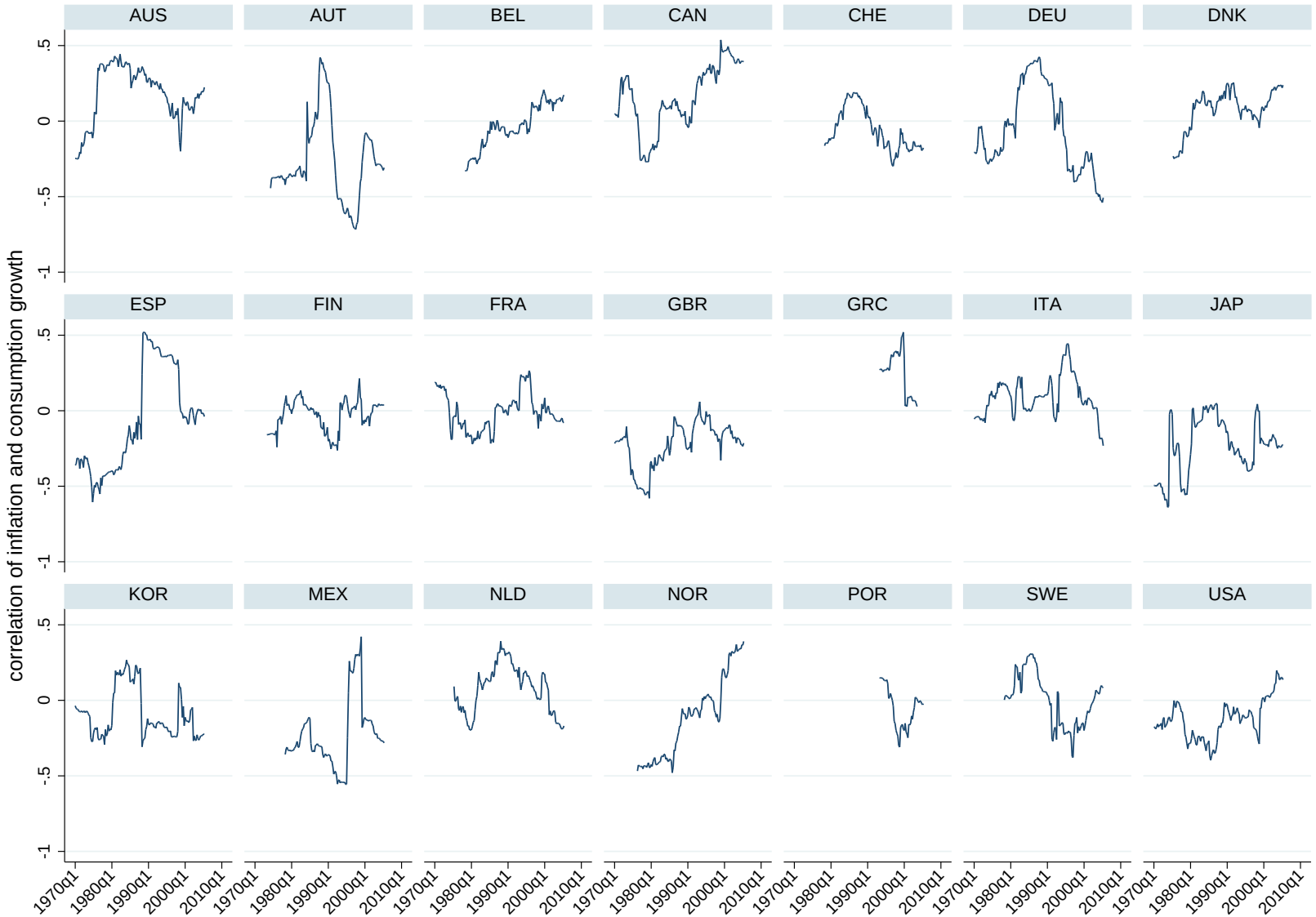
... a tale of periphery EMU accession?

Conclusion

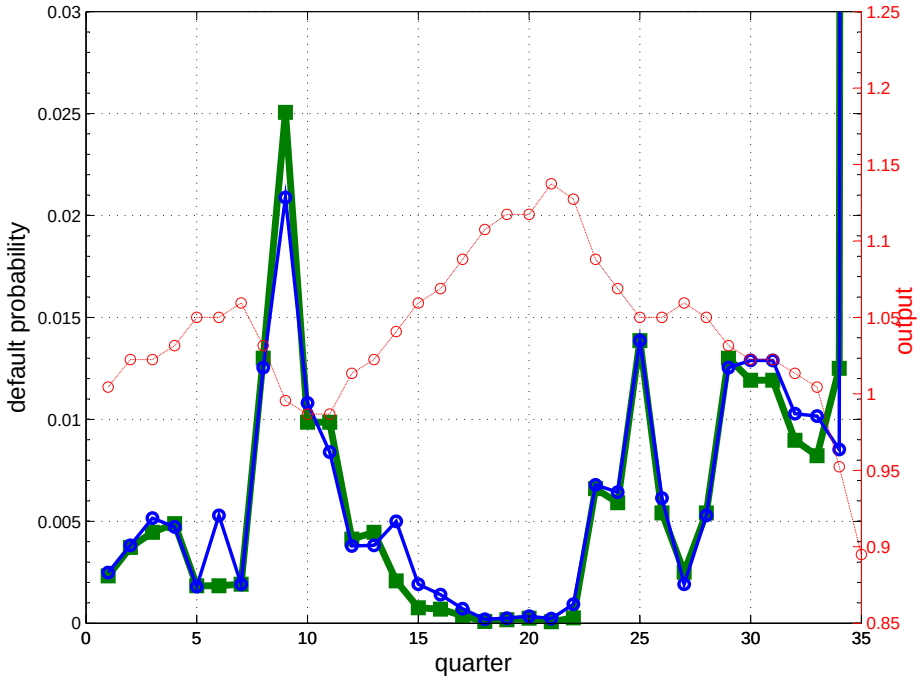
- Model of sovereign debt with risk averse domestic lenders and borrowers
- Inflation pro-cyclicality can be important in explaining the observed cross section of government debt, interest rates, and debt crises
- Next steps: robustness on default evidence + long term debt

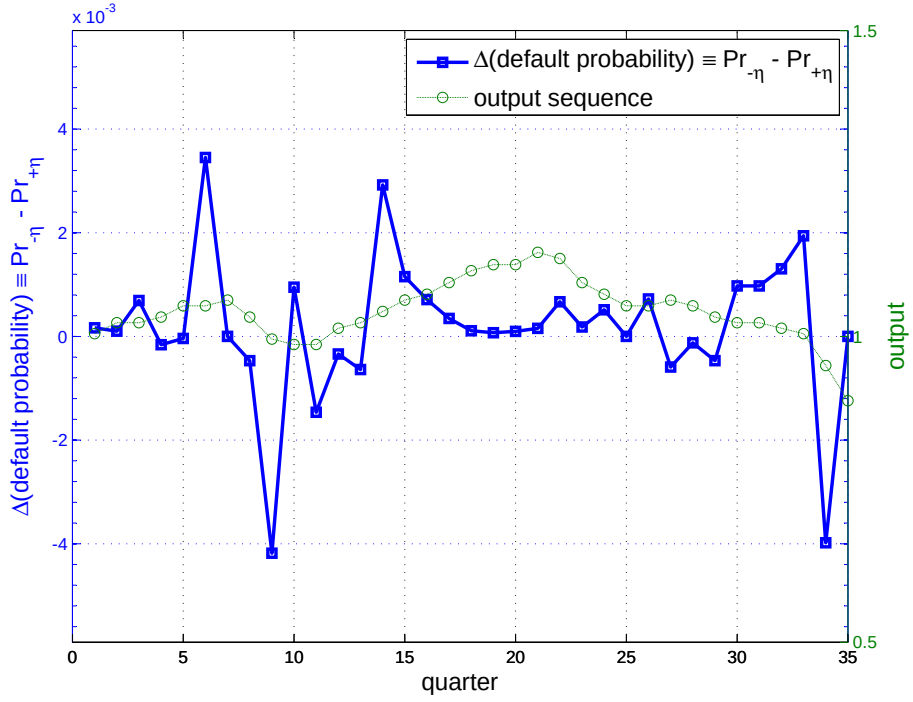
appendix

Conditional correlation between inflation and consumption growth



Default probabilities





Back

Default costs

- Consider the quadratic default costs

$$h^+(y) = \max\left\{0, \underbrace{d_0 d_1 y + (d_1 - d_0 d_1) y^2}_{h(y)}\right\}$$

  with $d_1 > 0$ and $d_0 < 0$
- The default cost at mean is $h(1) = d_1$
- Default costs matter when $h(y) > 0 \Rightarrow y > y^*$ with

$$y^* = \left(1 - \frac{d_1}{d_0 d_1}\right)^{-1} \sim 1 + \frac{1}{d_0} < 0$$

- So we aim for $d_1 \sim .10$ and $\frac{1}{d_0} \sim -.05$