SONOMA:
a Small Open ecoNOmy for MAcrofinance

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Main Questions and Objectives

Many SOEs feature a co-existence of corporate/public/external liabilities:

1. Role of internal and external credit shocks?
2. Implications for riskiness of corporate debt/equity and external debt?
3. Spillovers on economic activity?

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Objectives of this study:

1. Propose a quantitative macro-finance SOE model
2. Why? Reliable new setting for future policy analysis

Model and Findings

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1. Jermann and Quadrini (AER 2012) with EZ (closed)

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1. A quantitatively powerful macro-finance SOE model

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1. A quantitatively powerful macro-finance SOE model
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   - Internal credit shocks: less contractionary (NFA help!)
   - External credit shocks: as contractionary as the internal ones

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Results and insights:

1. A quantitatively powerful macro-finance SOE model
2. In our SONOMA:
   - Internal credit shocks: less contractionary (NFA help!)
   - External credit shocks: as contractionary as the internal ones
3. Data analysis:
   - Credit shocks difficult to hedge: VAR suggests negative correlation
   - External shocks and LRR: external credit shocks lead sluggish LR growth and 'coskewed'
   - SOE Accounting: (in progress)

Related Literature (I)

- **This study:** (i) modifies and expands Jermann and Quadrini (2012, AER) to SOE; (ii) complementary to:
  - **Methods:** Mendoza (1991), Schmitt-Grohéé (1998), Schmitt-Grohe and Uribe (2003),...
  - **Frictions:** Galí and Monacelli (2005) (SOE+NK),...
  - **Asset pricing:** Jahan-Parvar et al. (2013, JMCB) (GHH preferences, production-based) and Horvath (forthcoming, JEDC) (disaster risk), among others.
  - **Sovereign default:** Chodrow-Reich, Karabarbounis, and Kekre (2019), Aguiar and Gopinath (2006, AER), Uribe and Yue (2006), Arellano (2008), Yue (2010), among many ozfethers.
  - **Sudden stops:** Mendoza (2010, AER), Chari et al. (2005, AER), Mendoza and Uribe (2000), among many others.

Related Literature (II)

- **Long-run risk models:**
  - Consumption-based asset pricing: Bansal and Yaron (2004, JF), Bansal et al. (2007, REStud), Bansal et al. (2014, JF), Bansal, Kiku and Yaron (2012 and 2016 JME), Schorfheide et al. (2018, Econometrica), among others.
  - Consumption-based asset pricing for SOEs: Colacito and Croce (2013, JF and 2018, JF).
  - Production based asset pricing: Kaltenbrunner and Lochstoer (2010, RFS), Croce (2014, JME), Colacito et al. (2018, AER), among others.
- **Models with credit constraints:** Jermann and Quadrini (2012, AER), Gertler and Karadi (2011, JME), Guerrieri and Lorenzoni (2017, QJE), Khan and Thomas (2013, JPE), Iacoviello and Pavan (2013, JME), Guerrieri and Iacoviello (2017, JME), among many others.

Household

$$U_t = \max_{\substack{C_t, \ell_t, S_{t+1}, \\ D_{t+1}, X_{t+1}}} \left[(1-\beta)\widetilde{C}(C_t, \ell_t)^{1-\frac{1}{\psi}} + \beta(\mathbb{E}_t U_{t+1}^{1-\gamma})^{\frac{1-\frac{1}{\psi}}{1-\gamma}} \right]^{\frac{1}{1-\frac{1}{\psi}}},$$

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$$C_t^P \leq w_t^P H_t + \underbrace{(S_t - S_{t+1})V_t^{P,ex} + S_t \cdot d_t}_{Net\ Equity\ Payout} + \underbrace{(1+r_t^D)D_t - D_{t+1}}_{Net\ Debt\ Payout} + \underbrace{X_{t+1} - (1+r_t)X_t}_{Net\ New\ External\ Debt} - T_t^H$$

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$$1 \geq H_t^s + \ell_t$$

where

$$\widetilde{C}_t = \left(\tilde{w}_1 C_t^{1-\frac{1}{f}} + \tilde{w}_2 \left(A_{t-1}\ell_t\right)^{1-\frac{1}{f}} \right)^{\frac{1}{1-\frac{1}{f}}}$$

$$r_t = r_t^w + P\left(\frac{X_t}{Y_t}\right) \qquad (1)$$

Household

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▸ Table

- r^W: subject to external random shocks
- Closed Economy: replace (1) with $X = 0 \quad \forall t$
- In equilibrium, no default and $r_t^D = r_t \quad \forall t$.

Private Firm

$$
\begin{aligned}
V_t^P &= \max_{\substack{d_t, H_t, I_t, \\ K_{t+1}, D_{t+1}}} d_t + \mathbb{E}_t \left[M_{t+1} V_{t+1}^P \right] \\
d_t &\leq F\left(K_t, H_t, A_t\right) - w_t^P H_t^P - I_t - \chi\left(d_t\right) + \underbrace{D_{t+1} - D_t \left(1 + r_t^D\right)}_{-NDP} - T_t^c \\
K_{t+1} &\leq \left(1-\delta\right) K_t + I_t - \Phi\left(\frac{I_t}{K_t}\right) K_t \\
F\left(K_t, H_t, A_t\right) &\leq \xi_t \left(K_{t+1} - D_{t+1}\right)
\end{aligned}
$$

where

$$
\begin{aligned}
T_t^c &= \tau_F \left(F_t - w_t^P H_t^P\right) - D_t r_t^D \tau_F \\
\chi(d_t) &= A_{t-1} \cdot \kappa(d_t / MA_{t-1} - \bar{d})^2 \\
\log MA_t &= (1-\theta)(\mu + \log MA_{t-1} - \Delta a_t)
\end{aligned}
$$

- Capital adjustment costs, $\Phi(\cdot)$, as in Jermann (1998)
- Constraint slackness: Convex. Convex. Table

Exogenous Processes

- Productivity as in Croce (2014):

$$\begin{aligned} \Delta a_{t+1} &= \mu_a + x_t + e^{\sigma_t^{srv}} \epsilon_{t+1}^a \\ x_{t+1} &= \rho_x x_t + e^{\sigma_t^{lrv}} \epsilon_{t+1}^x \end{aligned}$$

- External borrowing cost as in Neumeyer and Perri (2005):

$$r_{t+1}^w = (1 - \rho_{rw}) \mu_{rw} + \rho_{rw} r_t^w + \epsilon_{t+1}^{rw}$$

- Internal credit conditions as in Jermann and Quadrini (2012):

$$\xi_{t+1} = (1 - \rho_\xi) \mu_\xi + \rho_\xi \xi_t + \epsilon_{t+1}^\xi$$

- All shocks $\sim N\left(\overrightarrow{0}, \Sigma\right)$.

Market Clearing and Tax policy

- Goods market:

$$F_t = C_t + I_t + \underbrace{(1 + r_t) X_t - X_{t+1}}_{CA} + \chi(d_t)$$

- The labor market: $H_t^{P,s} = H_t^{P,d}$
- The equity market: $S_t = 1 \quad \forall t$
- Domestic corporate debt market: $D_t^{HH} = D_t^{Firm}$
- Zero-deficit-zero-debt policy: $T_t^c + T_t^H = 0$

Key Insights from FOCs

1. The SDF features long-run risk aversion:

$$M_{t+1} = \beta \left(\frac{\widetilde{C}_{t+1}}{\widetilde{C}_t} \right)^{-\frac{1}{\psi}} \left(\frac{U_{t+1}}{E_t \left[U_{t+1}^{1-\gamma} \right]^{\frac{1}{1-\gamma}}} \right)^{\frac{1}{\psi}-\gamma} \frac{\partial \widetilde{C}_{t+1} / \partial C_{t+1}}{\partial \widetilde{C}_t / \partial C_t}$$

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2. The financial constraint causes a wedge in the labor market:

$$w_t^P = \left(1 - \frac{(1+\chi'(d_t))\,\Lambda_{CC,t}}{1-\tau_F} \right) F_{H,t}$$

a tighter constraint ($\Lambda_{CC} >> 0$) reduces labor demand (at ss, $\chi' = 0$).

Data Sources ▸ Details

Panel A: List of Sources	
Name	**Acronym**
Bank of International Settlements	BIS
International Monetary Fund	IMF
Organisation for Economic Co-Operation and Development	OECD
Penn World Table	PWT
Ken French Data Library	KF
Panel B: Data Sources	
Variable	**Source**
National aggregates (GDP, C, I)	OECD
Depreciation	PWT
Labor hours	OECD, PWT
Private sector debt	BIS
Net external debt	IMF
Domestic interest rates	OECD
Public equity data	KF
Inflation	IMF
Exchange rates	IMF

Takeaway: harmonized!

Country-level Measurements ▸ Samples

Country-level Measurements

Samples

Productivity:

$$Y_t^j = Z_t^j K_t^{j\theta_j} N_t^{j1-\theta_j},$$

$$\Delta z_{t+1}^j = \mu + \underbrace{\beta^j \cdot pd_t^j}_{x_t^j} + \epsilon_{t+1}^{j,srr}$$

Internal credit conditions:

$$\xi_t^j = \frac{Y_t^j}{K_{t+1}^j - B_{t+1}^{j,end}},$$

External credit conditions:

$$P_t^j \equiv p_2 e^{p_1\left(X_t^j / Y_t^j - \overline{XY}^j\right)} - 1$$

$$r_t^{j,w} = r_t^j - P_t^j,$$

VAR and Coskewness

Figures

$$Y_t = \Phi Y_{t-1} + \Sigma u_t; \qquad Y_t = \begin{bmatrix} r_t^{w,avg} & \xi_t^{avg} & x_t^{avg} \end{bmatrix}$$

	Estimate	**Confidence Interval**
Panel A: Impulse Response Function		
ξ^{avg} Response to a $r^{w,avg}$ Shock (%)		
GDP-Weighted Average	-0.368	[-0.574, -0.163]
Equal-Weighted Average	-0.305	[-0.470, -0.140]
x^{avg} Response to a $r^{w,avg}$ Shock (p.p.)		
GDP-Weighted Average	-0.014	[-0.019, -0.010]
Equal-Weighted Average	-0.009	[-0.014, -0.005]
Panel B: Coskewness		
$CoSk(r^{w,avg}, x^{avg})$ (VAR)	0.425	[0.065, 0.785]
$CoSk(r^{j,w}, x^{j})$ (Unbalanced Panel Regr.)	0.370	[0.181, 0.559]
$CoSk(r^{j,w}, x^{j})$ (Balanced GMM)	0.164	[0.059, 0.269]

VAR and Coskewness: Takeaways

1. Negative response of internal credit conditions to adverse external credit shock

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2. Negative response of expected growth to adverse external credit shock

   $\Longrightarrow$ deteriorating external credit conditions are an indicator of sluggish long-term growth

3. Positive coskewness between external credit conditions and expected long-term growth

   $\Longrightarrow$ relatively bad external credit shocks associated to relatively large declines in expected growth

Benchmark Calibration

Preferences		Open	
Relative Risk Aversion	(γ)	10	← LRR Literature
Intertemporal Elasticity of Substitution	(ψ)	2	
Subjective Discount Rate	(β)	0.99	
Consumption-Leisure Aggregator			
Consumption Coefficient	($\tilde{\omega}_1$)	0.35	← RBC Literature
Leisure Coefficient	($\tilde{\omega}_2$)	0.65	
Elasticity of Substitution	(f)	1	
Production			
Capital Share	(α_P)	0.36	
Capital Depreciation Rate	(δ)	0.10/4	← RBC Literature
Capital Adjustment Cost Elasticity	(ϕ_2)	2.0	
Corporate Tax Rate	(τ_F)	0.35	
Productivity Growth Rate			
Average	(μ_a)	0.020/4	
Volatility of Short-Run Shock	(σ_a)	0.046/2	← LRR Literature
Persistence of Long-Run Component	(ρ_x)	0.95	
Volatility of Long-Run Shock	(σ_x)	$0.10\sigma_a$	
Internal Financial Constraint			
Average	(μ_ξ)	0.24	
Persistence	(ρ_ξ)	0.97	← JQ
Volatility of Financial Shock	(σ_ξ)	0.012/4	
Equity Adj. Cost	(κ)	0.146	
Smooth rescaling factor	(θ)	0.02	
External Interest Rate (r^W)			
Average	(μ_{RW})	0.011/4	← SOE Literature
Persistence	(ρ_{RW})	0.80	
Volatility of r^W Shock	(σ_{RW})	0.010/2	
External Debt and Domestic Interest Rate			
Average External Debt Ratio	($\overline{XY}$)	0.60	← SOE Literature
Interest Rate Cost Function Exponent	(p_1)	8	
Interest Rate Cost Function Coefficient	(p_2)	0.008	

The parameters determining the impact of external shocks on domestic shocks and long-run risk are $\beta_{r,\xi} = -0.70$ and $\beta_{r,x} = -0.2\%$, respectively.

Inspecting the Mechanism

Closed Economy

1. Replace eq. (1) with $X_t = 0 \quad \forall t$

Removing Financial Frictions - three relevant cases:

2. No internal credit shocks: $\sigma_\xi = 0$
3. No financial frictions: 100% equity financing ($\kappa = 0$, no tax shield on debt, no collateral constraint)
4. No external credit shocks: $\sigma_{rw} = 0$

Replication: From Closed JQ to Closed SONOMA

JQ Open

	JQ (w. CAC)	Stronger CAC, Prod. LRR	SONOMA Closed
$E[C^P/Y^P]$ (%)	84.5	79.0	79.6
$E[I/Y^P]$ (%)	15.5	21.0	20.5
$E[X/Y^P]$ (%)	–	–	–
$\sigma(\Delta i)/\sigma(\Delta y_p)$	2.5	1.1	1.7
$\sigma(\Delta y_p)/\sigma(\Delta c_p)$	0.7	1.0	0.9
$corr(\Delta i, \Delta c_p)$	1.0	1.0	0.7
$\sigma(X/Y^P)$ (%)	–	–	–
$E[R - R_W]$ (%)	–	–	–
$\sigma(R - R_W)$ (%)	–	–	–
$E[R_{E,t} - R^W_{t-1}]$ (%)	0.08	0.12	4.24
$\sigma(R_{E,t} - R^W_{t-1})$ (%)	1.12	1.96	6.84
$E[R_{K,t} - R^W_{t-1}]$ (%)	0.04	0.04	2.81
$\sigma(R_{K,t} - R^W_{t-1})$ (%)	0.44	0.62	3.44
$E[D/K]$ (%)	53.8	59.9	40.00
$\sigma(D/K)$ (%)	2.3	2.2	6.30

Takeaway: Closed SONOMA inherits successes of Jermann and Quadrini (2012) and improves AP performance

Performance of SONOMA Open/Closed

	Data		Open	Closed
	Est.	Range		
$E[C^P/Y^P]$ (%)	68.74	[63.18 , 74.07]	79.60	79.55
$E[I/Y^P]$ (%)	27.88	[26.93 , 29.60]	20.54	20.47
$E[X/Y^P]$ (%)	50.68	[32.68 , 65.46]	44.93	–
$\sigma(\Delta i)/\sigma(\Delta y_p)$	2.12	[1.76 , 2.22]	1.72	1.74
$\sigma(\Delta c_p)/\sigma(\Delta y_p)$	0.72	[0.69 , 0.99]	0.98	0.90
$corr(\Delta i, \Delta c_p)$	0.42	[0.22 , 0.62]	0.76	0.68
$\sigma(\Delta(X/Y^P))$ (%)	3.12	[2.02 , 4.29]	2.44	–
$E[R - R_W]$ (%)	0.51	[0.26 , 0.77]	0.70	–
$\sigma(R - R_W)$ (%)	0.62	[0.53 , 0.91]	0.56	–
$E[R_E - R_W]$ (%)	8.07	[5.80 , 11.11]	4.14	4.24
$\sigma(R_E - R_W)$ (%)	23.04	[22.28 , 24.57]	6.02	6.84
$E[R_K - R_W]$ (%)	4.98	[1.99 , 6.94]	2.69	2.81
$\sigma(R_K - R_W)$ (%)	19.11	[13.54 , 20.97]	3.83	3.44
$E[D/K]$ (%)	22.44	[14.86 , 33.71]	39.56	40.00
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$E[I/Y^P]$ (%)	27.88	[26.93 , 29.60]	20.54	20.47
$E[X/Y^P]$ (%)	50.68	[32.68 , 65.46]	44.93	–
$\sigma(\Delta i)/\sigma(\Delta y_p)$	2.12	[1.76 , 2.22]	1.72	1.74
$\sigma(\Delta c_p)/\sigma(\Delta y_p)$	0.72	[0.69 , 0.99]	0.98	0.90
$corr(\Delta i, \Delta c_p)$	0.42	[0.22 , 0.62]	0.76	0.68
$\sigma(\Delta(X/Y^P))$ (%)	3.12	[2.02 , 4.29]	2.44	–
$E[R-R_W]$ (%)	0.51	[0.26 , 0.77]	0.70	–
$\sigma(R-R_W)$ (%)	0.62	[0.53 , 0.91]	0.56	–
$E[R_E-R_W]$ (%)	8.07	[5.80 , 11.11]	4.14	4.24
$\sigma(R_E-R_W)$ (%)	23.04	[22.28 , 24.57]	6.02	6.84
$E[R_K-R_W]$ (%)	4.98	[1.99 , 6.94]	2.69	2.81
$\sigma(R_K-R_W)$ (%)	19.11	[13.54 , 20.97]	3.83	3.44
$E[D/K]$ (%)	22.44	[14.86 , 33.71]	39.56	40.00
$\sigma(D/K)$ (%)	2.61	[0.99 , 4.08]	6.84	6.30

Performance of SONOMA Open/Closed

	Data		Open	Closed
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$E[C^P/Y^P]$ (%)	68.74	[63.18 , 74.07]	79.60	79.55
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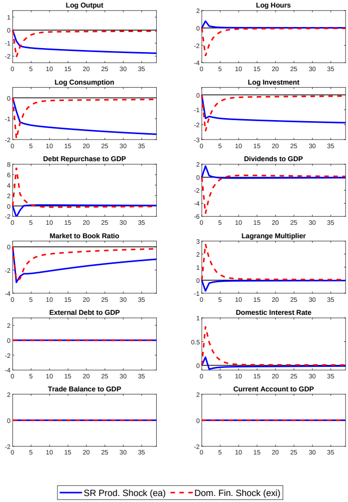
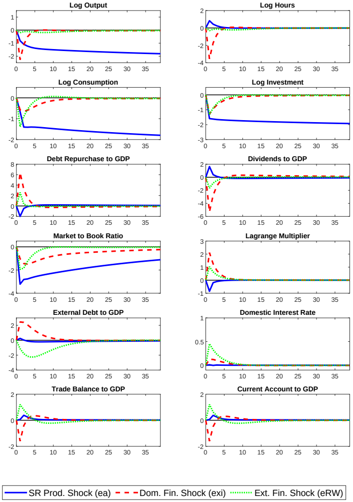
Key Macro Variables

▸ LR Shocks



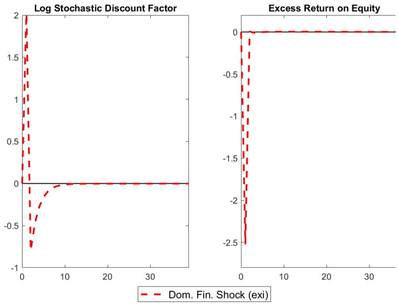
(a) SONOMA Closed



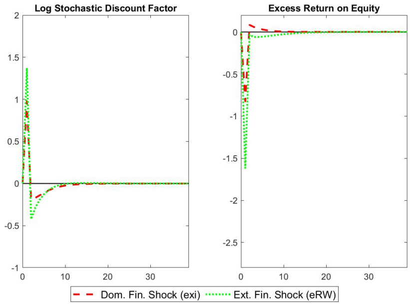
(b) SONOMA

Returns

▸ SR Shocks ▸ LR Shocks



(c) SONOMA Closed



(d) SONOMA

Note: responses to productivity shocks are standard.

Closed vs Open Impulse Responses: Takeaways

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SONOMA: Removing Financial Frictions

	SONOMA	No EZ	No Fin. Factors		
			$\sigma_\xi = 0$	$\kappa = D = 0$	$\sigma_{RW} = 0$
$E[C^P/Y^P]$ (%)	79.60	78.55	79.55	79.31	79.55
$E[I/Y^P]$ (%)	20.54	21.24	20.57	20.73	20.53
$E[X/Y^P]$ (%)	44.93	55.66	45.94	42.99	46.61
$\sigma(\Delta i)/\sigma(\Delta y_p)$	1.72	1.51	2.81	1.32	1.44
$\sigma(\Delta c_p)/\sigma(\Delta y_p)$	0.98	1.09	1.67	0.75	0.61
$corr(\Delta i, \Delta c_p)$	0.76	0.98	0.75	0.68	0.53
$\sigma(\Delta(X/Y^P))$ (%)	2.44	2.22	1.47	4.04	1.98
$E[R - R_W]$ (%)	0.70	2.78	0.82	0.29	0.79
$\sigma(R - R_W)$ (%)	0.56	1.07	0.50	0.99	0.42
$E[R_E - R]$ (%)	4.14	0.52	4.03	2.29	4.05
$\sigma(R_E - R)$ (%)	6.02	5.20	5.90	3.64	5.08
$E[R_K - R]$ (%)	2.69	0.30	2.64	2.29	2.64
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Overall Takeaway: Financial shocks/frictions are relevant for economic activity and asset prices

SONOMA and Tail Events

Coskewness. In the model 0.37 (in the data 0.43).

$$r^w_t = (1-\rho_{rw})(\mu_{rw} - j_0) + \rho_{rw} r^w_{t-1} + \epsilon_{r,t} + (1-\rho_{rw}) J_t$$
$$x_t = (1-\rho_x) j_0 + \rho_x x_{t-1} + \epsilon_{x,t} + s_{xr}\epsilon_{r,t} + s_{x\xi}\epsilon_{\xi,t} - (1-\rho_x) J_t,$$

$$J_t = j_0 e^{j_1 \cdot \epsilon_{j,t}} > 0 \qquad j_1 = 2.2 \qquad j_0 = 2.e^{-5} \qquad \epsilon_{j,t} \sim N(0,1)$$

Cost of equity: +19 bp;
Avg Capital: -0.9%;
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Takeaway: credit shocks can have strong detrimental effects because they are a leading indicator of a negative outlook about long-run growth.

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$$\log R_t^{E*} = r_{t-1}^{EW} + P^E \left(\frac{NEE_{t-1}}{Y_{t-1}} \right) + \sigma^{EWS} \epsilon_t^{EWS}$$

$$r_{t+1}^{EW} = (1 - \rho_{ew}) (\mu_{rw} + s_{rw}) + \rho_{ew} r_t^{EW} + \sigma^{EWL} \epsilon_{t+1}^{EWL}$$

$$\Delta NFA \equiv \left(NEE_{t+1} - R_t^{E*} NEE_t \right) - (X_{t+1} - (1 + r_t) X_t)$$

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- Next step: structural estimation

Conclusions

SONOMA:

1. Extremely powerful SOE setting for macro-finance
2. Enables to study equity, sovereign, and corporate risks simultanelously
3. Highlights interplay of fin. frictions and resolution of uncertainty

Data Sources ▸ Back

Table: Data Availability by Country

Country	National Aggregates	Depreciation	Labor		Private Sector Debt	Net External Debt		Domestic Interest Rate	Public Equity	Inflation
	Quarterly	Annual	*Quarterly*	*Annual*	*Quarterly*	*Quarterly*	*Annual*	*Quarterly*	*Monthly*	*Quarterly*
Austria	1960	1950	1995	1995	1995	2005	2005	1990	1987	1958
Belgium	1960	1950	1983	1970	1980	2005	1981	1955	1975	1956
Denmark	1960	1950	1990	1970	1994	2005	1991	1987	1989	1958
Finland	1960	1950	1998	1960	1970	1975	1975	1988	1988	1956
Greece	1960	1951	1989	1983	1994	2003	1998	1997	NA	1956
Ireland	1960	1950	1998	1998	2002	2011	2005	1971	1991	1958
Italy	1960	1950	1998	1995	1950	1999	1972	1991	1975	1956
Netherlands	1960	1950	1998	1975	1990	2003	2003	1959	1975	1958
Norway	1960	1950	2000	1962	1975	2012	1980	1985	1975	1951
Portugal	1960	1950	1998	1970	1979	1999	1996	1993	1995	1956
Spain	1960	1950	1999	1977	1980	1999	1981	1980	1975	1955
Sweden	1960	1950	2001	1963	1980	1999	1986	1987	1975	1956
Switzerland	1960	1950	2010	1998	1999	1999	1983	1955	1975	1956

Country-level Samples

Back

Table: Data Availability for Country-Level Measurements

Country	**External Credit**	**Internal Credit**	**TFP Growth**	**PD Ratio**
	r^w	ξ	Δa	PD
Austria	2005	1995	1995	1987
Belgium	1981	1980	1970	1975
Denmark	1991	1994	1970	1989
Finland	1988	1970	1960	1988
Italy	1991	1960	1995	1975
Netherlands	2003	1990	1975	1975
Portugal	1996	1979	1970	1995
Spain	1981	1980	1977	1975
Sweden	1987	1980	1963	1975
Switzerland	1983	1999	1998	1975

Interest Rates and External Debt

Back

$$\ln\left(1+P_t^j\right) = \ln(p_2^j) + p_1^j\left(X_t^j/Y_{t-1}^j - \overline{XY}^j\right) + resid_t^j \quad = 1,2,\ldots$$

Panel A: Selected Countries

	Finland	Italy	Portugal	Spain	Sweden	Switzerland
p_1^j	0.02*	0.06***	0.08***	0.04***	0.04**	0.03***
	(0.02)	(0.02)	(0.02)	(0.01)	(0.03)	(0.01)
$\ln\left(p_2^j\right)$	0.31*	0.71***	1.14**	0.26	0.76***	-0.35**
	(0.23)	(0.25)	(0.51)	(0.35)	(0.27)	(0.21)
R^2	0.11	0.44	0.56	0.45	0.05	0.31
$\overline{XY}^j$	25	33	59	49	49	-70
XY^j_{2017q4}	43	53	81	79	44	-33
$XY^j_{2017q4} - XY^j_{2010q1}$	23	7	2	-2	-4	30

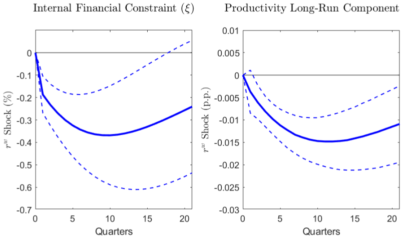
Panel B: Excluded Countries

	Austria	Belgium	Denmark	Netherlands
p_1^j	-0.01	-0.02*	-0.05***	-0.01***
	(0.01)	(0.01)	(0.01)	(0.00)
$\ln\left(p_2^j\right)$	-0.09*	-0.02	-0.10	0.12**
	(0.06)	(0.13)	(0.11)	(0.07)
R^2	0.01	0.08	0.33	0.20
$\overline{XY}^j$	22	-17	39	93
XY^j_{2017q4}	23	5	17	60
$XY^j_{2017q4} - XY^j_{2010q1}$	0	42	-34	-53

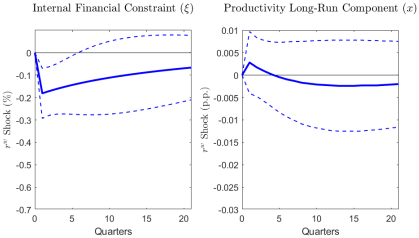
Panel C: Panel Regression

	Selected Countries	Excluded Countries	All Countries
p_1	0.05***	-0.02***	0.04***
	(0.01)	(0.01)	(0.01)
$\ln(p_2)$	0.46***	-0.03	0.29***
	(0.15)	(0.06)	(0.11)
R^2	0.35	0.13	0.24

VAR Figures Back

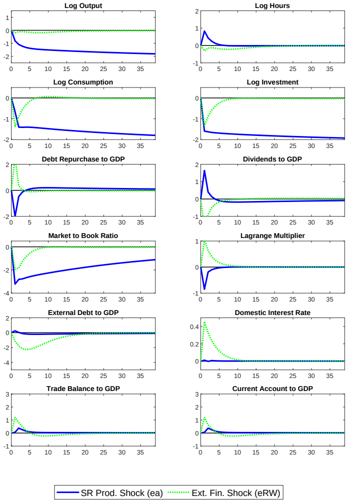


Selected Countries

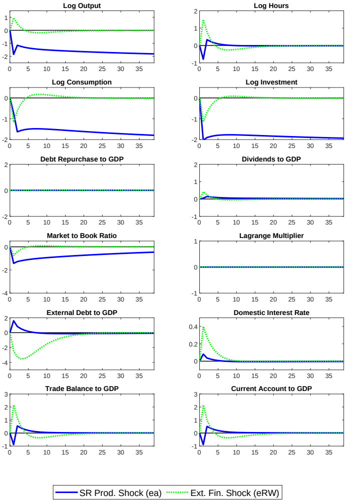


Excluded Countries

SONOMA: Role of Financial Frictions



(e) SONOMA

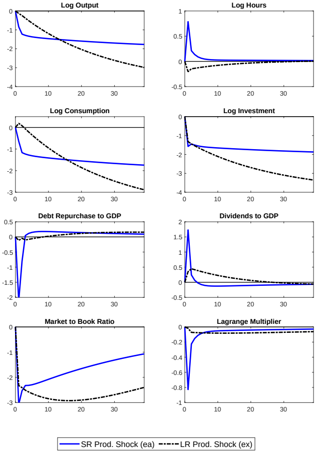


(f) SONOMA, No Fin. Frictions

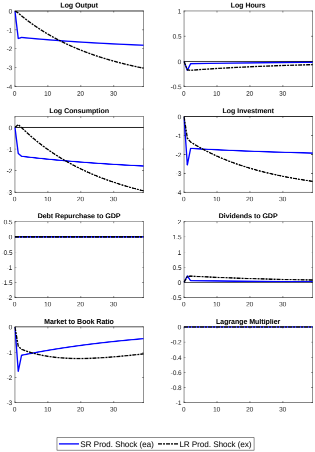
Closing SONOMA: Inspecting the Mechanism (I)

	SONOMA		No Fin. Factors	
	Closed	No EZ	$\sigma_\xi = 0$	$\kappa = D = 0$
$E[C^P/Y^P]$ (%)	80.6	79.2	80.5	81.2
$E[I/Y^P]$ (%)	19.4	20.8	19.5	18.8
$E[X/Y^P]$ (%)	–	–	–	–
$\sigma(\Delta y_p)$ (%)	2.5	2.4	1.0	1.5
$\sigma(\Delta i)/\sigma(\Delta y_p)$	1.4	1.1	2.0	1.9
$\sigma(\Delta y_p)/\sigma(\Delta c_p)$	1.1	1.0	1.1	1.2
$corr(\Delta i, \Delta c_p)$	0.8	1.0	0.4	0.8
$\sigma(X/Y^P)$ (%)	–	–	–	–
$E[R - R_W]$ (%)	–	–	–	–
$\sigma(R - R_W)$ (%)	–	–	–	–
$E[R_{E,t} - R^W_{t-1}]$ (%)	1.5	0.24	1.31	0.6
$\sigma(R_{E,t} - R^W_{t-1})$ (%)	5.38	3.72	4.90	1.93
$E[R_{K,t} - R^W_{t-1}]$ (%)	0.68	0.08	0.61	0.6
$\sigma(R_{K,t} - R^W_{t-1})$ (%)	1.86	1.09	1.75	1.9
$E[D/K]$ (%)	56.3	58.7	57.5	0
$\sigma(D/K)$ (%)	7.0	6.8	2.7	0

Closing SONOMA: Inspecting the Mechanism (II)

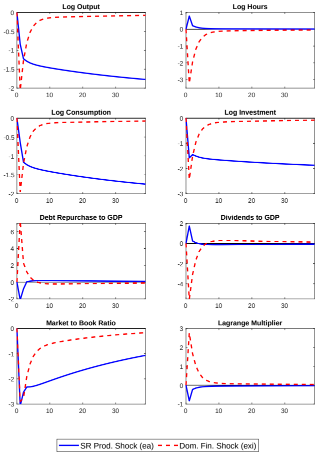


(g) SONOMA Closed

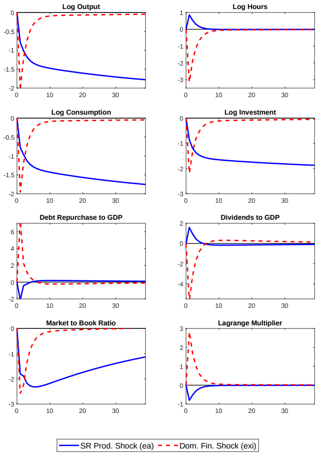


(h) SONOMA, No Fin. Frictions

Closing SONOMA: EZ vs CRRA



(i) SONOMA Closed



(j) No EZ ($\gamma = 0.5 = 1/\psi$)

Private Firm: Convexified Constraint

Back

$$V_t^P = \max_{\substack{d_t, H_t, I_t, \\ K_{t+1}, D_{t+1}}} d_t + \mathbb{E}_t \left[M_{t+1} V_{t+1}^P \right]$$

$$d_t \leq F(K_t, H_t, A_t) - w_t^P H_t^P - I_t - \chi(d_t) + \underbrace{D_{t+1} - D_t \left(1 + r_t^D\right)}_{-NDP} - T_t^c - CC_t$$

$$K_{t+1} \leq (1-\delta) K_t + I_t - \Phi\left(\frac{I_t}{K_t}\right) K_t$$

where

$$T_t^c = \tau_F \left(F_t - w_t^P H_t^P\right) - D_t r_t^D \tau_F$$

$$\chi(d_t) = A_{t-1} \cdot \kappa(d_t / MA_{t-1} - \overline{d})^2$$

$$\log MA_t = (1-\theta)(\mu + \log MA_{t-1} - \Delta a_t)$$

$$CC_t = A_{t-1} cc_1 e^{-cc2[\xi_t (K_{t+1} - D_{t+1}) - F_t]/A_{t-1}}$$

- CC convexifies: $\xi_t (K_{t+1} - D_{t+1}) \geq F\left(K_t, H_t^{P,d}; A_t\right)$
- Capital adjustment costs, $\Phi(\cdot)$, as in Jermann (1998)

Moments: Assume Binding vs Convexified Cost

Back

	SONOMA		Closed SONOMA	
	Binding	Convexified	Binding	Convexified
$E[C^P/Y^P]$ (%)	80.2	80.1	80.6	82.5
$E[I/Y^P]$ (%)	20.2	20.2	19.4	17.6
$E[X/Y^P]$ (%)	38.2	39.3	0	0
$\sigma(\Delta i)/\sigma(\Delta y_p)$	1	1	1.4	1.4
$\sigma(\Delta y_p)/\sigma(\Delta c_p)$	1.4	1.4	1.1	1
$corr(\Delta i, \Delta c_p)$	0.7	0.7	0.8	0.8
$\sigma(X/Y^P)$ (%)	10.5	10.7	0	0
$E[R - R_W]$ (%)	0.17	0.14	0	0
$\sigma(R - R_W)$ (%)	0.49	0.54	0	0
$E[R_{E,t} - R^W_{t-1}]$ (%)	1.63	1.63	1.5	1.31
$\sigma(R_{E,t} - R^W_{t-1})$ (%)	4.17	4.18	5.38	4.08
$E[R_{K,t} - R^W_{t-1}]$ (%)	0.7	0.69	0.68	0.65
$\sigma(R_{K,t} - R^W_{t-1})$ (%)	2	2	1.86	1.87

Note: Convexified cost function parameter values are $cc_1 = 0.001$ and $cc_2 = 1000$.

Simulation

Simulations: Assume Binding vs Convexified Cost

Back

Percent Negative Lagrange Multiplier Within Simulation

	SONOMA		Closed SONOMA	
	Binding	Convexified	Binding	Convexified
Average	47.1	9.8	53.9	11.5
Std. Dev.	20.6	9.7	19	12.4
p05	10	0	22.5	0
p50	48.8	7.3	52.8	8.5
p95	81.5	30.5	85	34

Percent Debt Slackness Negative Within Simulation

	SONOMA		Closed SONOMA	
	Binding	Convexified	Binding	Convexified
Average	0.7	1.7	0.7	1.2
Std. Dev.	0.5	0.8	0.6	0.5
p05	0.2	1	0.2	0.7
p50	0.6	1.4	0.6	1
p95	1.4	3.2	1.7	2

Note: Top panel summary statistics across a set of simulations for the percent of observations within a given simulation for which the Lagrange Multiplier is negative. Bottom panel summary statistics across a set of simulations for the percent of observations within a given simulation for which the debt slackness ratio is negative. The debt slackness ratio is a log ratio defined as $\log\left(\xi_t(K_{t+1} - D_t)/Y_t^P\right)$ and can be interpreted as a percent deviation from the binding constraint.

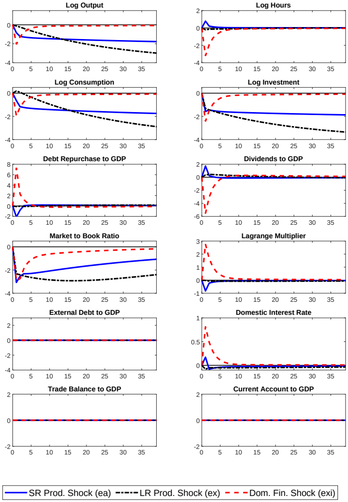
Replication: From Open JQ to SONOMA

Back

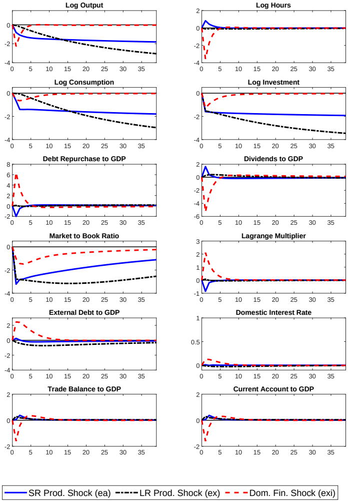
	Open JQ	w. CAC	Stronger CAC, Prod. LRR	SONOMA
$E[C^P/Y^P]$ (%)	81.5	81.4	78.1	80.2
$E[I/Y^P]$ (%)	17.2	18.1	21.7	20.2
$E[X/Y^P]$ (%)	45.6	48.5	48.3	38.6
$\sigma(\Delta y_p)$ (%)	1.0	0.9	0.9	2.8
$\sigma(\Delta i)/\sigma(\Delta y_p)$	46.7	4.0	1.4	1.1
$\sigma(\Delta y_p)/\sigma(\Delta c_p)$	2.9	0.9	0.8	1.4
$corr(\Delta i, \Delta c_p)$	0.7	1.0	1.0	0.7
$\sigma(X/Y^P)$ (%)	11.5	5.8	5.8	9.8
$E[R - R_W]$ (%)	0.76	0.75	0.75	0.17
$\sigma(R - R_W)$ (%)	0.76	0.40	0.39	0.52
$E[R_{E,t} - R^W_{t-1}]$ (%)	0.04	0.07	0.08	1.63
$\sigma(R_{E,t} - R^W_{t-1})$ (%)	0.34	1.58	1.92	4.32
$E[R_{K,t} - R^W_{t-1}]$ (%)	0.02	0.02	0.03	0.70
$\sigma(R_{K,t} - R^W_{t-1})$ (%)	0.40	0.66	0.76	2.01
$E[D/K]$ (%)	60.4	60.4	61.2	57.4
$\sigma(D/K)$ (%)	2.2	2.0	2.1	6.7

Key Macro Variables upon Negative LR Shock

Back



(k) SONOMA Closed



(l) SONOMA

Performance of SONOMA: Robustness ▸ Back

	Data		Current	Potential
	Est.	StErr	Calibration	Calibration
$E[C^P/Y^P]$ (%)	70.18	(0.90)	80.21	78.13
$E[I/Y^P]$ (%)	29.82	(0.90)	20.21	22.45
$E[X/Y^P]$ (%)	53.05	(19.93)	38.64	39.76
$\sigma(\Delta y_p)$ (%)	1.56	(0.37)	2.81	2.42
$\sigma(\Delta i)/\sigma(\Delta y_p)$	2.35	(0.10)	1.08	1.17
$\sigma(\Delta y_p)/\sigma(\Delta c_p)$	1.75	(0.40)	1.38	1.23
$corr(\Delta i, \Delta c_p)$	0.32	(0.06)	0.71	0.70
$\sigma(X/Y^P)$ (%)	21.94	(3.52)	9.79	8.17
$E[R - R_W]$ (%)	0.34	(0.06)	0.17	0.20
$\sigma(R - R_W)$ (%)	0.75	(0.14)	0.52	0.44
$E[R_E - R_W]$ (%)	2.18	(0.14)	1.63	1.50
$\sigma(R_E - R_W)$ (%)	10.09	(0.58)	4.32	4.49
$E[R_K - R_W]$ (%)	0.61	(0.18)	0.70	0.69
$\sigma(R_K - R_W)$ (%)	5.41	(0.47)	2.01	1.89
$E[D/K]$ (%)	46.75	(2.41)	57.41	62.81
$\sigma(D/K)$ (%)	3.54	(0.37)	6.70	3.61

Note: Potential calibration changes $\alpha_P = 0.4$, $\rho_\xi = 0.92$, and $\sigma_\xi = 0.012$.

Performance of SONOMA: Robustness

Back

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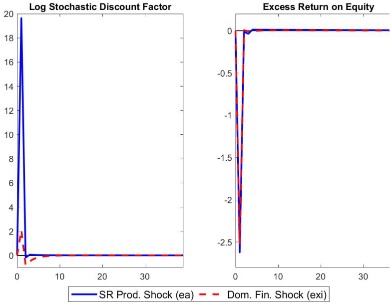
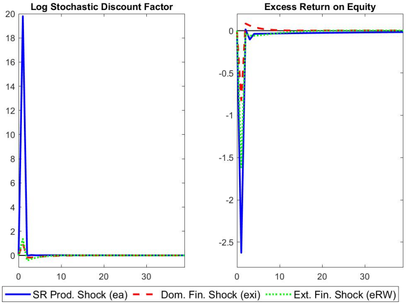
Returns with SR Shock

Back

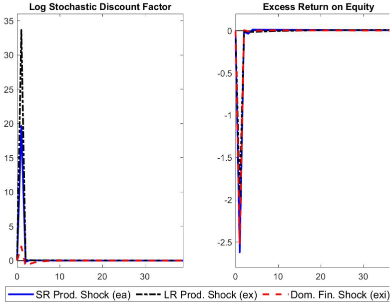


(m) SONOMA Closed

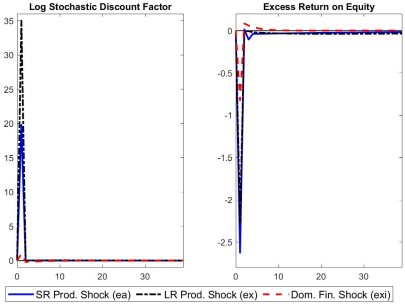


(n) SONOMA

Returns with LR Shock
Back



(o) SONOMA Closed



(p) SONOMA

Measuring R^{E*} Back

- R^{E*} is return on net external equity position (NEE)
- Compute NEE with gross IIP positions (Lane and Milesi-Feretti)
- Return to a country's NEE portfolio is

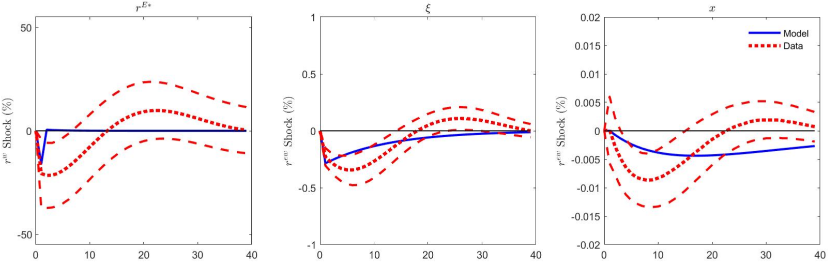
$$A_{t-1} R_t^{E,world} - L_{t-1} R_t^{E,country}$$

- Divide and multiply by $NEE_{t-1} \equiv A_{t-1} - L_{t-1}$ to find

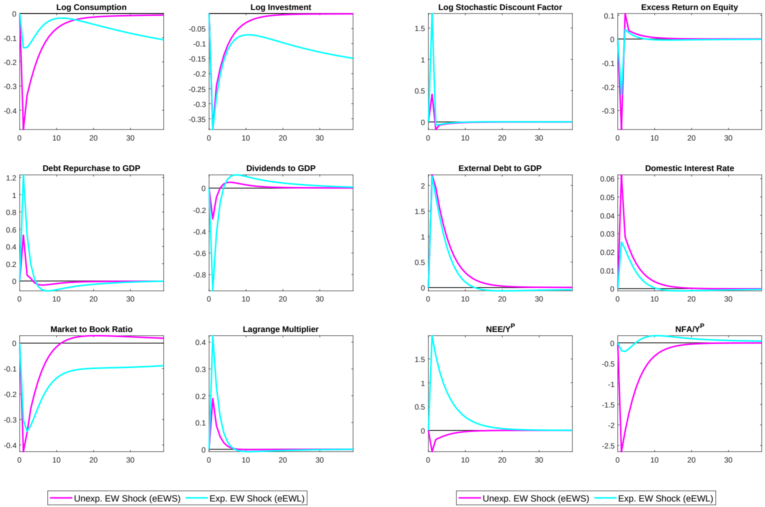
$$\left(\underbrace{\frac{A_{t-1}}{A_{t-1} - L_{t-1}} R_t^{E,world} - \frac{L_{t-1}}{A_{t-1} - L_{t-1}} R_t^{E,country}}_{R_t^{E*}} \right) NEE_{t-1}$$

Model versus VAR: Fundamental Shocks ▸ Back

$$Y_t = \begin{bmatrix} r_t^{w,avg} & r_t^{EW,avg} & \epsilon_t^{avg,ews} & \xi_t^{avg} & x_t^{avg} \end{bmatrix}$$



External Equity Shock Responses ▸ Back



Model versus VAR: Response of External Positions

Back

$$Y_t = \begin{bmatrix} r_t^{w,avg} & r_t^{EW,avg} & \epsilon_t^{avg,ews} & \xi_t^{avg} & x_t^{avg} & ZZ_t \end{bmatrix}$$

$$ZZ_t \in \{NEE_t, NED_t\}.$$