Asset Prices, Credit, and Consumption with Diagnostic Expectations

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What we do

empirically, we document that :

1. credit growth positively co-moves with contemporaneous asset returns
2. lagged credit growth negatively co-moves with asset returns

a DSGE model with financial frictions à la Gertler & Karadi (2011)

- Rational Expectations: fails to match the empirically estimated sign on regression coefficients
- Diagnostic Expectations (DE): can generate the empirically estimated sign + reversal

mechanism/ novel insight

- agents extrapolate tightening of financial constraints to the future
- this perceived tightening reduces value of capital,
- hence, DE can generate the correct sign as in empirical estimations

Novel mechanism

a tightening of collateral constraint

- increases the value of existing capital with rational expectations,

- but with diagnostic expectations,

    1. agents extrapolate a tightening shock to perceive persistently lower cash flows
    2. if extrapolation is severe enough, can lower equity return

Related literature

Macroeconomics with financial frictions

- Bernanke & Gertler (1989); Holmstrom & Tirole (1997); Kiyotaki & Moore (1997, 2019); Fostel & Geanakoplos (2008); Adrian & Shin (2010); Gertler & Kiyotaki (2010); Brunnermeier & Sannikov (2014); Shi (2015) ...

Leverage as pricing factor

- Gromb & Vayanos (2002); Brunnermeier & Pedersen (2009); He & Krishnamurthy (2013)
- Adrian & Boyarchenko (2013); Adrian, Etula, & Muir (2013); Adrian, Moench, & Shin (2014); Muir (2017), ...

Behavioral finance models

- Shiller (2005); Barberis (2011); Greenwood & Shleifer (2014); Barberis, Greenwood, Jin, & Shleifer (2015); Hirshleifer, Li, & Yu (2015); Bordalo, Gennaioli, & Shelifer (2018); Bordalo, Gennaioli, La Porta, & Shleifer (2019); Jin & Sui (2019); Adam & Nagel (2022); Nagel & Xu (2022); Maxted (2023); Krishnamurthy & Li (2023), Wachter & Kahana (2023); ...

Roadmap

1. Empirical Results
2. Gertler & Karadi Model of Financial Frictions
3. Subjective Expectations
4. Calibration & Simulation
5. Conclusion

1. Empirics: Data and Results

Data: annual 1950–2015
16 advanced economies

Jordà, Schularick & Taylor (2017)
www.macrohistory.net/data/
total equity returns, real consumption, total loans, real gdp

$$\text{Cred} = \log(\text{real total loans})$$
$$\text{Cons} = \log(\text{real consumption})$$
$$\text{ETR} = \log(\text{real total equity returns})$$

16 advanced economies in our sample:
Australia, Belgium, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, U.K., and U.S.

Asset Returns Regressions

$$
\begin{aligned}
\mathrm{ETR}_{i,t+k} - \mathrm{ETR}_{i,t} = \alpha_{i,k} &+ \beta_k \underbrace{\left(\mathrm{Cons}_{i,t+k} - \mathrm{Cons}_{i,t}\right)}_{\text{Contemp. Consm. Growth}} \\
&+ \gamma_k \underbrace{\left(\mathrm{Cred}_{i,t+k} - \mathrm{Cred}_{i,t}\right)}_{\text{Contemp. Credit Growth}} \\
&+ \zeta_k \underbrace{\left(\mathrm{Cred}_{i,t} - \mathrm{Cred}_{i,t-k}\right)}_{\text{Lagged Credit Growth}} \\
&+ \epsilon_{i,t+k}
\end{aligned}
$$

for $k \geq 1$.

Asset Returns Regressions: Consumption and Credit Factors

	k=1
β_k	0.637
Cons. Growth	(1.81)
γ_k	0.930***
Credit Growth	(5.85)
ζ_k	-0.772***
Lag Credit Growth	(-5.40)
_cons	3.358**
	(3.22)
R^2	0.056
N	1018

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions

	k=1	k=2	k=3	k=4	k=5
β_k	0.637				0.272
Cons. Growth	(1.81)				(0.96)
γ_k	0.930***				0.365**
Credit Growth	(5.85)				(3.29)
ζ_k	-0.772***				-0.657***
Lag Credit Growth	(-5.40)				(-7.82)
_cons	3.358**				30.28***
	(3.22)				(8.56)
R^2	0.056				0.081
N	1018				887

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions

	k=1	k=2	k=3	k=4	k=5
β_k	0.637	0.607	0.458	0.419	0.272
Cons. Growth	(1.81)	(1.89)	(1.51)	(1.43)	(0.96)
γ_k	0.930***	0.927***	0.652***	0.442***	0.365**
Credit Growth	(5.85)	(6.82)	(5.31)	(3.82)	(3.29)
ζ_k	-0.772***	-1.062***	-0.944***	-0.789***	-0.657***
Lag Credit Growth	(-5.40)	(-10.00)	(-10.17)	(-9.00)	(-7.82)
_cons	3.358**	10.14***	18.05***	24.87***	30.28***
	(3.22)	(5.93)	(7.82)	(8.41)	(8.56)
R^2	0.056	0.127	0.125	0.102	0.081
N	1018	985	952	919	887

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

2. A General Equilibrium Model of Financial Frictions à la Gertler & Karadi (2011)

Gertler & Karadi (2011)

1. monetary DSGE model (Christiano Eichenbaum Evans 2005, Smets Wouters 2007)
2. $+$ financial intermederies that transfer funds between hhs and non-financial firms
3. $-$ nominal rigidities, no role for monetary policy

4 Agents

1. households: consume (habits), save in deposits, and own banks
2. competitive non-financial goods producers produce using capital and labor
3. competitive capital producers, net investment subject to adjustment costs
4. financial intermediaries/banks: lend long-term to producers, take deposits from hhs

Overview

3 exogenous shock processes

1. capital quality shock (wealth shock)
2. productivity shock
3. credit policy shock

3. Subjective Expectations

for some random normally distributed variable x_t,

Rational expectations (RE):

$$\tilde{\mathbb{E}}_t[x_{t+1}] = \mathbb{E}_t[x_{t+1}]$$

Diagnostic Expectations (DE):

$$\tilde{\mathbb{E}}_t[x_{t+1}] = \mathbb{E}_t^{\theta}[x_{t+1}] \equiv \mathbb{E}_t[x_{t+1}] + \theta\left(\mathbb{E}_t[x_{t+1}] - \mathbb{E}_{t-1}[x_{t+1}]\right); \ \theta > 0$$

Bordalo, Gennaioli,& Shleifer (2018), L'Huillier, Singh,& Yoo (forthcoming)

Formula for Univariate Case and Example

- Diagnostic expectation is:

$$\mathbb{E}_t^{\theta}[x_{t+1}] = \mathbb{E}_t[x_{t+1}] + \theta(\mathbb{E}_t[x_{t+1}] - \mathbb{E}_{t-1}[x_{t+1}])$$

(Bordalo, Gennaioli & Shleifer 2018), henceforth BGS)

- We have that:

$\mathbb{E}_t[x_{t+1}] = \rho_x x_t$ and $\mathbb{E}_{t-1}[x_{t+1}] = \rho_x^2 x_{t-1}$

- So:

$$\mathbb{E}_t^{\theta}[x_{t+1}] = \rho_x x_t + \theta(\rho_x x_t - \rho_x^2 x_{t-1}) = \rho_x x_t + \theta \rho_x \varepsilon_t$$

$\implies$ extrapolation

4. Calibration & Simulation

Calibration: Parameters from Gertler & Karadi (2011)

Households		
β	0.990	Discount rate
h	0.815	Habit parameter
χ	3.409	Relative utility weight of labor
φ	0.276	Inverse Frisch elasticity of labor supply
Financial intermediaries		
λ	0.381	Fraction of capital that can be diverted
ω	0.002	Proportional transfer to the entering bankers
Ω	0.972	Survival rate of the bankers
Intermediate good firms		
α	0.330	Effective capital share
U	1.000	Steady state capital utilization rate
$\delta(U)$	0.025	Steady state depreciation rate
ζ	7.200	Elasticity of marginal depreciation with respect to utilization rate
Capital Producing firms		
η_i	1.728	Inverse elasticity of net investment to the price of capital
Government		
$\frac{G}{Y}$	0.200	Steady state proportion of government expenditures

Calibration of Shocks + Diagnosticity

We set standard deviation of shocks to 0.05

Persistence of Shocks:

- A_t TFP: 0.95 (GK'11);
- ξ_t capital quality: 0.66 (GK'11);
- ψ_t shocks to credit policy: 0.75 (we picked a number)

We set diagnosticity parameter $\theta = 1$
Bordalo, Gennaioli, & Shleifer (2018); Bordalo, Gennaioli, Ma, & Shleifer (2018); L'Huillier, Singh,& Yoo (forthcoming)

Simulation

- first-order approximation around the steady state
- stochastic simulation for 10,000 draws (drop first 1,000)
- credit $=$ market value of capital $-$ intermediary net worth
- transform quarterly data to annual
- run asset return regressions as in the data

Asset Returns Regressions

$$
\begin{aligned}
\mathsf{ETR}_{i,t+k} - \mathsf{ETR}_{i,t} = \alpha_{i,k} &+ \beta_k \underbrace{(\mathsf{Cons}_{i,t+k} - \mathsf{Cons}_{i,t})}_{\text{Contemp. Consm. Growth}} \\
&+ \gamma_k \underbrace{(\mathsf{Cred}_{i,t+k} - \mathsf{Cred}_{i,t})}_{\text{Contemp. Credit Growth}} \\
&+ \zeta_k \underbrace{(\mathsf{Cred}_{i,t} - \mathsf{Cred}_{i,t-k})}_{\text{Lagged Credit Growth}} \\
&+ \epsilon_{i,t+k}
\end{aligned}
$$

for $k \geq 1$.

Asset Returns Regressions: Consumption and Credit Factors

$k = 1$	Data	RE	DE
Cons. Growth	0.637	0.209	0.302**
	(1.81)	(1.13)	(2.80)
Credit Growth	0.930***	-0.615***	0.524***
	(5.85)	(-11.43)	(21.11)
Lag Credit Growth	-0.772***	0.292***	-0.453***
	(-5.40)	(5.84)	(-26.39)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Consumption and Credit Factors

$k = 2$	Data	RE	DE
Cons. Growth	0.607	2.162***	-0.366***
	(1.89)	(15.61)	(-3.56)
Credit Growth	0.927***	-0.721***	0.481***
	(6.82)	(-21.46)	(17.04)
Lag Credit Growth	-1.062***	0.0566*	-0.306***
	(-10.00)	(2.16)	(-23.49)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Consumption and Credit Factors

$k = 3$	Data	RE	DE
Cons. Growth	0.458	2.958***	0.0693
	(1.51)	(22.89)	(0.59)
Credit Growth	0.652***	-0.761***	0.283***
	(5.31)	(-25.57)	(9.08)
Lag Credit Growth	-0.944***	-0.0892***	-0.203***
	(-10.17)	(-4.55)	(-17.13)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Consumption and Credit Factors

$k = 4$	Data	RE	DE
Cons. Growth	0.419	3.572***	0.432***
	(1.43)	(27.51)	(3.39)
Credit Growth	0.442***	-0.848***	0.167***
	(3.82)	(-28.41)	(5.12)
Lag Credit Growth	-0.789***	-0.171***	-0.176***
	(-9.00)	(-9.85)	(-15.92)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Consumption and Credit Factors

$k = 5$	Data	RE	DE
Cons. Growth	0.272	4.039***	0.714***
	(0.96)	(29.74)	(5.19)
Credit Growth	0.365**	-0.937***	0.0880*
	(3.29)	(-29.62)	(2.54)
Lag Credit Growth	-0.657***	-0.236***	-0.178***
	(-7.82)	(-14.25)	(-16.44)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Conclusion

Using cross-country asset returns data, we find

- Credit is an important pricing factor for aggregate equity returns

Theoretically, and quantitatively

- A collateral constraints model with rational expectations fails to deliver the empirical asset pricing factors
- instead, with diagnostic expectations, the model based pricing factors resemble empirical factors.

Asset Returns Regressions: Consumption Based

	k=1
β_k	1.208***
Cons. Growth	(4.21)
γ_k	
Credit Growth	
ζ_k	
Lag Credit Growth	
_cons	2.893**
	(2.98)
R^2	0.017
N	1034

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Consumption Factor

	k=1	k=2	k=3	k=4	k=5
β_k	1.208***	1.541***	1.380***	1.174***	0.980***
Cons. Growth	(4.21)	(6.19)	(6.07)	(5.48)	(4.86)
γ_k					
Credit Growth					
ζ_k					
Lag Credit Growth					
_cons	2.893**	4.141**	7.266***	11.13***	15.26***
	(2.98)	(2.65)	(3.57)	(4.47)	(5.32)
R^2	0.017	0.037	0.036	0.030	0.024
N	1034	1017	1000	983	967

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Households

$$\max \tilde{\mathbb{E}}_t \; \Sigma_{i=0}^{\infty} \; \beta^i \left[\ln \left(C_{t+i} - hC_{t+i-1} \right) - \frac{\chi}{1+\varphi} L_{t+i}^{1+\varphi} \right]$$

subject to

$$C_t = W_t L_t + \Pi_t + T_t + R_t B_t - B_{t+1}$$

where B_{t+1} is the total qty of short term debt acquired by hh,
Π_t net payouts to hh from ownership of firms and banks,
T_t are lumpsum taxes.

Let $M_{t,t+1}$ denote the SDF of the household b/w t and $t+1$.

Bank Balance Sheet

$$Q_t S_{jt} = N_{jt} + B_{jt+1}$$

where N_{jt} is the net worth of banker j at end of period t,
B_{jt+1} are the deposits the bank obtains from households,
S_{jt} is the qty of financial claims on non-financial firms held by the banker,
Q_t is the relative price of each claim.

Net worth evolves as

$$N_{jt+1} = (R_{kt+1} - R_{t+1})Q_t S_{jt} + R_{t+1} N_{jt}$$

Risk-adjusted premium positive with limits on banks' ability to obtain funds:

$$\tilde{\mathbb{E}}_t \ \beta^i M_{t,t+1+i}(R_{kt+1+i} - R_{t+1+i}) \geq 0$$

Bank maximizes expected terminal wealth:

$$V_{jt} = \max \tilde{\mathbb{E}}_t \Sigma_{i=0}^{\infty} (1-\Omega)\Omega^i \beta^{i+1} M_{t,t+1+i} N_{jt+1+i}$$

subject to moral hazard:

- at beginning of period, bank can divert λ of available funds
- depositors can force bank into bankruptcy and recover $1-\lambda$ of assets

$$V_{jt} \geq \lambda Q_t S_{jt}$$

where $V_{jt} = \nu_t \cdot Q_t S_{jt} + \eta_t N_{jt}$ with

$$\nu_t = \tilde{\mathbb{E}}_t \{(1-\Omega)\beta M_{t,t+1}(R_{kt+1} - R_{t+1}) + \beta M_{t,t+1} \Omega x_{t,t+1} \nu_{t+1}\}$$
$$\eta_t = \tilde{\mathbb{E}}_t \{(1-\Omega) + \beta M_{t,t+1} \Omega z_{t,t+1} \eta_{t+1}\}$$

where $x_{t,t+1} \equiv Q_{t+1} S_{jt+1} / Q_t S_{jt}$ is gross growth rate in assets,
$z_{t,t+1} \equiv N_{jt+1}/N_{jt}$ is gross growth rate of net worth.

When the constraint binds

With binding constraint: $\nu_t \cdot Q_t S_{jt} + \eta_t N_{jt} = \lambda Q_t S_{jt}$:

$$Q_t S_{jt} = \frac{\eta_t}{\lambda - \nu_t} N_{jt} \equiv \phi_t N_{jt}$$

where ϕ_t is the private leverage ratio.

Can aggregate to get:

$$Q_t S_t = \phi_t N_t$$

Credit policy

$$S_t = S_{pt} + S_{gt}$$

where private intermediated assets S_{pt} , and government intermediated assets S_{gt}.

Govt can intermediate funds to producers with efficiency cost of τ per unit supplied. Assume Govt intermediation is not balance sheet constrained. Suppose

$$Q_t S_{gt} = \psi_t Q_t S_t$$

govt issues bonds B_{gt} to fund this intermediation. With Credit policy,

$$Q_t S_t = \phi_{ct} N_t$$

where $\phi_{ct} = \frac{1}{1-\psi_t}\phi_t$ is leverage ratio for total intermediated funds.

goods' producers

at end of period t, they acquire capital K_{t+1} to produce in the following period.
Obtain funds from banks by selling claims:

$$Q_t K_{t+1} = Q_t S_t$$

Produce using

$$Y_t = A_t \left(U_t \xi_t K_t \right)^{\alpha} L_t^{1-\alpha}$$

where ξ_t is capital quality shock. Firm chooses utilization rate U_t subject to cost $\delta(U_t)$, and labor demand.

capital producers

buy capital at end of period, repair depreciated capital, and build new capital.
net investment subject to adjustment costs

resource constraints

$$Y_t = C_t + I_t + f(I_{nt}) + G + \tau\psi_t Q_t K_{t+1}$$

where net capital created is:

$$I_{nt} \equiv I_t - \delta(U_t)\xi_t K_t$$

law of motion of capital:

$$K_{t+1} = \xi_t K_t + I_{nt}$$

Govt budget:

$$G + \tau\psi_t Q_t K_{t+1} = T_t + (R_{kt} - R_t)B_{gt-1}$$

credit policy

$$\psi_t = \psi + \nu\tilde{\mathbb{E}}_t \left[(\log R_{kt+1} - \log R_{t+1}) - \underbrace{(\log R_k - \log R)}_{\text{steady state premium}} \right] ; \nu > 0$$

Diagnostic Expectations

- Consider the process

$$x_t = \rho_x x_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_\varepsilon^2)$$

- Diagnostic pdf is defined as

$$f_t^\theta(x_{t+1}) = \underbrace{f(x_{t+1}|G_t)}_{true\ \ pdf} \cdot \underbrace{\left[\frac{f(x_{t+1}|G_t)}{f(x_{t+1}|-G_t)}\right]^\theta}_{distortion} \cdot C, \quad \theta > 0$$

- Information sets:
  - G_t: current state t
  - $-G_t$: reference state, here $t-1$.

  θ: degree of diagnosticity

Asset Returns Regressions: Consumption Factor

β_k	k=1	k=2	k=3	k=4	k=5
Data	1.208***				
	(4.21)				
RE	-0.620***				
	(-3.62)				
DE	1.126***				
	(15.05)				

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Consumption Factor

β_k	k=1	k=2	k=3	k=4	k=5
Data	1.208***	1.541***	1.380***	1.174***	0.980***
	(4.21)	(6.19)	(6.07)	(5.48)	(4.86)
RE	-0.620***				0.868***
	(-3.62)				(10.61)
DE	1.126***				1.176***
	(15.05)				(27.14)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Consumption Factor

β_k	k=1	k=2	k=3	k=4	k=5
Data	1.208***	1.541***	1.380***	1.174***	0.980***
	(4.21)	(6.19)	(6.07)	(5.48)	(4.86)
RE	-0.620***	0.205	0.487***	0.709***	0.868***
	(-3.62)	(1.77)	(5.33)	(8.26)	(10.61)
DE	1.126***	1.020***	1.045***	1.110***	1.176***
	(15.05)	(19.51)	(23.05)	(25.56)	(27.14)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Credit Factor

γ_k	k=1	k=2	k=3	k=4	k=5
Data	0.632***				
	(5.50)				
RE	-0.417***				
	(-10.47)				
DE	0.488***				
	(28.60)				

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Asset Returns Regressions: Credit Factor

γ_k	k=1	k=2	k=3	k=4	k=5
Data	0.632***	0.635***	0.545***	0.483***	0.457***
	(5.50)	(6.60)	(6.33)	(5.98)	(6.01)
RE	-0.417***	-0.390***	-0.258***	-0.153***	-0.0717***
	(-10.47)	(-15.27)	(-12.09)	(-7.65)	(-3.64)
DE	0.488***	0.310***	0.272***	0.275***	0.284***
	(28.60)	(22.52)	(22.74)	(24.33)	(25.46)

t statistics in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$