A Macroeconomic Model of Equities and Real, Nominal, and Defaultable Debt

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University of California, Irvine

Bank of Canada/Federal Reserve Bank of San Francisco
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San Francisco
November 5, 2015
Motivation

Goal: Show that a simple macroeconomic model (with Epstein-Zin preferences) is consistent with a wide variety of asset pricing facts

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- long-term bond premium puzzle (nominal and real)
- credit spread puzzle
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- financial intermediaries: Adrian-Etula-Muir (2013)
Implications for Finance:

- unifying explanation for asset pricing puzzles
- structural model of asset prices (provides intuition, robustness to breaks and policy interventions)
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Two key ingredients:
- Epstein-Zin preferences
- nominal rigidities
Households

Period utility function:

\[ u(c_t, l_t) \equiv \log c_t - \eta \frac{l_t^{1+\chi}}{1 + \chi} \]

- additive separability between \( c \) and \( l \)
- SDF comparable to finance literature
- log preferences for balanced growth, simplicity

Flow budget constraint:

\[ a_{t+1} = e^{it}a_t + w_t l_t + d_t - c_t \]

Calibration: (IES = 1), \( \chi = 3, \ l = 1 \) (\( \eta = .54 \))
Generalized Recursive Preferences

Household chooses state-contingent \( \{(c_t, l_t)\} \) to maximize

\[
V(a_t; \theta_t) = \max_{(c_t, l_t)} u(c_t, l_t) - \beta \alpha^{-1} \log \left[ E_t \exp(-\alpha V(a_{t+1}; \theta_{t+1})) \right]
\]

Calibration: \( \beta = .992, \) RRA \( (R^c) = 60 \) \( (\alpha = 59.15) \)
Firms

Firms are very standard:

- continuum of monopolistic firms (gross markup $\lambda$)
- Calvo price setting (probability $1 - \xi$)
- Cobb-Douglas production functions, $y_t(f) = A_t k^{1-\theta} l_t(f)^\theta$
- fixed firm-specific capital stocks $k$

Random walk technology: $\log A_t = \log A_{t-1} + \varepsilon_t$

- simplicity
- comparability to finance literature
- helps match equity premium

Calibration: $\lambda = 1.1, \xi = 0.8, \theta = 0.6, \sigma_A = .007, (\rho_A = 1), \frac{k}{4Y} = 2.5$
Fiscal and Monetary Policy

No government purchases or investment:

\[ Y_t = C_t \]

Taylor-type monetary policy rule:

\[ i_t = r + \pi_t + \phi_{\pi}(\pi_t - \bar{\pi}) + \phi_{y}(y_t - \bar{y}_t) \]

“Output gap” \((y_t - \bar{y}_t)\) defined relative to moving average:

\[ \bar{y}_t \equiv \rho_{\bar{y}}y_{t-1} + (1 - \rho_{\bar{y}})y_t \]

Rule has no inertia:
- simplicity

Calibration: \(\phi_{\pi} = 0.5, \phi_{y} = 0.75, \bar{\pi} = .008, \rho_{\bar{y}} = 0.9\)
Solution Method

Write equations of the model in recursive form
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Divide nonstationary variables ($Y_t$, $C_t$, $w_t$, etc.) by $A_t$
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- second-order: risk premia are constant
- third-order: time-varying risk premia
- higher-order: more accurate over larger region
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Model has 2 state variables \((\bar{y}_t, \Delta_t)\), one shock \((\varepsilon_t)\)
Impulse Responses

Consumption $C_t$

percent

0.0
0.2
0.4
0.6
0.8
1.0

0 10 20 30 40 50
Impulse Responses

Inflation $\pi_t$

ann. pct.
Impulse Responses

Short-term nominal interest rate $i_t$
Impulse Responses

Short–term real interest rate $r_t$
Equity: Levered Consumption Claim

Equity price

\[ p_t^e = E_{t}m_{t+1}(C_{t+1}^{\nu} + p_{t+1}^e) \]

where \( \nu \) is degree of leverage
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Calibration: \( \nu = 3 \)
Table 2: Equity Premium

In the data: 3–6.5 percent per year (e.g., Campbell, 1999, Fama-French, 2002)
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Equity Premium

Equity premium $\psi_t^e$

ann. bp

0 10 20 30 40 50

-80 -60 -40 -20 0
Real Government Debt

Real $n$-period zero-coupon bond price:

$$p_t^{(n)} = E_t m_{t+1} p_{t+1}^{(n-1)},$$
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<sup>a</sup> Gürkaynak, Sack, and Wright (2010) online dataset
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# Real Yield Curve

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Supply shocks make nominal long-term bonds risky: inflation risk.
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<td>6.29</td>
<td>6.54</td>
<td>6.81</td>
<td>1.28</td>
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<tr>
<td>US Treasuries, 1990–2007$^a$</td>
<td>4.56</td>
<td>4.84</td>
<td>5.06</td>
<td>5.41</td>
<td>5.68</td>
<td>5.98</td>
<td>1.42</td>
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<td>UK gilts, 1970–2014$^b$</td>
<td>7.07</td>
<td>7.25</td>
<td>7.41</td>
<td>7.65</td>
<td>7.84</td>
<td>8.02</td>
<td>0.95</td>
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<td>UK gilts, 1990–2007$^b$</td>
<td>6.20</td>
<td>6.29</td>
<td>6.38</td>
<td>6.47</td>
<td>6.50</td>
<td>6.48</td>
<td>0.28</td>
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<td>macroeconomic model</td>
<td>5.35</td>
<td>5.59</td>
<td>5.80</td>
<td>6.09</td>
<td>6.27</td>
<td>6.44</td>
<td>1.09</td>
</tr>
</tbody>
</table>

$^a$Gürkaynak, Sack, and Wright (2007) online dataset

$^b$Bank of England web site

Supply shocks make nominal long-term bonds risky: inflation risk
Nominal Term Premium

Nominal term premium $\psi_t^{(40)}$

ann. bp

0 10 20 30 40 50

-10

-8

-6

-4

-2

0
Defaultable Debt

Default-free depreciating nominal consol:

\[ p_t^c = E_t m_{t+1} e^{-\pi_t} (1 + \delta p_{t+1}) \]
Defaultable Debt

Default-free depreciating nominal consol:

\[ p^c_t = E_t m_{t+1} e^{-\pi_{t+1}} (1 + \delta p^c_{t+1}) \]

Yield to maturity:

\[ i^c_t = \log \left( \frac{1}{p^c_t + \delta} \right) \]
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Nominal consol with default:

\[ p_t^d = E_t m_{t+1} e^{-\pi_{t+1}} \left[ (1 - 1_{t+1}^d)(1 + \delta p_{t+1}^d) + 1_{t+1}^d \omega_{t+1} p_t^d \right] \]
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\]

The credit spread is \(i_t^d - i_t^c\)
### Table 5: Credit Spread

<table>
<thead>
<tr>
<th>average ann. default prob.</th>
<th>cyclicality of default prob.</th>
<th>average recovery rate</th>
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If default isn’t cyclical, then it’s not risky
Default Rate is Countercyclical

A. Default rates and credit spreads

Figure 1. Default rates, credit spreads, and recovery rates over the business cycle.

Panel A plots the Moody's annual corporate default rates during 1920 to 2008 and the monthly Baa-Aaa credit spreads during 1920/01 to 2009/02. Panel B plots the average recovery rates during 1982 to 2008. The “Long-Term Mean” recovery rate is 41.4%, based on Moody's data. Shaded areas are NBER-dated recessions. For annual data, any calendar year with at least 5 months being in a recession as defined by NBER is treated as a recession year.

The dashed line in Panel A plots the annual default rates over 1920 to 2008. There are several spikes in the default rates, each coinciding with an NBER recession. The solid line plots the monthly Baa-Aaa credit spreads from January 1920 to February 2009. The spreads shoot up in most recessions, most visibly during the Great Depression, the savings and loan crisis in the early 1980s, and the recent financial crisis in 2008. However, they do not always move in lock-step with default rates (the correlation at an annual frequency is 0.65), which suggests that other factors, such as recovery rates and risk premia, also affect the movements in spreads.

Next, business cycle variation in the recovery rates is evident in this figure. The recovery rates are calculated as the percentage of defaulted loans that are recovered. A high recovery rate means that banks are able to recover a large portion of the loan value, which reduces the financial burden on the borrower.

source: Chen (2010)
Recovery Rate is Procyclical

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Discussion

1. Endogenous conditional heteroskedasticity
2. IES \leq 1 vs. IES > 1
3. Volatility shocks
4. Monetary and fiscal policy shocks
5. Financial accelerator
Rudebusch and Swanson (2012) consider similar model with:

- technology shock
- government purchases shock
- monetary policy shock
Monetary and Fiscal Policy Shocks

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All three shocks help the model fit macroeconomic variables
Monetary and Fiscal Policy Shocks

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- technology shock
- government purchases shock
- monetary policy shock

All three shocks help the model fit macroeconomic variables

But technology shock is most important (by far) for fitting asset prices:
- technology shock is more persistent
- technology shock makes nominal assets risky
No Financial Accelerator

With model-implied stochastic discount factor $m_{t+1}$, we can price any asset.

Economy affects $m_{t+1}$ $\Rightarrow$ economy affects asset prices.

However, asset prices have no effect on economy.
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To generate feedback, want financial intermediaries whose net worth depends on assets.

...but not in this paper.
Conclusions

1. The standard textbook New Keynesian model (with Epstein-Zin preferences) is consistent with a wide variety of asset pricing facts/puzzles

2. Unifies asset pricing puzzles into a single puzzle—Why does risk aversion in macro models need to be so high? (Literature provides good answers to this question)

3. Provides a structural framework for intuition about risk premia

4. Suggests a way to model feedback from risk premia to macroeconomy