How the Wealth Was Won: Factor Shares as Market Fundamentals

Daniel L. Greenwald, Martin Lettau, and Sydney C. Ludvigson

MIT Sloan, UC Berkeley Haas, NYU
Sharp Rise in Equity Values in Post-War Period

- Stock market risen sharply in post-war era, driven mostly *last 30 years*.

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- Upshot? Widening chasm between stock market and broader economy.

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Stock Market v.s Broader Economy

- **ME**: Total value of market equity of the NFCS.

**Notes:**
Stock Market v.s Broader Economy

- ME relative to 3 different measures of agg. economic activity is at or near post-war high.

Stock Market v.s Broader Economy

- Notably, ME/E not near post-war high.

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*What is responsible for sharply rising equity values over post-war period?*
Addressing question *empirically* requires not just data, but a model of how investors value equity.
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  - **Shareholder payout**: Changes in how economic growth expected to be linked to cash payments to shareholders
  - **Discount rates**: Changes in how those payments are discounted back to present (expected path of future short rates, risk premia)
  - **Economic growth**: Could still be key to market’s rise over post-war period, even if last 30 years have been a striking exception.
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- Allow data to speak as much as possible.
  - Estimate **Flexible parametric** model of how equities are priced
  - Allows for influence from several **Mutually uncorrelated latent factors**
  - Infer what values latent factors must have taken over sample to explain the data.
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Identification of mutually uncorrelated components + loglinear model => precisely decompose 100% of market’s observed growth into distinct component sources in the model.
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- Estimate *full dynamic model* that incorporates time variation in:

  - Expect. growth of rents generated from productive activity
  - How rents are apportioned between shareholders and labor
  - Equity risk premium
  - Expected future path of short rates in near- and long-term

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- Not economic growth, short-term interest rates, or risk premia. Instead, single most important factor is...

Factors share shock that reallocates rewards of production without affecting size of rewards. FS shocks persist. reallocated rents to shareholders away from labor. Realization of these shocks:

2. Interest rates explain 11% since 1989, 2.6% over full sample.
3. Risk Premia explain 11% since 1989, 11% over full sample.

Economic growth contributed 23% since 1989, and 50% over full sample. From 1952-1988, economic growth accounted for 92%, but that 37 year period created less than half wealth generated in 29 years since 1989.
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Model & estimates \( \Rightarrow \) common practice of averaging of returns, dividend, payout data over post-war sample to estimate ERP overstates the true risk premium by \( \approx 50\% \).
Related Literature

- **Drivers of real level of stock market**: Few studies. Lettau & Ludvigson ’13, and Greenwald, Lettau, Ludvigson (GLL) ’14.

- This paper replaces GLL, differs substantively from both. Neither study did formal estimation of asset pricing model. GLL model is less flexible, less general.

- **Heterogeneous agent, limited participation** perspective adds **realism**: just 52% households own equity in 2016 (any amt, any form); most own very little: top 5% of stock wealth dist. owns 76% of market and earns small fraction of income in form of labor compensation.
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- **Decline in labor share**: Karabarounis, Neiman ’13, Lansing ’13.

- **Negative correlation returns human wealth and stock market**: Lustig, Van Nieuwerburgh ’08; Lettau, Ludvigson ’09; Chen et. al., ’14.
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- Aggregate output:
  \[ Y_t = A_t N_t^\alpha K_t^{1-\alpha} \]
  - \( A_t \) mean zero TFP; \( N_t \) labor endowment (hours × prod. factor).
- Workers inelastically supply labor; hours fixed, normalized to unity.
- \( K_t \) grows deterministically at gross rate \( G \equiv 1 + g \Rightarrow K_t = K_0 G^t \).
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  - Labor productivity grows: \(N_t = G^t\).
- Fraction \(\tau_t\) of \(Y_t\) devoted to taxes & interest & other. Earnings \(E_t\) (after-tax profits):
  \[ E_t \equiv S_t Z_t Y_t \]
  \(Z_t \equiv 1 - \tau_t; S_t \equiv AT\) profit share of AT profit+labor comp.
- Labor compensation
  \[ W_t N_t \equiv (1 - S_t) Z_t Y_t, \]
- \(E_t / Y_t\) “earnings share” and \((W_t N_t) / Y_t\) “labor share”.

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How the Wealth Was Won
Factors Share Shock

- Variable $S_t$ modeled as exogenous factors share shock.
- Captures changes may occur, for any reason, in allocation of rewards between firms and workers under imperfect competition.
- Possible sources include changes in:
  1. **Industry concentration** structure alters labor intensivity of production
  2. **Bargaining power** of US workers (international competition, prevalence of unions, off-shoring)
  3. **Technological factors** alter substitutability of labor for capital.
The Model

- **Cash payments to shareholders** = net payout ("cashflows") differs from $E_t$ by **net new investment**.

- Firm reinvests fixed fraction $\omega Y_t$ each period $=>$

  $$C_t = E_t - \omega Y_t = (S_t Z_t - \omega) Y_t.$$  

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- Reinvestment needed to achieve long-term growth in $Y_t$ at rate $g$—simple method of allowing for retained earnings.
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- Shareholders (SH): identical pref., face identical risks $\Rightarrow$ equity priced by a **representative shareholder** consumes per-capita shareholder cons.

- In equilibrium, agg. SH consumption $= \text{agg. net payout } C_t$. 

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- In equilibrium, agg. SH consumption = agg. **net payout** *C* *t*.

- Distinguished from **representative household** who consumes p.c. aggregate consumption.
The Model: SDF

- IMRS of *shareholder* consumption is the SDF and takes the form:

\[
M_{t+1} = \beta_t \left( \frac{C_{t+1}}{C_t} \right)^{-x_t}, \quad \beta_t \equiv \exp(\delta_t) / \exp(d_t)
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- \( x_t \) drives price of risk in SDF; latent state variable affects risk premia.
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More general version SDFs Campbell, Cochrane ’99, Lettau, Wachter ’07.

Preference shifter \(x_t\) and time varying sub. time-discount factor taken as given by ind. shareholders, driven by market as whole.

\(x_t\) drives **price of risk** in SDF; latent state variable affects risk premia.

SDF reflects both preferences and beliefs \(\Rightarrow\) decrease in \(x_t\) interpreted as either a decrease in **effective risk aversion** or decrease in **pessimism**.
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M_{t+1} = \beta_t \left( \frac{C_{t+1}}{C_t} \right)^{-x_t}, \quad \beta_t \equiv \frac{\exp(\delta_t)}{\exp(d_t)}
\]

\[
\ln M_{t+1} = -1' \delta_t - d_t - x_t \Delta \ln C_{t+1}
\]

- More general version SDFs Campbell, Cochrane ’99, Lettau, Wachter ’07.

- Preference shifter \( x_t \) and time varying sub. time-discount factor taken as given by ind. shareholders, driven by market as whole.

- \( x_t \) drives price of risk in SDF; latent state variable affects risk premia.

- SDF reflects both preferences and beliefs \( \Rightarrow \) decrease in \( x_t \) interpreted as either a decrease in effective risk aversion or decrease in pessimism.

- \( x_t \) positive on average but may occasionally go negative reflecting occasional risk tolerance or confidence.
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\( x_t \) **positive on average** but may occasionally go negative reflecting occasional risk tolerance or confidence.

Time varying \( \beta_t \) essential for obtaining **stable risk-free rate** along with volatile equity premium.
Loglinear Model: Earnings

- Work with loglinear approximation solved analytically. $\ln\left(\frac{E_t}{Y_t}\right)$ could go above 1, but does so rarely (less than 1% of time in 10,000 period simulation).

- Lowercase letters denote log variables.
Loglinear Model: Earnings

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- **TFP and Output growth:**

  \[
  \Delta a_{t+1} = \varepsilon_{a,t+1}, \quad \Delta y_{t+1} = g + \varepsilon_{a,t+1}, \quad \varepsilon_{a,t+1} \sim N \text{i.i.d.} \left(0, \sigma_a^2\right).
  \]
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  \]

- **Earnings:** Since \( E_t = S_t Z_t Y_t \), earnings growth

  \[
  \Delta e_t = \Delta s_t + \Delta z_t + \Delta y_t.
  \]
Loglinear Model: Payout

- **Payout:** Let $Q_t \equiv S_t Z_t$, then $C_t = (Q_t - \omega) Y_t$, or $c_t = \ln (Q_t - \omega) + y_t$.

- Loglinearize to obtain approximate equation for log payout
  
  $$c_t = \bar{c} + \bar{\xi} (s_t + z_t) + y_t,$$

  where $\bar{\xi} = \frac{SZ}{SZ - \omega}$ and $\bar{SZ}$ is the average value of $S_t Z_t$.

- **Log payout growth** is given by
  
  $$\Delta c_t = \bar{\xi} (\Delta s_t + \Delta z_t) + \Delta y_t.$$
Data on earnings share suggests existence of both low- and higher-frequency components.

Allow for this in model. Denote $s_t = (s_{LFt}, s_{HFt})'$. 

$s_t = 1's_t$, where $1' = (1, 1)$. $s_{LF,t}$ a lower frequency component, $s_{HF,t}$ a higher frequency component.

Specify dynamics of $\Delta c_t, \Delta s_t$ as

$$\Delta c_{t+1} = \zeta 1' \Delta s_{t+1} + \zeta \Delta z_{t+1} + \Delta y_{t+1}$$

$$s_{t+1} = (I - \Phi_s)\bar{s} + \Phi_s s_t + \epsilon_{s,t+1}, \quad \epsilon_{s,t+1} \sim N(0, \Sigma_s)$$

$$\Delta s_{t+1} = -(I - \Phi_s)\bar{s}_t + \epsilon_{s,t+1}, \quad \bar{s}_t \equiv s_t - \bar{s}$$
Loglinear Model: Risk Free Rate

- **Risk-free rate of return** known with certainty at $t$:

  $$R_{f, t+1} \equiv (\mathbb{E}_t [M_{t+1}])^{-1}, \quad \beta_t \equiv \frac{\exp (\delta_t)}{\exp (d_t)}.$$

- Data on short rates suggests **low- and higher-frequency components**.
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- Data on short rates suggests **low- and higher-frequency components**.

- Model $\delta_t = 1'\delta_t$, where $\delta_t = (\delta_{LF_t}, \delta_{HF_t})'$ and

  $$ m_{t+1} \equiv \ln M_{t+1} = -1'\delta - d_t - x_t \Delta c_{t+1} $$

  $$ \delta_{t+1} = (I - \Phi_\delta)\bar{\delta} + \Phi_\delta \delta_t + \epsilon_{\delta, t+1}, \quad \epsilon_{\delta, t+1} \sim N(0, \Sigma_\delta), $$

Greenwald, Lettau, and Ludvigson

How the Wealth Was Won
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- Model $\delta_t = \mathbf{1}'\delta_t$, where $\delta_t = (\delta_{LFt}, \delta_{HFt})'$ and
  
  $$m_{t+1} \equiv \ln M_{t+1} = -\mathbf{1}'\delta_t - d_t - x_t\Delta c_{t+1},$$
  $$\delta_{t+1} = (I - \Phi_\delta)\tilde{\delta} + \Phi_\delta \delta_t + \varepsilon_{\delta,t+1}, \quad \varepsilon_{\delta,t+1} \sim N(0, \Sigma_\delta),$$

- Parameter $d_t$ is a compensating factor chosen to ensure
  
  $$r_{f,t} = -\ln \mathbb{E}_t \exp(m_{t+1}) = \mathbf{1}'\delta_t.$$
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  \]

- Parameter \( d_t \) is a compensating factor chosen to ensure
  \[
  r_{f,t} = -\ln \mathbb{E}_t \exp(m_{t+1}) = 1'\delta_t.
  \]

- Gaussian shocks, the SDF is **conditionally lognormal**:
  \[
  r_{f,t+1} = 1'\delta_t + d_t + x_t (g - \zeta \phi_z \tilde{z}_t - \zeta 1' (I - \Phi_s)\tilde{s}_t) - \frac{1}{2} x_t^2 \left( \sigma_a^2 + \zeta (1' \Sigma_s 1) \right).
  \]
  \[
  d_t = -x_t (g - \zeta \phi_z \tilde{z}_t) + \zeta x_t 1' (I - \Phi_s)\tilde{s}_t + \frac{1}{2} x_t^2 \left( \sigma_a^2 + \zeta (1' \Sigma_s 1) \right).
  \]
Price of Risk Dynamics

- **Price of risk** $x_t$ follows:

\[ x_{t+1} = (1 - \phi_x) \bar{x} + \phi_x x_t + \varepsilon_{x,t+1}, \quad \varepsilon_{x,t+1} \sim N \text{i.i.d.} \left(0, \sigma_x^2 \right). \]
Price of Risk Dynamics

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- **Latent process** $Z_t$: Data on taxes & interest filtered to infer values of latent stochastic process for $Z_t$. (Equilibrium asset returns in model depend not only on today’s $Z_t$ but also expected future path of $Z_t$.)

$$z_{t+1} = (1 - \phi_z) \bar{z} + \phi_z z_t + \epsilon_{z,t+1}, \quad \epsilon_{z,t+1} \sim N \text{i.i.d.} \left(0, \sigma_z^2\right).$$
**Loglinear Model: Equilibrium Stock Market Values**

- **Equity return**: Let $P_t$ denote total market equity, with $C_t$ equity payout, return on equity is
  \[ R_{t+1} = \frac{P_{t+1} + C_{t+1}}{P_t}. \]

- $pc_t \equiv \ln \left( \frac{P_t}{C_t} \right)$. The log return obeys the following approximate identity:
  \[ r_{t+1} = \kappa_0 + \kappa_1 pc_{t+1} - pc_t + \Delta c_{t+1}, \]
  where $\kappa_1 = \exp(\overline{pc}) / (1 + \exp(\overline{pc})), \text{ and } \kappa_0 = \exp(\overline{pc}) + 1 - \kappa_1 \overline{pc}.$
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where $\kappa_1 = \exp (\bar{pc}) / (1 + \exp (\bar{pc}))$, and $\kappa_0 = \exp (\bar{pc}) + 1 - \kappa_1 \bar{pc}$.

- The first-order-condition for optimal shareholder consumption:

$$\frac{P_t}{C_t} = E_t \exp \left[ m_{t+1} + \Delta c_{t+1} + \ln \left( \frac{P_{t+1}}{C_{t+1}} + 1 \right) \right].$$

- **Conjecture and verify** a solution takes form:

$$pc_t = A_0 + A_s \tilde{s}_t + A_r \tilde{\delta}_t + A_x \tilde{x}_t + A_z \tilde{z}_t.$$
Loglinear Model Solution

\[ pc_t = A_0 + A'_s \tilde{s}_t + A'_r \tilde{\delta}_t + A_x \tilde{x}_t + A_z \tilde{z}_t \]

\[ A'_s = -\xi 1' (I - \Phi_s) (I - \kappa_1 \Phi_s)^{-1} \]
\[ A'_x = -\left[ \left( \frac{\xi^2}{\delta} \left( 1' \Sigma_s 1 + \sigma_z^2 \right) + \sigma_g^2 \right) + \xi \kappa_1 (A'_s \Sigma_s 1) \right] (1 - \kappa_1 \phi_x)^{-1} \]
\[ A'_\delta = -1' (I - \kappa_1 \Phi_\delta)^{-1} \]
\[ A_z = -\xi (1 - \phi_z)(1 - \kappa_1 \phi_z)^{-1} \]

- All terms LHS are negative.
- \( A'_\delta \) and \( A'_x \) < 0: ↑ risk-free rate or in price of risk increases rate future cash payments discounted.
- \( A'_s \) < 0: \( \Phi_s \) < 1. Equity values rise proportionally less than \( c_t \) in anticipation of eventual mean-reversion in payout.
- **Size of effects** depends on magnitudes of \( \Phi_\delta, \phi_x, \) and \( \Phi_s \).
Model solution implies log equity premium:

\[
E_t[r_{t+1}] - r_{f,t} = \left[ (\bar{\sigma}^2 \left( 1^\prime \Sigma_s 1 + \sigma_z^2 \right) + \sigma_a^2) + \xi \kappa_1 \left( A_s^\prime \Sigma_s 1 + A_z \sigma_T^2 \right) \right] x_t \\
- \frac{1}{2} \nabla_t (r_{t+1}) \\
\n\n\n\n\n\n\n\n
\n
\n
\n
\n
Homoskedastic shocks: \( \nabla_t \) constant, but risk premium varies with \( x_t \).
Estimation and Data

- **Primitive parameters**

\[ \theta = \left( \xi, g, \sigma^2_a, \text{vec}(\Phi_s), \text{vec}(\Phi_\delta), \phi_x, \phi_Z, \text{vec}(\Sigma_s), \text{vec}(\Sigma_\delta), \sigma^2_x, \sigma^2_Z, \bar{s}, \bar{\delta}, \bar{x}, \bar{z} \right)' \]
Estimation and Data

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- **Two groups**
  - Small number (\( \bar{s}, \xi, \phi_x \)) calibrated (discussed below).
  - Remaining parameters freely estimated.
Estimation and Data

- **Primitive parameters**
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- **Two groups**
  - Small number \((s, \xi, \phi_x)\) calibrated (discussed below).
  - Remaining parameters freely estimated.

- **Estimation of Parameters**: Bayesian methods with flat priors.

- **Estimation of Latent States**: Model linear in logs so can use Kalman filter.
Confront model with observations 1952:Q1-2017:Q4 on:

1. Log output growth \( \Delta y_t \)
2. Log earnings share \( e_t - y_t \equiv ey_t \)
3. Interest rate to proxy \( r_f, t \)
4. Taxes & interest share \( z_t \)
5. Equity-to-output ratio \( p_t - y_t \equiv py_t \)

Risk-free rate 3-Mo T-bill minus fitted \( \hat{\pi}_t \) from regression on lagged \( \pi_t \).

NFCS observations for all others.

Need \( y_t, ey_t, py_t \) etc., to be measured for same sector of economy. Otherwise subject to confounding compositional effects.

Corporate sector advantage: 1 - \( S_t \) not affected by statistical imputation of labor income from total income reported by sole proprietors and unincorporated business.
Estimation and Data

Confront model with observations **1952:Q1-2017:Q4** on:

1. Log output growth $\Delta y_t$
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4. Taxes & interest share $z_t$
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NFCS observations for all others.

1. Need $y_t, e y_t, p y_t$ etc., to be measured for same sector of economy. Otherwise subject to confounding compositional effects.
2. Corporate sector advantage: $1 - S_t$ not affected by statistical imputation of labor income from total income reported by sole proprietors and unincorporated business.
Forgoing variables are related to $\theta$ and latent states:

\[

ey_t = 1'(\tilde{s}_t + \bar{s}) \\
rf_t = 1'(\tilde{\delta}_t + \bar{\delta}) \\
py_t = \bar{p}\bar{y} + (A'_s + \zeta 1')\tilde{s}_t + A'_r\tilde{\delta}_t + A_x\tilde{x}_t + (A_Z + \zeta)\tilde{z}_t \\
\tilde{z}_{t+1} = \phi_Z\tilde{z}_t + \varepsilon_{Z,t+1} \\
z_t = \tilde{z}_t + \bar{z} \\
\Delta y_t = g + \Delta\tilde{y}_t
\]

$\bar{p}\bar{y} \equiv A_0 + \bar{c} + \bar{\zeta}\bar{z}_t$

Last two are identities that exactly pin down values of $\varepsilon_{z,t}$ and $\varepsilon_{a,t}$. 
Estimation and Data

- **State space form:**
  \[ Y_t = H' \beta_t + G' 1 \]  
  \[ \beta_t = F \beta_{t-1} + v_t, \]  

- **Observation equation:** \( Y_t \equiv (e_y t, r_f t, p y t, \Delta z_t, \Delta y_t)' \)

- **Latent states:** \( \beta_t \equiv (\tilde{s}_{LF,t}, \tilde{s}_{HF,t}, \tilde{\delta}_{LF,t}, \tilde{\delta}_{HF,t}, \tilde{x}_t, \tilde{z}_t, \Delta \tilde{y}_t)' \), where
  \[ v_t = (\varepsilon_{s,LF,t}, \varepsilon_{s,HF,t}, \varepsilon_{\delta,LF,t}, \varepsilon_{\delta,HF,t}, \varepsilon_{x,t}, \varepsilon_{Z,t}, \varepsilon_{a,t})' \]

and \( F, H', \) and \( G' \) are matrices of primitive parameters.
Estimation and Data

- **State space form:**
  \[
  \mathcal{Y}_t = H'\beta_t + G'1 \tag{1}
  \]
  \[
  \beta_t = F\beta_{t-1} + v_t, \tag{2}
  \]

- **Observation equation:** \( \mathcal{Y}_t \equiv \left( e_y t, r_{ft}, p y_t, \Delta z_t, \Delta y_t \right)' \)

- **Latent states:** \( \beta_t \equiv (\tilde{s}_{LF,t}, \tilde{s}_{HF,t}, \tilde{\delta}_{LF,t}, \tilde{\delta}_{HF,t}, \tilde{x}_t, \tilde{z}_t, \Delta \tilde{y}_t)' \), where
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  \]
  and \( F, H', \) and \( G' \) are matrices of primitive parameters.

- **Kalman filter** gives *smoothed* estimates of latent states \( \beta_t | T \).

- **Measurement error effectively zero** in (1) due to flexible loglinear model and use of 7 latent states to match only 5 variables.
Estimation and Data

- **Posterior of $\theta$**: Obtained by computing likelihood using KF and combining with priors.

- **Flat priors**: posterior coincides with likelihood, posterior mode coincides with MLE estimate.

- **Parameter uncertainty**: Characterized using a RWMH algorithm.


- **Error bands** therefore reflect both parameter and latent state uncertainty.
Estimation and Data

- Three parameters are calibrated: $\bar{s}$, $\zeta$, $\phi_x$

- Mean earnings share variable $\bar{s}$: forces exactly right mean in $ey$ without error.

- Payout-earnings growth relation $\zeta$

\[
\Delta c_t = \zeta (\Delta s_t + \Delta z_t) + \Delta y_t.
\]

Calibrated to match relative vol of $\Delta c_t$ to $\Delta e_t \approx 2$.

- Persistence of $x_t$: No observable series to discipline $\phi_x$.
  - If $\phi_x$ freely estimated with flat prior, procedure will choose parameters of FS and RF process to fit $s_t$, $r_{f,t}$ exactly, set $\phi_x$ to explain all variation in $py_t$.
  - Implausible implication: RP shocks very persistent, since $\hat{\phi}_x > 0.97$.
  - Estimates of risk-premium: $cay_t$ proxy AR1 $\approx 0.9$; Martin '17 SVIX proxy: AR1 $\approx 0.8$.
  - Baseline happy medium $\phi_x = 0.85$; robustness: $\phi_x = 0.80$, $\phi_x = 0.90$. 
Effective mean risk aversion modest reflecting volatility cash payments to shareholders.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Mode</th>
<th>5%</th>
<th>Median</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Price Mean</td>
<td>$\bar{x}$</td>
<td>4.4832</td>
<td>3.3174</td>
<td>4.3791</td>
<td>5.8452</td>
</tr>
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<td>3.8086</td>
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<td>Risk-Free Rate Mean</td>
<td>$\bar{r}_f$</td>
<td>0.0023</td>
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<td>0.0027</td>
<td>0.0048</td>
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<td>Risk-Free (HF) Pers.</td>
<td>$\phi_{\delta, HF}$</td>
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<td>0.0019</td>
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<tr>
<td>Factor Share (HF) Pers.</td>
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<td>$\phi_{s, LF}$</td>
<td>0.9997</td>
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<td>0.9996</td>
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<tr>
<td>Tax + Interest Share Pers.</td>
<td>$\phi_Z$</td>
<td>0.9545</td>
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<td>$\sigma_Z$</td>
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<td>0.0038</td>
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<td>Productivity Vol.</td>
<td>$\sigma_a$</td>
<td>0.0160</td>
<td>0.0148</td>
<td>0.0159</td>
<td>0.0171</td>
</tr>
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Parameter Estimates

- Short rates: $\phi_{\delta,LF} = 0.93 \Rightarrow$ substantial declines recently in $r_{f,t}$ not important impetus for equity boom.

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</tr>
<tr>
<td>Risk-Free (HF) Pers.</td>
<td>$\phi_{\delta,HF}$</td>
<td>0.1587</td>
<td>0.0290</td>
<td>0.1928</td>
<td>0.4109</td>
</tr>
<tr>
<td>Risk-Free (HF) Vol.</td>
<td>$\sigma_{\delta,HF}$</td>
<td>0.0019</td>
<td>0.0016</td>
<td>0.0019</td>
<td>0.0022</td>
</tr>
<tr>
<td>Risk-Free (LF) Pers.</td>
<td>$\phi_{\delta,LF}$</td>
<td>0.9321</td>
<td>0.8949</td>
<td>0.9314</td>
<td>0.9558</td>
</tr>
<tr>
<td>Risk-Free (LF) Vol.</td>
<td>$\sigma_{\delta,LF}$</td>
<td>0.0015</td>
<td>0.0012</td>
<td>0.0015</td>
<td>0.0019</td>
</tr>
<tr>
<td>Factor Share (HF) Pers.</td>
<td>$\phi_{s,HF}$</td>
<td>0.9250</td>
<td>0.8981</td>
<td>0.9245</td>
<td>0.9455</td>
</tr>
<tr>
<td>Factor Share (HF) Vol.</td>
<td>$\sigma_{s,HF}$</td>
<td>0.0680</td>
<td>0.0633</td>
<td>0.0683</td>
<td>0.0734</td>
</tr>
<tr>
<td>Factor Share (LF) Pers.</td>
<td>$\phi_{s,LF}$</td>
<td>0.9997</td>
<td>0.9984</td>
<td>0.9996</td>
<td>0.9999</td>
</tr>
<tr>
<td>Factor Share (LF) Vol.</td>
<td>$\sigma_{s,LF}$</td>
<td>0.0179</td>
<td>0.0132</td>
<td>0.0179</td>
<td>0.0230</td>
</tr>
<tr>
<td>Tax + Interest Share Pers.</td>
<td>$\phi_Z$</td>
<td>0.9545</td>
<td>0.9244</td>
<td>0.9583</td>
<td>0.9875</td>
</tr>
<tr>
<td>Tax + Interest Vol.</td>
<td>$\sigma_Z$</td>
<td>0.0041</td>
<td>0.0038</td>
<td>0.0041</td>
<td>0.0044</td>
</tr>
<tr>
<td>Productivity Vol.</td>
<td>$\sigma_a$</td>
<td>0.0160</td>
<td>0.0148</td>
<td>0.0159</td>
<td>0.0171</td>
</tr>
</tbody>
</table>

### Parameter Estimates

#### Factors share:
\[ \phi_{s,LF} = 0.9997 \] estimated to be more persistent.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Mode</th>
<th>5%</th>
<th>Median</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Price Mean</td>
<td>( \bar{x} )</td>
<td>4.4832</td>
<td>3.3174</td>
<td>4.3791</td>
<td>5.8452</td>
</tr>
<tr>
<td>Risk Price Vol.</td>
<td>( \sigma_x )</td>
<td>3.8086</td>
<td>2.8981</td>
<td>3.8307</td>
<td>5.1905</td>
</tr>
<tr>
<td>Risk-Free Rate Mean</td>
<td>( \bar{r}_f )</td>
<td>0.0023</td>
<td>0.0008</td>
<td>0.0027</td>
<td>0.0048</td>
</tr>
<tr>
<td>Risk-Free (HF) Pers.</td>
<td>( \phi_{\delta,HF} )</td>
<td>0.1587</td>
<td>0.0290</td>
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<td>0.4109</td>
</tr>
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<td>0.0016</td>
<td>0.0019</td>
<td>0.0022</td>
</tr>
<tr>
<td>Risk-Free (LF) Pers.</td>
<td>( \phi_{\delta,LF} )</td>
<td>0.9321</td>
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<td>0.9314</td>
<td>0.9558</td>
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<td>Risk-Free (LF) Vol.</td>
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<td>0.0148</td>
<td>0.0159</td>
<td>0.0171</td>
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</table>

**Notes:** The table reports parameter estimates from the posterior distribution. The sample spans the period 1952:Q1-2017:Q4.
Asset Pricing Moments

- “Model” numbers from simulations. “Fitted” numbers use estimated latent states obtained from fitting model to historical data.

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<thead>
<tr>
<th>Variable</th>
<th>Model Mean(%)</th>
<th>Model SD(%)</th>
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<tbody>
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<td>Log Equity Return</td>
<td>5.264</td>
<td>16.868</td>
<td>7.516</td>
<td>17.203</td>
<td>8.671</td>
<td>16.872</td>
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<tr>
<td>Log Risk-Free Rate</td>
<td>0.942</td>
<td>1.515</td>
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<tr>
<td>Log Price-Payout Ratio</td>
<td>3.507</td>
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<td>0.493</td>
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<tr>
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<tr>
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<td>28.678</td>
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Notes: All statistics are computed for annual (continuously compounded) data. “Model” numbers are averages across 1000 simulations of the model of the same size as our data sample. “Fitted” numbers use the estimated latent states fitted to observed data in our historical sample. The sample spans the period 1952:Q1-2017:Q4.
Asset Pricing Moments

- Fitted moments are model’s implications *conditional on observed sequence of shocks*; are therefore *directly comparable* to “Data” moments.

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<tr>
<th>Variable</th>
<th>Model Mean(%)</th>
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Asset Pricing Moments

- **Fitted moments** of $\Delta e_t$, $\Delta ey_t$, and $r_{f,t}$ match exactly b/c observables.

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<tr>
<th>Variable</th>
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Asset Pricing Moments

- Fitted moments of log $R$, log excess returns, and $pc_t$ match data moments reasonably well.

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Asset Pricing Moments

- Fitted mean of excess return understates data mean because model understates mean PO growth over the sample (not an estimation target).

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Asset Pricing Moments

- Fitted mean log $\text{ER}^e$ (6.4%) > model mean log $\text{ER}^e$ (4.3%) by 2.1 perc. points, attributable to good luck, string of favorable shocks redistributed rents to shareholders.

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<th>Model SD(%)</th>
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Asset Pricing Moments

- *Fitted means* for $\Delta e_t$ and $\Delta c_t$ larger than *model means*.

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Asset Pricing Moments

- Estimates imply roughly 2.1 percentage points of the post-war mean log return on stocks in excess of a T-bill is attributable to this string of favorable factors share shocks, rather than to genuine compensation for bearing risk.

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<td>15.041</td>
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<td>26.607</td>
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</table>

Notes: All statistics are computed for annual (continuously compounded) data. “Model” numbers are averages across 1000 simulations of the model of the same size as our data sample. “Fitted” numbers use the estimated latent states fitted to observed data in our historical sample. The sample spans the period 1952:Q1-2017:Q4.
Earnings Share Over Time

- Look at key data series we match exactly, starting with $e_{yt}$.

Notes: The figure exhibits the observed log earnings share series for the nonfinancial corporate sector. The sample spans the period 1952:Q1-2017:Q4.
Earnings Share Over Time

- Increases in $e_y_t$ equivalent to declines in labor share.

Notes: The figure exhibits the observed log earnings share series for the nonfinancial corporate sector. The sample spans the period 1952:Q1-2017:Q4.
Earnings Share Over Time

- High in 1950s, 1960s, low in 1970s, 1980s, **upward trajectory** since 1990.

*Notes:* The figure exhibits the observed log earnings share series for the nonfinancial corporate sector. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Earnings Share Over Time

Notes: The figure exhibits the observed earnings share series along with the model-implied variation in the series attributable to the latent factor share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Earnings Share Over Time

- $s_{HF,t}$ captures transitory variation in $e_{yt}$.

Notes: The figure exhibits the observed earnings share series along with the model-implied variation in the series attributable to the latent factor share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Earnings Share Over Time

- $s_{LF,t}$ captures *longer term trend* in $e_y_t$.

**Notes:** The figure exhibits the observed earnings share series along with the model-implied variation in the series attributable to the latent factor share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Risk-Free Rate Over Time

- Real rates **low** in 1950s & late 1970s, **high** during Volcker disinflation and after, **low** post-financial crisis.

*Notes:* The real risk-free rate is computed as the three-month T-bill rate minus the fitted value from a regression of GDP deflator inflation on lags of inflation. The sample spans the period 1952:Q1-2017:Q4.
Risk-Free Rate Over Time

- Although rates are low today, they are not unusually low by historical standards.

Notes: The real risk-free rate is computed as the three-month T-bill rate minus the fitted value from a regression of GDP deflator inflation on lags of inflation. The sample spans the period 1952:Q1-2017:Q4.
Sources of Risk-Free Rate Variation

Notes: The real risk-free rate is computed as the three-month T-bill rate minus the fitted value from a regression of GDP deflator inflation on lags of inflation and interest rates. The figure exhibits the observed risk-free rate series along with the model-implied variation in the series attributable to the latent risk-free rate components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Risk-Free Rate Variation

- Component $\delta_{HF,t}$ picks up transitory variation in $r_{f,t}$.

Notes: The real risk-free rate is computed as the three-month T-bill rate minus the fitted value from a regression of GDP deflator inflation on lags of inflation and interest rates. The figure exhibits the observed risk-free rate series along with the model-implied variation in the series attributable to the latent risk-free rate components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Risk-Free Rate Variation

- **Low-high-low** pattern of $r_{f,t}$ well captured by $\delta_{LF,t}$

**Notes:** The real risk-free rate is computed as the three-month T-bill rate minus the fitted value from a regression of GDP deflator inflation on lags of inflation and interest rates. The figure exhibits the observed risk-free rate series along with the model-implied variation in the series attributable to the latent risk-free rate components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Risk-Free Rate Variation

- LF component shows downward trend since about 1989.

Notes: The real risk-free rate is computed as the three-month T-bill rate minus the fitted value from a regression of GDP deflator inflation on lags of inflation and interest rates. The figure exhibits the observed risk-free rate series along with the model-implied variation in the series attributable to the latent risk-free rate components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Price-Output Ratio Over Time

- Equity relative to output has **short-term “wiggles”**, longer-term **trends**.

Notes: The figure exhibits the observed log market equity-to-output series for the nonfinancial corporate sector. The sample spans the period 1952:Q1-2017:Q4.
Over the sample observe an *upward* trend.

*Notes:* The figure exhibits the observed log market equity-to-output series for the nonfinancial corporate sector. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

Notes: The figure exhibits the observed log market equity-to-output series along with the model-implied variation in the series attributable to the latent factors share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Upward trend well captured by LF FS factor $s_{LF,t}$.

Notes: The figure exhibits the observed log market equity-to-output series along with the model-implied variation in the series attributable to the latent factors share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- **HF FS factor** $s_{HF,t}$ captures “wiggles”.

**Notes:** The figure exhibits the observed log market equity-to-output series along with the model-implied variation in the series attributable to the latent factors share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Fix the LF component, model is unable to capture *any of upward trend* since 1989.

Notes: The figure exhibits the observed log market equity-to-output series along with the model-implied variation in the series attributable to the latent factors share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Zero-in on period post-1989 => **large role for factors share shifts** in driving upward value of ME relative to output.

**Notes:** The figure exhibits the observed log market equity-to-output series along with the model-implied variation in the series attributable to the latent factors share components. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Role of risk-free rate?

\[ \text{Log ME/Y} \]

- Risk-free rate (LF) Only

- Risk-free rate (HF) Only

- Risk-free rate (LF) Fixed at Mean

- Risk-free rate (LF) Fixed Since 1989

Notes: The figure exhibits the observed market equity-to-output series along with the model-implied variation in the series attributable to the risk-free rate component. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Shutting down either LF or HF component does little to model’s ability to match trend movements in $p_u_t$.

Notes: The figure exhibits the observed market equity-to-output series along with the model-implied variation in the series attributable to the risk-free rate component. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Modest role since 1989.

Notes: The figure exhibits the observed market equity-to-output series along with the model-implied variation in the series attributable to the risk-free rate component. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Risk premium ($x_t$) variation explains almost all of transitory booms & busts.

Notes: The figure exhibits the observed market equity-to-output series along with the model-implied variation in the series attributable to the risk premium component. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Does not explain trend component.

Notes: The figure exhibits the observed market equity-to-output series along with the model-implied variation in the series attributable to the risk premium component. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Small portion of increase in $e_y_t$, esp since 1989, explained by decline in risk premia.

**Notes:** The figure exhibits the observed market equity-to-output series along with the model-implied variation in the series attributable to the risk premium component. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Sources of Variation in Price-Output Ratio

- Tax & interest component explains negligible fraction of variation in $p_{yt}$.

Notes: The figure exhibits the observed market equity-to-output series along with the model-implied variation in the series attributable to the tax/interest component. The shaded areas surrounding each estimated component are 90% credible sets that take into account both parameter and latent state uncertainty. The sample spans the period 1952:Q1-2017:Q4.
Growth Decompositions

- Now **quantify importance** of different drives of equity values over time.
- Decompose total growth in equity values into *distinct component sources*.
- Parts attributable to a single source obtained by **fixing all other components** at their values at beginning of sample.
- Components sum to **100% of observed variation**: model + estimated latent components perfectly match time-series on $py_t$ and $\Delta y_t$, over sample and **at each point in time**.
**Market’s rise**: 54% since 1989 and 36% over full sample attributable to $S_{LF,t} + S_{HF,t}$.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
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*Notes:* The table presents the growth decompositions for the real value of market equity (top panel) or the market equity-output ratio (bottom panel). The persistence parameter of the risk price is set to its baseline value of 0.85. The sample spans the period 1952:Q1-2017:Q4.
**Growth Decompositions**

- **Other components since 1989**: much smaller roles, e.g., $r_{f,t}$, risk premium.

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Greenwald, Lettau, and Ludvigson

How the Wealth Was Won
Growth Decompositions

- **Economic Growth** contributes **just 23%** since 1989; **50%** over full sample.

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**Growth Decompositions**

- **1952-1988**: $\Delta y_t$ explained 92% of market’s rise. But...

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Growth Decompositions

- That **37 year period** created *less than half* wealth created in **29 years** since 1989.

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Notes: The table presents the growth decompositions for the real value of market equity (top panel) or the market equity-output ratio (bottom panel). The persistence parameter of the risk price is set to its baseline value of 0.85. The sample spans the period 1952:Q1-2017:Q4.
Growth Decompositions: Alternative $\phi_x$

- $\phi_x = 0.9$: Declining $x_t$ explains 17% (rather than 11%) of market’s rise. $s_{LF,t} + s_{HF,t}$ explain 48% (vs. 54% baseline) since 1989 and 30% (vs. 36% baseline) over full sample.

<table>
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<tr>
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<td>Risk premium</td>
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Notes: The table presents the growth decompositions for market equity with persistence parameter of the risk price set to 0.80 (top panel) and set to 0.90 (bottom panel). The sample spans the period 1952:Q1-2017:Q4.
Growth Decompositions: Alternative $\phi_x$

- $\phi_x = 0.8$: Declining $x_t$ explains 8% (rather than 11%) of market’s rise. $s_{LF,t} + s_{HF,t}$ explain 57% (vs. 54% baseline) since 1989 and 39% (vs. 36% baseline) over full sample.

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<td>-2.18% -5.58% 1.65%</td>
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Conclusion and Summary

- **Why has the market risen** over the post-war period? Of importance to financial economists and long-term investors alike.

- We estimate **flexible parametric model** allows influence from several latent components, while inferring values components must have taken to explain the data.

- **Finding**: high returns to holding equity due in large part to good luck, attributable to **string of shocks that reallocated rents** toward shareholders away from workers.

- Realizations **added 2.1 percentage points** to mean log excess return, according to estimates (overstating risk premium by $\approx 50\%$).

- Factors share shocks account for most of market’s rise since 1989; economic growth and other factors relatively little.

- **For 37 years** from 1952-1989, **economic growth was king** for the equity market.

- But that period was **comparatively lackluster for equity values**, generating less than half as much wealth as the 29 years since 1989.
Appendix
## Growth Decompositions: Representative Agent

### Panel: Representative Agent

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### Panel B: Baseline Model

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</tbody>
</table>

**Notes:** The table presents the growth decompositions for the real value of market equity. The sample spans the period 1952:Q1-2017:Q4.
### Parameter Estimates: Representative Agent

<table>
<thead>
<tr>
<th>Variable</th>
<th>Parameter</th>
<th>Rep. Agent</th>
<th>Baseline Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Price Mean</td>
<td>$\bar{x}$</td>
<td>56.3120</td>
<td>4.4832</td>
</tr>
<tr>
<td>Risk Price Vol.</td>
<td>$\sigma_x$</td>
<td>47.8386</td>
<td>3.8086</td>
</tr>
<tr>
<td>Risk-Free Rate Mean</td>
<td>$\bar{r}_f$</td>
<td>0.0023</td>
<td>0.0023</td>
</tr>
<tr>
<td>Risk-Free (HF) Pers.</td>
<td>$\phi_{\delta, HF}$</td>
<td>0.1587</td>
<td>0.1587</td>
</tr>
<tr>
<td>Risk-Free (HF) Vol.</td>
<td>$\sigma_{\delta, HF}$</td>
<td>0.0019</td>
<td>0.0019</td>
</tr>
<tr>
<td>Risk-Free (LF) Pers.</td>
<td>$\phi_{\delta, LF}$</td>
<td>0.9321</td>
<td>0.9321</td>
</tr>
<tr>
<td>Risk-Free (LF) Vol.</td>
<td>$\sigma_{\delta, LF}$</td>
<td>0.0015</td>
<td>0.0680</td>
</tr>
<tr>
<td>Factor Share (HF) Pers.</td>
<td>$\phi_{s, HF}$</td>
<td>0.9250</td>
<td>0.9250</td>
</tr>
<tr>
<td>Factor Share (HF) Vol.</td>
<td>$\sigma_{s, HF}$</td>
<td>0.0680</td>
<td>0.0633</td>
</tr>
<tr>
<td>Factor Share (LF) Pers.</td>
<td>$\phi_{s, LF}$</td>
<td>0.9997</td>
<td>0.9997</td>
</tr>
<tr>
<td>Factor Share (LF) Vol.</td>
<td>$\sigma_{s, LF}$</td>
<td>0.0179</td>
<td>0.0179</td>
</tr>
<tr>
<td>Tax + Interest Share Pers.</td>
<td>$\phi_Z$</td>
<td>0.9545</td>
<td>0.9545</td>
</tr>
<tr>
<td>Tax + Interest Vol.</td>
<td>$\sigma_Z$</td>
<td>0.0041</td>
<td>0.0041</td>
</tr>
<tr>
<td>Productivity Vol.</td>
<td>$\sigma_a$</td>
<td>0.0160</td>
<td>0.0160</td>
</tr>
</tbody>
</table>

**Notes:** The table reports parameter estimates from the posterior distribution. The sample spans the period 1952:Q1-2017:Q4.