

# The Demographics of Innovation and Asset Returns

Nicolae Garleanu<sup>1</sup>   Leonid Kogan<sup>2</sup>   Stavros Panageas<sup>3</sup>

<sup>1</sup>UC Berkeley, NBER and CEPR

<sup>2</sup>MIT and NBER

<sup>3</sup>LBS, Chicago Booth and NBER

October 2009

# Outline

- 1 Introduction
- 2 The Model
- 3 Empirical Results
- 4 Conclusion

# Outline

1 Introduction

2 The Model

3 Empirical Results

4 Conclusion

# Contribution

- New description of aggregate fundamental risk

# Contribution

- New description of aggregate fundamental risk
- Systematic risk factor created by innovation: **displacement risk**

# Contribution

- New description of aggregate fundamental risk
- Systematic risk factor created by innovation: **displacement risk**
- Empirical evidence for displacement risk

# Contribution

- New description of aggregate fundamental risk
- Systematic risk factor created by innovation: **displacement risk**
- Empirical evidence for displacement risk
- Value-growth factor and the value premium, equity premium

# Contribution

- New description of aggregate fundamental risk
- Systematic risk factor created by innovation: **displacement risk**
- Empirical evidence for displacement risk
- Value-growth factor and the value premium, equity premium
- Long-horizon asset allocation and risk faced by retail investors



# Motivation

- Innovation generates systematic risks

# Motivation

- Innovation generates systematic risks
- Existing firms may lose market share to competition

Risk to financial capital

# Motivation

- Innovation generates systematic risks
- Existing firms may lose market share to competition

Risk to financial capital

- Human capital of the current generation of workers is less compatible with new technologies than human capital of new generations

Risk to human capital

# Motivation

- Innovation generates systematic risks
- Existing firms may lose market share to competition

Risk to financial capital

- Human capital of the current generation of workers is less compatible with new technologies than human capital of new generations

Risk to human capital

- Displacement Risk

# Motivation

- Benefits of future technological innovation will be partly captured by the innovators creating new firms and new generations of workers with superior human capital

# Motivation

- Benefits of future technological innovation will be partly captured by the innovators creating new firms and new generations of workers with superior human capital
- Risk sharing is not perfect: no trading with future generations

# Motivation

- Benefits of future technological innovation will be partly captured by the innovators creating new firms and new generations of workers with superior human capital
- Risk sharing is not perfect: no trading with future generations
- Older cohorts of agents cannot hedge displacement risk

# Motivation

- Benefits of future technological innovation will be partly captured by the innovators creating new firms and new generations of workers with superior human capital
- Risk sharing is not perfect: no trading with future generations
- Older cohorts of agents cannot hedge displacement risk
- Displacement risk is a priced risk factor



# Key Implications

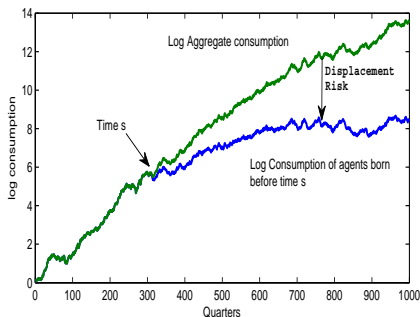
- Standard Consumption-CAPM is misspecified: omits displacement risk

# Consumption Risk

SDF = marginal rate of substitution for the **same agent**

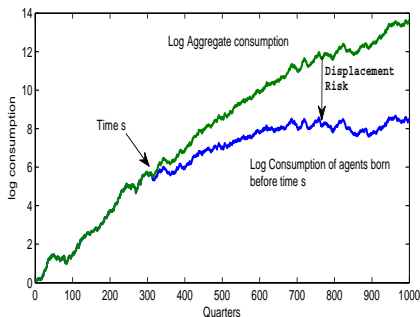
# Consumption Risk

SDF = marginal rate of substitution for the **same agent**



# Consumption Risk

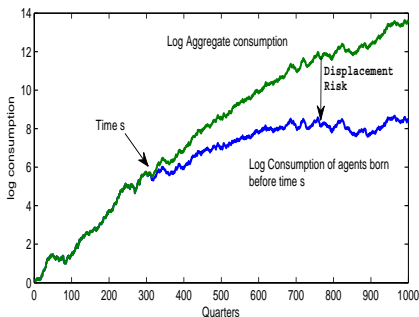
SDF = marginal rate of substitution for the **same agent**



Future per-capita **aggregate** consumption is not the same as the future per-capita consumption of the **current population** of agents

# Consumption Risk

SDF = marginal rate of substitution for the **same agent**



Future per-capita **aggregate** consumption is not the same as the future per-capita consumption of the **current population** of agents

$$\frac{\xi_{t+1}}{\xi_t} = \underbrace{\beta \left( \frac{Y_{t+1}}{Y_t} \right)^{-\gamma}}_{\text{Standard Term}} \times \underbrace{\left[ \frac{1}{1 - \lambda} \left( 1 - \lambda \frac{C_{t+1,t+1}}{Y_{t+1}} \right) \right]^{-\gamma}}_{\text{Displacement correction}}$$

# Key Implications

- Standard Consumption-CAPM is misspecified: omits displacement risk
- Value-growth factor captures exposure to displacement risk

# Key Implications

- Standard Consumption-CAPM is misspecified: omits displacement risk
- Value-growth factor captures exposure to displacement risk
- Value premium due to hedging demand for growth stocks

# Hedging Demand and the Value Premium

- Some firms more innovative than others, higher valuation ratios: growth firms



# Hedging Demand and the Value Premium

- Some firms more innovative than others, higher valuation ratios: growth firms
- Growth and value firms have unequal exposure to innovation shocks  $\Rightarrow$  growth-value factor

# Hedging Demand and the Value Premium

- Some firms more innovative than others, higher valuation ratios: growth firms
- Growth and value firms have unequal exposure to innovation shocks  $\Rightarrow$  growth-value factor
- Growth-value factor tracks displacement shocks  $\Rightarrow$  priced risk factor

# Hedging Demand and the Value Premium

- Some firms more innovative than others, higher valuation ratios: growth firms
- Growth and value firms have unequal exposure to innovation shocks  $\Rightarrow$  growth-value factor
- Growth-value factor tracks displacement shocks  $\Rightarrow$  priced risk factor
- Growth firms provide a valuable hedge against displacement risk  $\Rightarrow$  positive value premium

# Key Implications

- Standard Consumption-CAPM is misspecified: omits displacement risk
- Value-growth factor captures exposure to displacement risk
- Value premium due to hedging demand for growth stocks
- Long-horizon investing: indexing  $\neq$  keeping up

# Long-Horizon Investing

- An average investor cannot beat the market

# Long-Horizon Investing

- An average investor cannot beat the market
- Popular advice: index, stay average

# Long-Horizon Investing

- An average investor cannot beat the market
- Popular advice: index, stay average
- Holding the market does not protect against displacement risk

# Long-Horizon Investing

- An average investor cannot beat the market
- Popular advice: index, stay average
- Holding the market does not protect against displacement risk
- A typical investor will fall behind the “market” on average!



# Long-Horizon Investing

- An average investor cannot beat the market
- Popular advice: index, stay average
- Holding the market does not protect against displacement risk
- A typical investor will fall behind the “market” on average!
- A growth tilt in the portfolio could help mitigate displacement risk, but it is costly

# Outline

- 1 Introduction
- 2 The Model**
- 3 Empirical Results
- 4 Conclusion

# Agents

- Arrive and die randomly each period

# Agents

- Arrive and die randomly each period
- Supply labor to firms, trade in financial markets

# Agents

- Arrive and die randomly each period
- Supply labor to firms, trade in financial markets
- Behave rationally and competitively

# Technology

- Representative competitive firm produces the final consumption good using labor and intermediate goods

# Technology

- Representative competitive firm produces the final consumption good using labor and intermediate goods
- Many intermediate goods produced by monopolistically competitive firms

# Technology

- Representative competitive firm produces the final consumption good using labor and intermediate goods
- Many intermediate goods produced by monopolistically competitive firms
- Innovation = Increased variety of intermediate goods



# Technology

- Representative competitive firm produces the final consumption good using labor and intermediate goods
- Many intermediate goods produced by monopolistically competitive firms
- Innovation = Increased variety of intermediate goods
- Innovation  $\Rightarrow$  Higher output and more competition between intermediate-good producers

# Innovation

## Inventions, firms, and inventors

- Inventions are patents for production of new intermediate goods

# Innovation

## Inventions, firms, and inventors

- Inventions are patents for production of new intermediate goods
- Intellectual property of inventions belongs to inventors (new firms) and old firms

# Innovation

## Inventions, firms, and inventors

- Inventions are patents for production of new intermediate goods
- Intellectual property of inventions belongs to inventors (new firms) and old firms
- New firms can be of “value” and “growth” type

# Innovation

## Inventions, firms, and inventors

- Inventions are patents for production of new intermediate goods
- Intellectual property of inventions belongs to inventors (new firms) and old firms
- New firms can be of “value” and “growth” type
- **Value** firms **produce** and do not invent, responsible for a fraction of production of new goods

# Innovation

## Inventions, firms, and inventors

- Inventions are patents for production of new intermediate goods
- Intellectual property of inventions belongs to inventors (new firms) and old firms
- New firms can be of “value” and “growth” type
- **Value** firms **produce** and do not invent, responsible for a fraction of production of new goods
- **Growth** firms produce and **invent**, responsible for the rest of production and a fraction of invention

# Innovation

## Inventions, firms, and inventors

- Inventions are patents for production of new intermediate goods
- Intellectual property of inventions belongs to inventors (new firms) and old firms
- New firms can be of “value” and “growth” type
- **Value** firms **produce** and do not invent, responsible for a fraction of production of new goods
- **Growth** firms produce and **invent**, responsible for the rest of production and a fraction of invention
- Old generations capture a fraction of inventions through ownership of growth firms

# Innovation

## Workers

- A fraction of new generation are workers



# Innovation

## Workers

- A fraction of new generation are workers
- Workers are born with endowment of hours

# Innovation

## Workers

- A fraction of new generation are workers
- Workers are born with endowment of hours
- Assumption: older workers do not keep up with innovative technologies as well as the younger workers

# Asset Markets

- Complete set of state-contingent claims

# Asset Markets

- Complete set of state-contingent claims
- Assets are priced by the standard DCF formula

# Equilibrium

- Consumers (workers and inventors) chose their consumption optimally subject to their budget constraints

# Equilibrium

- Consumers (workers and inventors) chose their consumption optimally subject to their budget constraints
- Firms maximize their profits

# Equilibrium

- Consumers (workers and inventors) chose their consumption optimally subject to their budget constraints
- Firms maximize their profits
- Markets for labor and goods clear

# Summary

- Innovation = Increased variety of intermediate goods



# Summary

- Innovation = Increased variety of intermediate goods
- Agents

# Summary

- Innovation = Increased variety of intermediate goods
- Agents
  - Inventors (own patents/firms)

# Summary

- Innovation = Increased variety of intermediate goods
- Agents
  - Inventors (own patents/firms)
  - Workers (sell labor)

# Summary

- Innovation = Increased variety of intermediate goods
- Agents
  - Inventors (own patents/firms)
  - Workers (sell labor)
- Firms

# Summary

- Innovation = Increased variety of intermediate goods
- Agents
  - Inventors (own patents/firms)
  - Workers (sell labor)
- Firms
  - Value (production, no innovation)

# Summary

- Innovation = Increased variety of intermediate goods
- Agents
  - Inventors (own patents/firms)
  - Workers (sell labor)
- Firms
  - Value (production, no innovation)
  - Growth (some innovation)

# Outline

- 1 Introduction
- 2 The Model
- 3 Empirical Results**
- 4 Conclusion

# The Displacement Factor

- Theory: can estimate the displacement factor as a change in relative consumption of a group of households:

$$\log \left( \frac{C_{t+1,s}^i}{C_{t+1}} \right) - \log \left( \frac{C_{t,s}^i}{C_t} \right)$$



# The Displacement Factor

- Theory: can estimate the displacement factor as a change in relative consumption of a group of households:

$$\log \left( \frac{C_{t+1,s}^i}{C_{t+1}} \right) - \log \left( \frac{C_{t,s}^i}{C_t} \right)$$

- Use household-level consumption data (CEX, 1984-2003)

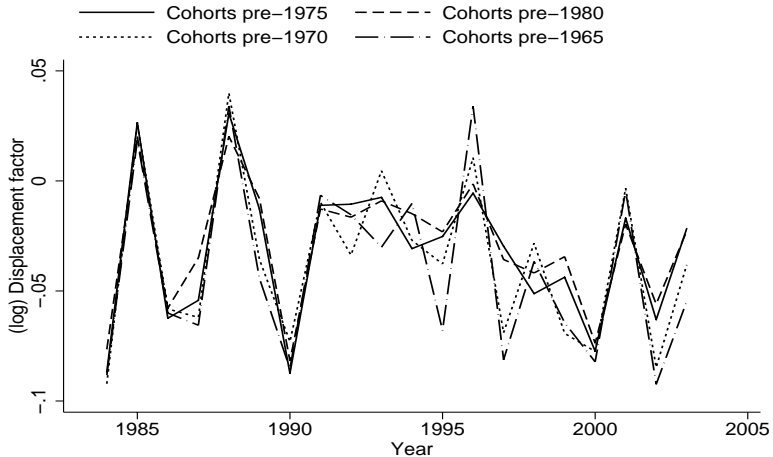
# The Displacement Factor

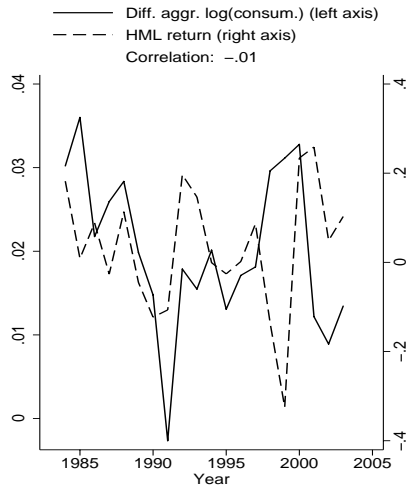
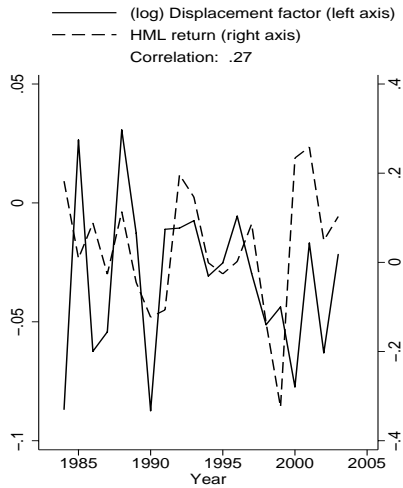
- Theory: can estimate the displacement factor as a change in relative consumption of a group of households:

$$\log \left( \frac{C_{t+1,s}^i}{C_{t+1}} \right) - \log \left( \frac{C_{t,s}^i}{C_t} \right)$$

- Use household-level consumption data (CEX, 1984-2003)
- Group all cohorts of households that entered the economy before date  $s$

# The Displacement Factor





# Consumption Cohort Effects

- Time-series dimension of CEX is limited

# Consumption Cohort Effects

- Time-series dimension of CEX is limited
- Use theory to exploit the cross-section of consumption

# Consumption Cohort Effects

- Time-series dimension of CEX is limited
- Use theory to exploit the cross-section of consumption
- Our model implies existence of consumption cohort effects

$$\log c_{t,s} = a_s + b_t$$

$t$  - calendar time

$s$  - cohort

# Consumption Cohort Effects

- Time-series dimension of CEX is limited
- Use theory to exploit the cross-section of consumption
- Our model implies existence of consumption cohort effects

$$\log c_{t,s} = a_s + b_t$$

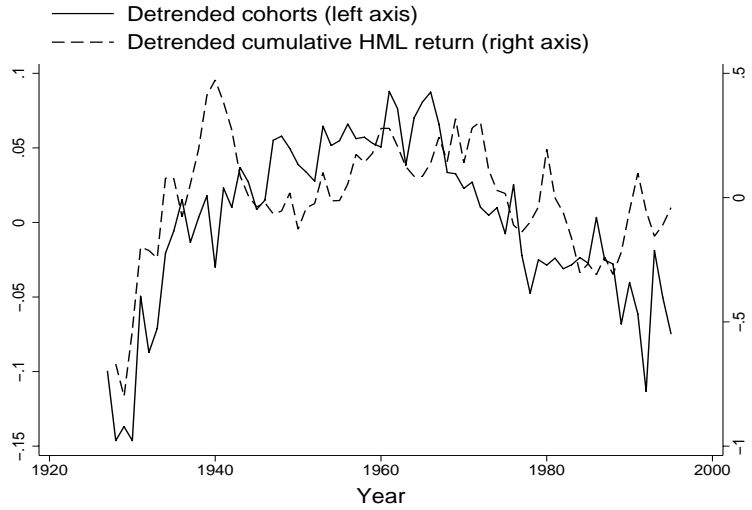
$t$  - calendar time

$s$  - cohort

- Displacement shocks are the permanent component of consumption cohort effects  $a_s$

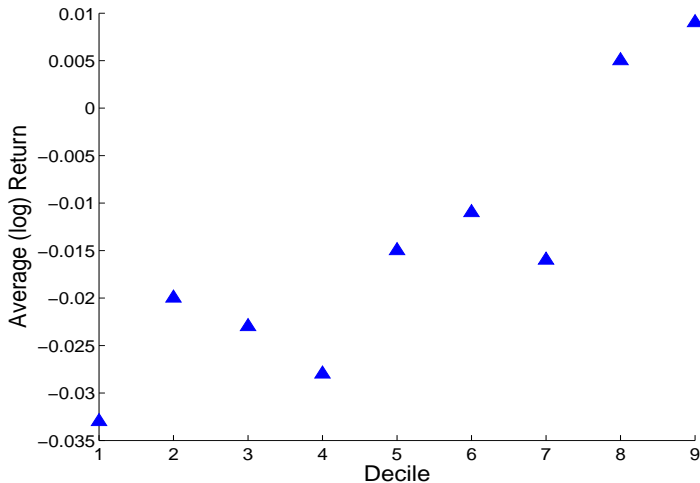


# Consumption Cohorts



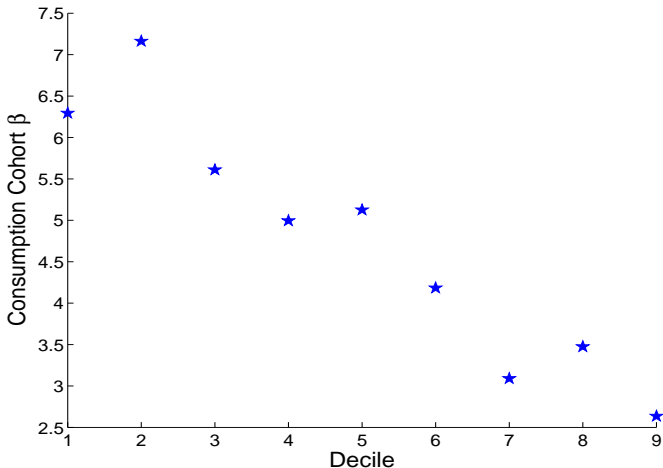
# Value Premium

Long-short B/M portfolios: Decile  $i$  – Decile 10: 1927-2007



# Innovation Betas and Book-to-Market

Long-short B/M portfolios: Decile  $i$  – Decile 10: 1927-1995



# Alternative Measures of Innovation

- We extract innovation shocks from consumption cohort effects

# Alternative Measures of Innovation

- We extract innovation shocks from consumption cohort effects
- Can one identify other, more direct proxies for innovation?

# Alternative Measures of Innovation

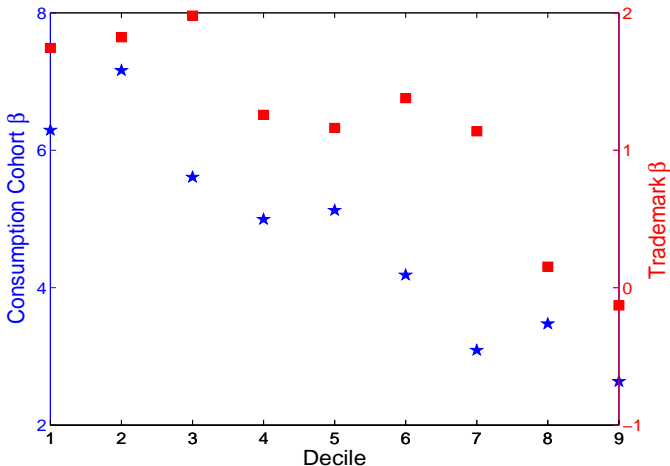
- We extract innovation shocks from consumption cohort effects
- Can one identify other, more direct proxies for innovation?
- Motivated by the model: changes in the stock of trademarks

# Alternative Measures of Innovation

- We extract innovation shocks from consumption cohort effects
- Can one identify other, more direct proxies for innovation?
- Motivated by the model: changes in the stock of trademarks
- Relate average returns on the book-to-market decile portfolios to innovation betas

# Innovation Betas and Book-to-Market

Long-short B/M portfolios: Decile  $i$  – Decile 10: 1927-2000





# Outline

- 1 Introduction
- 2 The Model
- 3 Empirical Results
- 4 Conclusion**

# Conclusion

- Displacement risk is a fundamental risk factor

# Conclusion

- Displacement risk is a fundamental risk factor
- Empirical evidence for displacement risk

# Conclusion

- Displacement risk is a fundamental risk factor
- Empirical evidence for displacement risk
- Calibration (not shown) is quantitatively realistic

# Conclusion

- Displacement risk is a fundamental risk factor
- Empirical evidence for displacement risk
- Calibration (not shown) is quantitatively realistic
- Better understanding of the value-growth factor, value premium, equity premium