Financial Health Economics

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Three Questions

1. Do we spend enough/too much/just enough on health care?
   Health expenditures have been rising from 7.1% of GDP to 15.7% of GDP in the United States.

   *Hall and Jones (2007, QJE)*: Luxury-good explanation using a deterministic model without medical R&D.

2. Do we spend enough/too much/just enough on medical R&D?
   *Murphy and Topel (2006, JPE)*: Puzzle of “missing R&D.” Given the productivity of medical R&D, one would expect we spend more using a deterministic model.

3. Why are health care stock returns so high?
   Will show: additional 4% excess return on health stocks above “usual” equity premium.
Three answers

In reverse order:

1. The excess health equity premium is a risk-adjusted reward for bearing government intervention risk. More than half of it is a “risk premium”, the rest a “disaster premium”.

2. Health R&D investments are thus risky, and need to earn this excess return. Without government intervention risk, R&D would currently be more than twice as high.

3. As a consequence, medical progress has been held back. Without government intervention risk, health spending would be higher by 4% of GDP. Long-run: health spending share is 38%.
Three approaches


2. Examine 10k filings and draw downs. Examine Clinton healthcare reform attempt, Obama healthcare reform. Argue: the premium is government intervention risk.

3. Provide a long-run general equilibrium model with many distortions and risk of government intervention disaster. Calibrate and solve to obtain quantitative answers to questions. (Additional: complement with simple models, arguing it must be government intervention risk).
Health Care Data

- US health care spending
  National Health Expenditure Accounts from the Centers for Medicare and Medicaid Services

- International data on health expenditures to GDP and the data on pharmaceutical expenditures
  OECD Health Data 2010
Health Care Spending Shares in the United States
## Health Care Spending Shares in the OECD Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Health exp. (% GDP)</th>
<th>Pharma (% health exp.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>4.8</td>
<td>8.5</td>
</tr>
<tr>
<td>Belgium</td>
<td>4.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Canada</td>
<td>7.2</td>
<td>10.1</td>
</tr>
<tr>
<td>Germany</td>
<td>6.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Japan</td>
<td>4.7</td>
<td>8.1</td>
</tr>
<tr>
<td>Spain</td>
<td>4.0</td>
<td>8.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>7.1</td>
<td>9.1</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>4.5</td>
<td>8.4</td>
</tr>
<tr>
<td>United States</td>
<td>7.3</td>
<td>15.7</td>
</tr>
<tr>
<td>Average</td>
<td>5.6</td>
<td>9.5</td>
</tr>
<tr>
<td>Median</td>
<td>5.2</td>
<td>9.1</td>
</tr>
</tbody>
</table>
Financial Markets Data

- Standard data from Ken French
- Divide universe of Amex/NYSE/Nasdaq stocks into
  - Consumer goods
  - Manufacturing
  - Technology
  - Health care
  - Other
- Three subcategories of health care
  - Drugs
  - Devices
  - Services (starting in the seventies)
- Sample periods
  - 1927-2010
  - 1946-2010
  - 1961-2010
Market Cap Shares Health Care Sector
Benchmarking Returns in the Health Care Sector

To analyze returns, we study the returns on all industries relative to factor models

\[ r_t - r_{ft} = \alpha + \beta' F_t + \varepsilon_t \]

Factor choices \((F_t)\)

- CAPM: Market
- 3-factor Fama and French (1992) model: Market, Size \((SMB)\), and Value \((HML)\) factors
The Medical Innovation Premium

Alphas based on annual returns from 1961 - 2012

<table>
<thead>
<tr>
<th></th>
<th>Cons</th>
<th>Manu</th>
<th>HiTec</th>
<th>Health</th>
<th>Other</th>
<th>Devices</th>
<th>Drugs</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPM</td>
<td>1.81</td>
<td>1.66</td>
<td>-0.83</td>
<td>3.31</td>
<td>0.22</td>
<td>3.71</td>
<td>3.70</td>
</tr>
<tr>
<td>T-statistic</td>
<td>1.40</td>
<td>1.54</td>
<td>-0.54</td>
<td>1.61</td>
<td>0.17</td>
<td>1.40</td>
<td>1.78</td>
</tr>
<tr>
<td>Fama and French</td>
<td>-0.13</td>
<td>1.04</td>
<td>1.67</td>
<td>5.01</td>
<td>-2.66</td>
<td>6.44</td>
<td>5.37</td>
</tr>
<tr>
<td>T-statistic</td>
<td>-0.09</td>
<td>0.84</td>
<td>0.86</td>
<td>2.44</td>
<td>-2.75</td>
<td>2.05</td>
<td>2.63</td>
</tr>
<tr>
<td>No. of observations</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>52</td>
</tr>
</tbody>
</table>
We show in the paper that shocks to

- Health care productivity ("stochastic Murphy-Topel")
- Longevity ("stochastic Hall-Jones")

generate a negative instead of a positive alpha

⇒ Profits rise when consumption declines

Mechanism that generates a positive correlation:
Government intervention risk

⇒ US health care companies face the risk that the US government adopts the European model and restricts markups
Empirical Evidence Supporting the Main Mechanism

In general, it is challenging to conclusively show that a risk premium is due to a certain risk (e.g., the size and value premium, momentum, . . . )

Three pieces of supportive evidence

1. Risk factors identified from textual analysis of 10-K filings
2. Drawdowns of the health care sector
3. The cross-section of announcement returns and health factor betas around Clinton-care reforms
Empirical Evidence: 10-K Filings

- All 10-K Filings contain a section “Risk Factors” in which companies list the “most significant factors” that affect the company.

- We take the largest 50 health and non-health care companies.

- Build a dictionary of government related words, which are not specific to the health care sector.

  E.g., “regulatory” and not “FDA.”

⇒ See Table 2 for the full dictionary.
Empirical Evidence: 10-K Filings

Panel A: Main dictionary without health care-specific terms

<table>
<thead>
<tr>
<th></th>
<th>Average word count</th>
<th>Average fraction of words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health care sector</td>
<td>138.98</td>
<td>1.51%</td>
</tr>
<tr>
<td>Non-health care sector</td>
<td>76.58</td>
<td>1.23%</td>
</tr>
<tr>
<td>S.e. of difference in means</td>
<td>15.06</td>
<td>0.10%</td>
</tr>
<tr>
<td>T-statistic</td>
<td>4.14</td>
<td>2.78</td>
</tr>
</tbody>
</table>

Panel B: Dictionary including health care-specific terms

<table>
<thead>
<tr>
<th></th>
<th>Average word count</th>
<th>Average fraction of words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health care sector</td>
<td>180.60</td>
<td>1.89%</td>
</tr>
<tr>
<td>Non-health care sector</td>
<td>78.86</td>
<td>1.27%</td>
</tr>
<tr>
<td>S.e. of difference in means</td>
<td>19.68</td>
<td>0.13%</td>
</tr>
<tr>
<td>T-statistic</td>
<td>5.17</td>
<td>4.96</td>
</tr>
</tbody>
</table>
Empirical Evidence: Drawdowns

Drawdowns to measure risk: \[ D_t = \sum_{s=1}^{t} r_s - \max_{u=1,\ldots,t} \sum_{s=1}^{u} r_s \]
## Empirical Evidence: Clinton Health Care Reform

<table>
<thead>
<tr>
<th>Date</th>
<th>Description of event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/19/92</td>
<td>Clinton issues health care reform proposals before New Hamps. primary</td>
</tr>
<tr>
<td>2/18/92</td>
<td>Clinton unexpectedly finishes second in the New Hampshire primary</td>
</tr>
<tr>
<td>3/10/92</td>
<td>Clinton does well in the Super Tuesday primaries</td>
</tr>
<tr>
<td>4/7/92</td>
<td>Clinton wins NY primary and turns favorite to win the Dem. nomination</td>
</tr>
<tr>
<td>6/4/92</td>
<td>Republicans in the House of Rep. offer their health care reform proposal</td>
</tr>
<tr>
<td>9/24/92</td>
<td>Clinton speaks at Merck on health care reform</td>
</tr>
<tr>
<td>11/3/92</td>
<td>Clinton wins presidential election</td>
</tr>
<tr>
<td>1/25/93</td>
<td>Clinton names Hillary Clinton to head his Health Care Task Force</td>
</tr>
<tr>
<td>2/12/93</td>
<td>Clinton says drug prices are too high</td>
</tr>
<tr>
<td>9/11/93</td>
<td>NY Times describes probable regulations based on a leaked copy of plan</td>
</tr>
<tr>
<td>9/22/93</td>
<td>Clinton officially announces his health care reform plan</td>
</tr>
</tbody>
</table>

Abnormal returns during 11 events: **-24%**

Uses 10-day event window and CAPM as the benchmark model
Empirical Evidence: Clinton Health Care Reform

We link the exposure to the health care factor, which earns the medical innovation premium, to the announcement returns

\[ CAR_i = \delta_0 + \delta_1 \frac{\beta_{iHC}}{\sigma(\beta_{iHC})} + u_i \]

<table>
<thead>
<tr>
<th>Intercept ((\delta_0))</th>
<th>-0.21</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-statistics</td>
<td>-8.28</td>
</tr>
<tr>
<td>Slope coefficient ((\delta_1))</td>
<td>-7.7%</td>
</tr>
<tr>
<td>t-statistic</td>
<td>-2.66</td>
</tr>
<tr>
<td>R-squared</td>
<td>4.0%</td>
</tr>
<tr>
<td>Number of firms</td>
<td>327</td>
</tr>
<tr>
<td>Average number of years</td>
<td>20.8</td>
</tr>
</tbody>
</table>

used to estimate health care betas
Households

- **Time:** \( t = 0, 1, \ldots \)
- **Two types of infinitely lived households:**
  - “Consumers:” \( i \in [0, 1] \)
  - “Entrepreneurs:” \( i \in (1, 1 + \kappa] \) for some \( \kappa > 0 \)
- **Preferences**
  - **Consumers:**
    \[
    U = E \left[ \sum_{t=0}^{\infty} \beta^t \frac{c_{nt}^{\xi} h_t^{1-\xi}}{1 - \eta} \right], \tag{1}
    \]
  - **Entrepreneurs:**
    \[
    U_t = V (c_{et}, E[\Upsilon(U_{t+1})]) \tag{2}
    \]
- **In paper:** Endogenize the preferences of the entrepreneurs
- **Endowment of consumers:**
  - One unit of time per period, supplied as labor. Productivity: \( \gamma^t \)
  - Base level of health: \( h \gamma^t \)
Technologies

- Consumption ($L_{ct}$: labor devoted to producing consumption):
  
  \[ c_{nt} + \kappa c_{et} = \gamma^t L_{ct} \]  

- Health: with a continuum $j \in [0, 1]$ of medical care types,
  
  \[ h_t = h\gamma^t + m_t \]
  
  \[ m_t = \left( \int_0^1 m_{jt}^{1/\phi} dj \right)^\phi, \]

- Medical care production:
  
  \[ m_{jt} \equiv \int_0^1 m_{ijt} di = q_{jt}\gamma^t L_{mjt}, \]

- Evolution of quality, per R&D,
  
  \[ q_{j,t+1} = (q_{jt}^\nu + d_{jt}^\nu)^{1/\nu}, \text{ where } d_{jt} = \gamma^t L_{djt} \]

- Feasibility: $L_{ct} + \int L_{mjt} dj + \int L_{djt} dj = 1$
Decentralization

- Government
- Firms
- Households and their budget constraints

We impose symmetry throughout:

\[ p_{jt} \equiv p_t, \ m_{jt} \equiv m_t, \ d_{jt} \equiv d_t, \ q_{jt} \equiv q_t \]
Government

The government intervenes in three ways

- **Subsidize R&D**: Firms pay fraction $1 - \chi$
- **Subsidize medical care**: Households pay fraction $1 - \sigma$
- **Regulate markups**: $p_t \leq \zeta / q_t$
  - Monopolistic competition: $p_t = \phi / q_t$
  - **Source of aggregate risk**: Start from $\zeta \geq \phi$ ("$z_t = 0'$")
    With probability $\omega$ iid across time, government imposes
    $0 \leq \zeta < \phi$ forever after ("$z_t = 1'$").

Government budget constraint:

$$\sigma p_t m_t di + \chi d_t = \tau_t + \kappa \tau_{t,e}$$  \hspace{1cm} (4)

Incidence of taxation:

$$\sigma p_t m_t = \tau_t$$
$$\chi d_t = \kappa \tau_{t,e}$$
Firms

- They live for two periods
  - Do R&D $d_t$ in $t$ to obtain patent
  - Sell $m_{t+1}$ in monopolistic competition

- Firms maximize firm value $v_t$:
  $$ v_t = \max_{d_t} E_t (M_{t+1}\pi_{t+1}) - (1 - \chi)d_t $$

- $M_{t+1}$: market stochastic discount factor

- Profits: $\pi_{t+1}$ per monopolistic competition. Price $p_{t+1}$ per unit

- R&D: useful beyond $t + 1$. Externality
Budget Constraints

- Consumers:
  \[ c_{nt} + (1 - \sigma) p_t m_t + \tau_t = \gamma^t \]  (5)

- Entrepreneurs: pay for R&D to create and hold new firms. “Marginal investor”.
  \[ c_{et} + \tau_{t,e} + (1 - \chi) \frac{1}{\kappa} d_t = \frac{1}{\kappa} \pi_t \]  (6)
Highly nonlinear
Assumptions made to avoid complicated numerical techniques
Monopolistic competition and government regulation:

\[ p_t = \mu_t / q_t, \] (7)

where

\[ \mu_t = \begin{cases} 
\phi & \text{if } z_{t+1} = 0, \\
\zeta & \text{if } z_{t+1} = 1 
\end{cases} \] (8)

Entrepreneurs: \( \kappa \) tiny, dividend income much larger than wage income. Thus

\[ \kappa c_{t,e} = \pi_t - d_t \] (9)

Impose SDF per \( \bar{M} > M \) with \( (1 - \omega)\bar{M} + \omega M = 1 \):

\[ M_{t+1} = \begin{cases} 
\bar{R}^{-1}M & , \text{ if new regul. at } t + 1 \\
\bar{R}^{-1}M & , \text{ if unregul. in } t \text{ and } t + 1 \\
\bar{R}^{-1} & , \text{ if regul. in } t \text{ and } t + 1 
\end{cases} \]
**Key Implications**

- Medical spending share increases only due to medical R&D, which lowers prices

- $\varphi_t = \frac{p_t m_t}{\gamma^t}$: share of gross labor income spent by households on medical care

- Share evolution:

  $$\varphi_t = \frac{p_t m_t}{\gamma^t} = \frac{1 - \xi}{1 - \sigma \xi} - \frac{1 - \sigma}{1 - \sigma \xi} \xi h p_t$$

  (10)

- The **long-run share** equals $(1 - \xi)/(1 - \sigma \xi)$

- Optimal R&D: with $R_{t+1}$ as return to health care firms,

  $$1 - \chi = \frac{1}{q_t' d_t^{1-\nu} + d_t} \frac{1}{\phi - 1} \frac{E_t[\pi_{t+1}]}{E_t[R_{t+1}]}$$

  Discouragement of R&D with high risk premium, i.e. high $E_t[R_{t+1}]$
Calibration

- Parameters: $t$ counts decades.

$$\Theta = \{\gamma, h, \nu, q_0, \overline{M}, \phi, \xi, \zeta, \chi, \beta\}. \quad (11)$$

- $\bar{M}$ and $\eta$: no impact on med. spending, no need for calibration.

- Approximation: $y_t = (1 + \kappa)\gamma^t + \pi_t \approx (1 + \kappa)\gamma^t$. Facts:
  - Output growth: 3% p.a.. Thus $\gamma = 1.35$.
  - Markup: 200%, thus $\phi = 3$. (Caves-Whinston-Hurwitz: generics=20%, so $\phi = 5$)
  - If government intervention: assume markup = 0, $\zeta = 1$.
  - $\bar{R}$: 4% p.a.
  - Expected ret. of health care firms: $\bar{R}M^{-1}$. Per $\alpha$: $M = 0.63$.
  - R&D share in 1990 and 2010. Health share in 1960 and 2010. Numerically solve for parameters $h, \nu, q_0, \xi$ to deliver these.
  - Per “Medicare/Medicaid”: medical subsidy $\sigma = 0.5$
  - $\chi = 0.5$ (Jones, 2011)
  - Intervention risk: assumed. We choose $\omega = 10\%$ (per decade). Sensitivity: $\omega = 20\%$. 

Calibration
Back-of-the-envelope

- Excess premium is 4
- \( \omega = 0.1 \): “disaster risk” is 1% p.a..
- So, “risk premium on disaster” is 3% p.a..
- \( \text{Prob(”no intervention in 60 years”) } = 53\% \)
- If \( \omega = 0.2 \): “disaster risk” is 2% p.a., risk premium is 2%.
- \( \text{Prob(”no intervention in 60 years”) } = 26\% \)
- \( \omega > 0.2 \): implausible. Thus, more than half of the premium is “risk premium against disaster” rather than “disaster premium”.
## Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma$</td>
<td>10-yr growth</td>
<td>1.35</td>
</tr>
<tr>
<td>$\phi$</td>
<td>Markup</td>
<td>3</td>
</tr>
<tr>
<td>$\zeta$</td>
<td>Constrained markup</td>
<td>1</td>
</tr>
<tr>
<td>$\chi$</td>
<td>R&amp;D subsidy</td>
<td>50%</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Medical care subsidy</td>
<td>50%</td>
</tr>
<tr>
<td>$R$</td>
<td>10-yr benchmark return</td>
<td>1.48</td>
</tr>
<tr>
<td>$Q$</td>
<td>10-yr return on health R&amp;D, if no interv.</td>
<td>2.37</td>
</tr>
<tr>
<td>$q_0$</td>
<td>Initial level of medical knowledge</td>
<td>4.74</td>
</tr>
<tr>
<td>$\nu$</td>
<td>Curvature R&amp;D production function</td>
<td>0.42</td>
</tr>
<tr>
<td>$h$</td>
<td>Health endowment</td>
<td>0.80</td>
</tr>
<tr>
<td>$\xi$</td>
<td>Weight non-health consumption in $U$</td>
<td>0.77</td>
</tr>
<tr>
<td>$X$</td>
<td>Price of government risk, if $\omega = 10%$</td>
<td>0.69</td>
</tr>
<tr>
<td>$X$</td>
<td>Price of government risk, if $\omega = 20%$</td>
<td>0.78</td>
</tr>
</tbody>
</table>
Health Share: Model Versus Data

Health spending share: data vs model

Percent of GDP

Model

Data

Year

1960
1970
1980
1990
2000
2010

16
18
20
22

6
8
10
12
14
16
18
20
R&D Share: Model Versus Data

R&D spending share: data vs model

- Model
- Data
Health Share: Counterfactual

Health spending share

- **no gov. risk**
- **no gov. risk premium**
- **no gov. risk prem., ω=20**
- **benchmark**

Y-axis: Percent of GDP
X-axis: Years (1960-2010)
R&D Shares: Counterfactual

R&D spending share

- no gov. risk
- no gov. risk premium
- no gov. risk prem., $\omega=20$
- benchmark

Percent of GDP

- 1960
- 1970
- 1980
- 1990
- 2000
- 2010
Long-run Health Share

Health spending share: long-run

Percent of GDP

- 1950
- 2000
- 2050
- 2100
- 2150
- 2200

- 5
- 10
- 15
- 20
- 25
- 30
- 35
- 40

Introduction
Facts
Evidence
Infinite horizon theory
Quantitative Results
Conclusions
Additional slides
Long-run R&D Share

Health spending share: long-run

Percent of GDP

Year

1950
2000
2050
2100
2150
2200

5
10
15
20
25
30
35
40
Long-run Health Share: Counterfactual

Health spending share: long-run

- no gov. risk
- no gov. risk premium
- no gov. risk prem., $\omega=20$
- benchmark
Conclusions

- **Medical innovation premium** ($\alpha$) of 4-6% for health care firms
  $\Rightarrow$ Must correspond to health-care relevant aggregate risk

- Litmus test for theories

- Our favorite explanation is **government intervention risk**:
  - Monopoly profits are motor for R&D
  - Risk that profits will be erased

**Punchline**

Government intervention risk leads to excess equity returns in the health sector. Because of it, more than half of medical R&D and 4% of GDP spending on health is “missing”.
Asset Pricing

\[ 1 = E_t[M_{t+1} R_{t+1}] = E_t \left[ \frac{\partial U}{\partial c_{t+1}} \frac{\partial U}{\partial c_t} R_{t+1} \right] \]

\( R_{t+1} \) for health industry: unexpectedly high, when profits are unexpectedly high.

**Key insight:**
Positive health industry alphas

\[ \Rightarrow \]
when health industry profits \( \pi_{t+1} \) are high,
\( \frac{\partial U}{\partial c_{t+1}} \) is low,
and thus consumption \( c_{t+1} \) is high.

Caveat for “thus”: that may depend on other arguments of \( U \).
Budget constraints, markups, profits, subsidies

Some theory, “stripped down”:
- Health: \( h \). Productivity ("Quality", 1/marg.costs): \( q \). Price: \( p \). Markup: \( \phi \). Profits: \( \pi \). Income: \( y \). Cons.: \( c \). Subsidy: \( \sigma \). Taxes: \( \tau \).
- Profits (linear production function):
  \[
p = \frac{\phi}{q} \quad \text{and} \quad \pi = (\phi - 1)\frac{h}{q}
\]
- Household budget constraint:
  \[
y + \pi = c + (1 - \sigma)ph + \tau
\]
- Government budget constraint:
  \[
\sigma ph = \tau
\]
- Together:
  \[
c = y - \frac{h}{q} = y - \frac{\pi}{(\phi - 1)} \\
\pi = (\phi - 1)\frac{h}{q}
\]
Approaches That Do Not Work

\[ c = y - h/q = y - \pi/\left(\phi - 1\right) \]
\[ \pi = (\phi - 1)h/q \]

\(\pi, h, c\): endogenous.
\(y, \phi, q\): parameters or constant.

- Medical progress and longevity: \(q \uparrow\), thus \(h \uparrow\).
- Preference shock for \(h\), with \(c\) and \(h\) separable or complements.
- Subsidy shock. \(\sigma \uparrow\).

Hard to get them to work:

- Suppose \(\pi \uparrow\). Then \(c \downarrow\).
- Suppose \(\pi \downarrow\). Then \(c \uparrow\).
- Negative correlation, not positive correlation.
Approaches That Might Work

\[
c = y - h/q = y - \pi/(\phi - 1) \\
\pi = (\phi - 1)h/q
\]

\(\pi, h, c, y, \phi, q\): possibly all endogenous.

1. Medical progress and productivity: \(q \uparrow\), thus \(y \uparrow\), \(\pi \uparrow\) and \(c \uparrow\).
2. Preference shock for \(h\), with \(c\) and \(h\) (strong) substitutes: \(h \uparrow\), thus \(\pi \uparrow\) and \(c \downarrow\), but nonetheless \(u_c(c, h) \downarrow\).
3. Government regulation on \(\phi\): \(\phi \downarrow\), thus \(\pi \downarrow\), \(h \uparrow\) and \(c \downarrow\).

We pursue the third approach. We also need to explain:

- Share for “health” rising over time. R&D rising over time.
- Share for “health” not rising with higher individual income (“cross-section”).