A Production-based Economic Explanation for the Gross Profitability Premium

PRESENTER
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Production costs and cash flow risk

- Re-examine the basic question of how cash flow risk is shaped by firm production costs
- Main idea:

  \[ \text{Profit} = \text{Revenue} - \text{Cost} \]

  - If costs are fixed, profits are more risky than revenue – operating leverage
- Commonly used is structural models of the value premium. All else equal,
  - Firms with low profitability have low valuation ratios – “value firms”
  - These firms have higher cash flow risk due to operating leverage – higher returns
- Challenge: how can we reconcile this with a positive profitability premium?
Variable costs and operating hedge

- Operating leverage is a part of the story, but another important element is *operating hedge*.

- Firms face some fixed costs, but many costs are variable:
  - Intermediate inputs, labor, services, etc. – costs of producing finished goods
  - Intermediate input costs are volatile, and highly cyclical relative to revenue
  - While fixed costs magnify risk (*operating leverage*), variable costs reduce risk (*operating hedge*)
  - Empirically, operating hedge effect is correlated negatively with firm profitability – more profitable firms experience less risk reduction due to cost variability.
Volatility of input and output value

- Annual data, BEA, 1947—2014
- Value of Gross Output \( V(GO) \) vs value of Intermediate Inputs \( V(II) \)
- In the aggregate, value of intermediate inputs is volatile relative to output

<table>
<thead>
<tr>
<th>Volatility of annual growth of Aggregate Gross Output vs Intermediate Input</th>
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<tbody>
<tr>
<td><strong>Gross Output</strong></td>
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<tr>
<td>2.9%</td>
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</table>

- The value of intermediate inputs is high relative to output

<table>
<thead>
<tr>
<th>Aggregate: average ( V(II)/V(GO) )</th>
<th>Firm level: median COGS/REVТ</th>
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<tbody>
<tr>
<td>44.7%</td>
<td>66.5%</td>
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</table>
Cyclicality of input vs output value

- Value of intermediate inputs is highly positively correlated with aggregate output: 92% annual correlation
- Cost of inputs is cyclical relative to output, reduces cyclicality of value added

<table>
<thead>
<tr>
<th>Elasticity of intermediate inputs and value added</th>
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<tr>
<td></td>
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<tr>
<td>--------------------------------</td>
</tr>
<tr>
<td>$\beta_{Go}$</td>
</tr>
<tr>
<td>$t$-stat</td>
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</table>
A model of firm production

- A static model of firm production
- Firm uses capital and intermediate inputs
- Assume a CES production function:

\[
\pi = X \left[ (ZE)^{\frac{\eta-1}{\eta}} + K^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} - PE
\]

- \( X \) – Aggregate profitability shock
- \( Z \) – Idiosyncratic profitability shock
- \( K \) – Capital input (fixed)
- \( E \) – Intermediate input (firm’s choice)
- \( P \) – Price of intermediate input
- \( \eta \) – Elasticity of substitution between capital and intermediate input
Properties of firm cash flows

- Gross profitability increases with idiosyncratic profitability shock ($\eta > 0$)

\[
\frac{GP}{A} \equiv \frac{\pi}{K} = X \left[ \frac{(ZE)^\eta - 1}{\eta} + 1 \right]
\]

- Elasticity of gross profit with respect to the aggregate profitability shock

\[
\frac{\partial \ln \pi}{\partial \ln X} \equiv \beta^\pi_X = \beta^P_X + (1 - \beta^P_X) \left[ \frac{(ZE)^\eta}{\eta} + 1 \right], \quad \beta^P_X \equiv \frac{\partial \ln P}{\partial \ln X}
\]
Conditions for profitability premium

- \( \frac{\partial \beta_X^\pi}{\partial z} > 0 \) means profits of high-profitability firms load stronger on the aggregate profitability shock \( X \)
  \[
  \frac{\partial \beta_X^\pi}{\partial z} > 0 \iff (\eta - 1)(1 - \beta_X^P) > 0
  \]

- The same condition is required for VA to be less cyclical than output,
  \[
  \beta_{X}^{VA} < \beta_{X}^{GO} \iff (\eta - 1)(1 - \beta_X^P) > 0 \iff \frac{\partial \beta_X^\pi}{\partial z} > 0
  \]

- In our model, higher cyclical value of \( V(\Pi) \) relative to \( V(GO) \) implies more profitable firms have higher cash flow risk

- \( \beta_{X}^{VA} < \beta_{X}^{GO} \) is supported by evidence on aggregate elasticities
Firm-level evidence

- Consider relative risk of gross profits and sales in COMPUSTAT sample, 1964—2014

  - **Aggregate level:**
    - Annual sales growth is more volatile than gross profit growth: 5.75% vs 4.99%
    - Elasticity of aggregate profit growth w.r.t sales is 0.75

  - **Different picture at the firm level**
    - Profit growth is more volatile than sales growth: 26.7% vs 21.1%
    - Loading of profit growth on sales growth (in cross-section) is 1.14

- Operating hedge does not work as well at the firm level: price of intermediate inputs correlates with the aggregate profitability shock, but not with idiosyncratic profitability!
Portfolio-level evidence

- Form 5 portfolios by sorting firms on GP/A
- Profit sensitivity to sales rises with profitability: operating hedge is stronger for low-profitability firms
- Operating leverage effect is relatively weak

<table>
<thead>
<tr>
<th>GP/A portf.</th>
<th>Low</th>
<th>2</th>
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<th>Hi</th>
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</thead>
<tbody>
<tr>
<td>$\beta_{Sales}^{GP}$</td>
<td>0.40</td>
<td>0.96</td>
<td>0.95</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(2.44)</td>
<td>(13.03)</td>
<td>(11.34)</td>
<td>(23.89)</td>
<td>(18.78)</td>
</tr>
<tr>
<td>$\beta_{GP}^{OP}$</td>
<td>1.33</td>
<td>1.36</td>
<td>1.53</td>
<td>1.63</td>
<td>1.37</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(7.44)</td>
<td>(41.04)</td>
<td>(32.25)</td>
<td>(23.16)</td>
<td>(26.35)</td>
</tr>
<tr>
<td>$\beta_{Sales}^{OP}$</td>
<td>0.34</td>
<td>1.27</td>
<td>1.41</td>
<td>1.61</td>
<td>1.42</td>
</tr>
<tr>
<td>$t$-stat</td>
<td>(1.85)</td>
<td>(13.29)</td>
<td>(10.41)</td>
<td>(12.94)</td>
<td>(18.49)</td>
</tr>
</tbody>
</table>
Systematic risk in cash flows

- Consider exposure to utilization-adjusted TFP growth (Basu, Fernald, and Kimball, 2006; Fernald 2014) as a measure of systematic risk
- Portfolio-level: regress growth in GP, Sales, and COGS, on TFP growth
- Beta difference between high- and low-profitability portfolios (Hi-Lo):

<table>
<thead>
<tr>
<th>Gross Profit</th>
<th>Sales</th>
<th>COGS</th>
</tr>
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<tbody>
<tr>
<td>1.43</td>
<td>0.84</td>
<td>0.64</td>
</tr>
<tr>
<td>(4.01)</td>
<td>(0.87)</td>
<td>(0.77)</td>
</tr>
</tbody>
</table>

- Spread in Gross Profit risk is driven primarily by composition: COGS/Sales
- Risk of Sales (and COGS) is relatively flat across GP/A portfolios
Gross profitability portfolios differ in systematic risk

- GP/A portfolios differ in exposures to TFP shocks and consumption growth
- TFP shocks are systematic risk: forecast GDP and consumption growth 3-5 years forward
- TFP shocks carry a positive price of risk (GMM test on industry portfolios)
- Direct evidence on portfolio consumption risk: multi-year aggregate consumption response (Parker and Julliard, 2005), 3 and 5 yrs

<table>
<thead>
<tr>
<th></th>
<th>GDP</th>
<th>Durables</th>
<th>Nondurables</th>
<th>Services</th>
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<tbody>
<tr>
<td>3 years</td>
<td>1.35</td>
<td>5.53</td>
<td>1.65</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>(1.91)</td>
<td>(2.88)</td>
<td>(4.69)</td>
<td>(2.2)</td>
</tr>
<tr>
<td>5 years</td>
<td>3.66</td>
<td>9.74</td>
<td>3.64</td>
<td>2.23</td>
</tr>
<tr>
<td></td>
<td>(6.26)</td>
<td>(3.53)</td>
<td>(3.51)</td>
<td>(1.31)</td>
</tr>
</tbody>
</table>
Quantitative analysis: a dynamic model

- Introduce dynamics, capital accumulation
- Investment-specific technological shocks (similar to Kogan and Papanikolaou, 2014)
- Heterogeneity in growth opportunities generates value premium and value factor
- Exogenous stochastic discount factor
- Three systematic aggregate shocks:
  - Investment-specific technology shock
  - Permanent profitability shock
  - Transient profitability shock
- Distinct profitability and value factors in stock returns
Project profitability and capital accumulation

- Firms accumulate projects, each project $j$ uses 1 unit of capital, and $E_{jt}$ units of intermediate inputs

\[
\pi_{jt} = Y_t \left\{ X_t \left[ \left( Z_{jt} E_{jt} \right)^{\frac{\eta-1}{\eta}} + 1 \right]^{\frac{\eta}{\eta-1}} - P_t E_{jt} \right\}
\]

- $Y_t$ -- permanent component of aggregate profitability process

- Capital accumulation subject to aggregate and firm-specific shocks

\[
K_{j,t+1} = (1 - \delta) K_{jt} + \delta S_t A_{jt} K_{jt}
\]

- $A_{jt}$ -- firm-specific investment technology shock, generate dispersion in B/M, growth opportunities

- “Growth” firms have higher loading on the aggregate investment technology shock, $S_t$
Distribution of exogenous shocks

- We assume that (in logs), all productivity shocks except for $Y_t$ follow AR(1) processes.

- $Y_t$ is a geometric random walk.

- Stochastic discount factor assigns constant prices of risk: positive to profitability shocks, negative to investment-specific shock.
  - Based on prior work, e.g., Kogan and Papanikolaou (2013, 2014).

- Cross-sectional differences in average stock returns driven by cash flow exposures to priced fundamental factors.

- This is not an equilibrium model: prices of risk, and the price of intermediate inputs are exogenous.
Price of intermediate inputs

- Price of intermediate inputs (normalized by $Y_t$) is related to aggregate profitability $X_t$
  \[
  \log P_t = \log P_0 + p_1 \log X_t
  \]
- Recall the cyclicality condition $(\eta - 1)(1 - \beta^P_X) > 0$
- Use the cross-sectional relation to estimate $\eta$:
  \[
  \log GM_{jt} = (1 - \eta) \log \left(\frac{GP}{A}\right)_{jt} + (\eta - 1) \log X_t
  \]
- Empirical estimates of $\eta < 1$, therefore set $p_1 > 1$
  - Intermediate good prices are highly cyclical w.r.t. aggregate profitability
Quantitative performance: highlights

- Calibration complicated by lack of direct measurement of primitive shocks
- GP factor in the model (1,000 firms; 600 months; 100 replications)

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<tr>
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<th>4</th>
<th>Hi</th>
<th>Hi-Lo</th>
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<tbody>
<tr>
<td>Mean</td>
<td>6.87</td>
<td>7.74</td>
<td>8.39</td>
<td>9.09</td>
<td>10.00</td>
<td>3.13</td>
</tr>
<tr>
<td>Std</td>
<td>16.95</td>
<td>17.08</td>
<td>17.15</td>
<td>17.23</td>
<td>17.45</td>
<td>5.59</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>-1.52</td>
<td>-0.72</td>
<td>-0.11</td>
<td>0.56</td>
<td>1.36</td>
<td>2.88</td>
</tr>
<tr>
<td></td>
<td>(-3.15)</td>
<td>(-1.51)</td>
<td>(-0.23)</td>
<td>(1.15)</td>
<td>(2.77)</td>
<td>(3.67)</td>
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<tr>
<td>MKT</td>
<td>0.99</td>
<td>0.99</td>
<td>1.00</td>
<td>1.00</td>
<td>1.01</td>
<td>0.03</td>
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<tr>
<td></td>
<td>(117.18)</td>
<td>(119.79)</td>
<td>(122.44)</td>
<td>(119.73)</td>
<td>(120.19)</td>
<td>(2.15)</td>
</tr>
<tr>
<td>$R^2$(%)</td>
<td>95.86</td>
<td>96.03</td>
<td>96.11</td>
<td>96.01</td>
<td>96.01</td>
<td>0.96</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>-2.00</td>
<td>-0.92</td>
<td>-0.17</td>
<td>0.68</td>
<td>1.79</td>
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<tr>
<td></td>
<td>(-4.11)</td>
<td>(-1.89)</td>
<td>(-0.35)</td>
<td>(1.34)</td>
<td>(3.58)</td>
<td>(4.84)</td>
</tr>
<tr>
<td>MKT</td>
<td>1.00</td>
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<td>1.00</td>
<td>0.00</td>
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<tr>
<td></td>
<td>(116.67)</td>
<td>(116.40)</td>
<td>(117.42)</td>
<td>(114.71)</td>
<td>(116.24)</td>
<td>(0.22)</td>
</tr>
<tr>
<td>HML</td>
<td>0.11</td>
<td>0.05</td>
<td>0.01</td>
<td>-0.03</td>
<td>-0.10</td>
<td>-0.20</td>
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<td></td>
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<td>(-1.20)</td>
<td>(-4.19)</td>
<td>(-5.61)</td>
</tr>
<tr>
<td>$R^2$(%)</td>
<td>96.08</td>
<td>96.07</td>
<td>96.12</td>
<td>96.03</td>
<td>96.18</td>
<td>7.82</td>
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</tbody>
</table>
Quantitative performance: highlights

- Model replicates the value premium
- Value factor is distinct from the GP factor (negative correlation)

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<td>8.78</td>
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<tr>
<td>(\alpha)</td>
<td>-2.64</td>
<td>0.31</td>
<td>1.12</td>
<td>1.73</td>
<td>1.86</td>
<td>4.50</td>
</tr>
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<td>MKT</td>
<td>1.07</td>
<td>1.00</td>
<td>0.97</td>
<td>0.96</td>
<td>0.94</td>
<td>-0.13</td>
</tr>
<tr>
<td>(R^2) (%)</td>
<td>94.88</td>
<td>97.20</td>
<td>97.05</td>
<td>96.58</td>
<td>95.58</td>
<td>8.94</td>
</tr>
</tbody>
</table>
Conclusion

- Variable costs are an important component of firm cash flow risk
- Operating leverage is not a full story – variable costs are economically important, create operating hedge
- Lever of gross profitability correlates with the degree of operating hedge in the cross-section, giving rise to the profitability factor and premium
- Directions for future work:
  - Relative price of intermediate inputs is exogenous here. Endogeneity: market power, input-output network, equilibrium effects
  - Estimation and identification analysis
  - Implications for pricing of aggregate shocks from GP return cross-section