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A Production-based Economic Explanation for the Gross Profitability Premium

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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:

$$Profit = Revenue - Cost$$

  - 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 **G**ross **O**utput V(GO) vs value of **I**ntermediate **I**nputs V(II)
- In the aggregate, value of intermediate inputs is volatile relative to output

Volatility of annual growth of Aggregate Gross Output vs Intermediate Input	
Gross Output	**Intermediate Inputs**
2.9%	4.21%

- The value of intermediate inputs is high relative to output

Aggregate: average V(II)/V(GO)	Firm level: median COGS/REVT
44.7%	66.5%

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

Elasticity of intermediate inputs and value added		
	Intermediate Inputs	**Value Added**
β_{GO}	1.34	0.74
***t*-stat**	12.73	9.72

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
  - η – Elasticity of substitution between capital and intermediate input

Properties of firm cash flows

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

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

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

$$\frac{\partial \ln \pi}{\partial \ln X} \equiv \boldsymbol{\beta_X^{\pi}} = \beta_X^P + (1 - \beta_X^P)\left[\left(\frac{ZE}{K}\right)^{\frac{\eta-1}{\eta}} + 1\right], \qquad \beta_X^P \equiv \frac{\partial \ln P}{\partial \ln X}$$

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

$$\frac{\partial \beta_X^{\pi}}{\partial Z} > 0 \;\Leftrightarrow\; (\eta - 1)(1 - \beta_X^{P}) > 0$$

- The same condition is required for VA to be less cyclical than output,

$$\beta_X^{VA} < \beta_X^{GO} \;\Leftrightarrow\; (\eta - 1)(1 - \beta_X^{P}) > 0 \;\Leftrightarrow\; \frac{\partial \beta_X^{\pi}}{\partial Z} > 0$$

- In our model, higher cyclicality of V(II) 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

GP/A portf.	Low	2	3	4	Hi
$\boldsymbol{\beta_{Sales}^{GP}}$	**0.40**	**0.96**	**0.95**	**1.06**	**1.06**
t-stat	(2.44)	(13.03)	(11.34)	(23.89)	(18.78)
β_{GP}^{OP}	1.33	1.36	1.53	1.63	1.37
t-stat	(7.44)	(41.04)	(32.25)	(23.16)	(26.35)
$\boldsymbol{\beta_{Sales}^{OP}}$	**0.34**	**1.27**	**1.41**	**1.61**	**1.42**
t-stat	(1.85)	(13.29)	(10.41)	(12.94)	(18.49)

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):

Gross Profit	Sales	COGS
1.43	0.84	0.64
(4.01)	(0.87)	(0.77)

- 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

	GDP	Durables	Nondurables	Services
3 years	1.35	5.53	1.65	1.32
	(1.91)	(2.88)	(4.69)	(2.2)
5 years	3.66	9.74	3.64	2.23
	(6.26)	(3.53)	(3.51)	(1.31)

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 $(\eta - 1)(1 - \beta_X^P) > 0$
- Use the cross-sectional relation to estimate η:

$$\log GM_{jt} = (1 - \eta) \log \left(\frac{GP}{A} \right)_{jt} + (\eta - 1) \log X_t$$

- 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)

	Lo	2	3	4	Hi	Hi-Lo
Mean	6.87	7.74	8.39	9.09	10.00	3.13
Std	16.95	17.08	17.15	17.23	17.45	5.59
α	-1.52	-0.72	-0.11	0.56	1.36	2.88
	(-3.15)	(-1.51)	(-0.23)	(1.15)	(2.77)	(3.67)
MKT	0.99	0.99	1.00	1.00	1.01	0.03
	(117.18)	(119.79)	(122.44)	(119.73)	(120.19)	(2.15)
$R^2(\%)$	95.86	96.03	96.11	96.01	96.01	0.96
α	-2.00	-0.92	-0.17	0.68	1.79	3.79
	(-4.11)	(-1.89)	(-0.35)	(1.34)	(3.58)	(4.84)
MKT	1.00	1.00	1.00	1.00	1.00	0.00
	(116.67)	(116.40)	(117.42)	(114.71)	(116.24)	(0.22)
HML	0.11	0.05	0.01	-0.03	-0.10	-0.20
	(4.87)	(2.15)	(0.59)	(-1.20)	(-4.19)	(-5.61)
$R^2(\%)$	96.08	96.07	96.12	96.03	96.18	7.82

Quantitative performance: highlights

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

	Lo	2	3	4	Hi	Hi-Lo
Mean	6.45	8.78	9.42	9.89	9.86	3.40
Std	18.46	17.01	16.67	16.42	16.18	7.32
α	-2.64	0.31	1.12	1.73	1.86	4.50
	(-4.50)	(0.76)	(2.80)	(4.07)	(3.90)	(4.59)
MKT	1.07	1.00	0.97	0.96	0.94	-0.13
	(105.63)	(144.85)	(140.35)	(129.89)	(114.20)	(-7.58)
$R^2(\%)$	94.88	97.20	97.05	96.58	95.58	8.94

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