Operations and Finance Interactions

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Overview: What to Remember?

- Assuming long-term arbitrage is dangerous
  - Systematic risk is different from idiosyncratic
  - Requires some adjustment to MSOM model

- Assuming no arbitrage can create computational efficiencies

- In imperfect (i.e., real) markets, operations-finance interactions matter
  - for the firm and the supply chain

- Operational-financial considerations can
  - guide policy and explain empirical observations
Assuming No Arbitrage

• Arbitrage: the ability to start out with (possibly nothing) and never lose and to make a profit in some future states

• Easy to miss because:
  in a pure decision model, “profit” needs to be examined – often not really present

• In particular, financial instruments should not able to provide (sustainable) arbitrage
Risk Implications

• With risky returns, there is a difference between what can be hedged (idiosyncratic) and what cannot be hedged (systematic).

• To (a diversified investor):

\[\text{Hedged} \quad \text{Un-Hedged}\]
Risk Takeaway

• The type of risk matters:
  – Idiosyncratic risk (without other market imperfections) should not be priced
  – Systematic risk should be priced by investors at the market price of risk
  – Lumping systematic and idiosyncratic risk is inconsistent with no-arbitrage

• Paying more for a market item than others are willing to pay is dangerous
Risk-Neutral Pricing Conclusion
(Inter-temporal CAPM)

• The market and idiosyncratic components of cash flows can be separated
• The market components should be priced by the market price of risk (with the remainder diversifiable)
• Simple changes of the probability distribution then give consistent results
Implications for Capacity
(JRB/MSOM 2000)

• USE CORRELATION TO THE MARKET?
  • Can measure for known markets (beta values)
  • If capacitated, depends on decisions
    • Constrained resources - capacity
    • Correlations among demands

• Approach: convert the demand distribution to a risk-neutral equivalent by removing the risk premium
  – Capacity is like an option that can be priced using this approach
Computing Capacity Value

• **Goal:** Production value with capacity $K$
  - Compute uncapacitated value based on CAPM:
    - $S_t = e^{-r(T-t)}\int c_T S_T dF(S_T)$
    - where $c_T$ = margin, $F$ is distribution (with risk aversion),
    - $r$ is rate from CAPM (with risk aversion)
  - **Assume $S_t$ now grows at riskfree rate, $r_f$; evaluate as if risk neutral:**
    - Production value = $S_t - C_t = e^{-rf(T-t)}\int c_T \min(S_T, K) dF_f(S_T)$
    - where $F_f$ is distribution (with risk neutrality)
Computational Efficiencies

• In capacity models (with log-normal demand):
  – Demand distribution transformation is equivalent to a shift of capacity by the risk premium, $e^{(r_m-r_f)(T-t)}$

• For the news vendor (JRB/Zhang, TEE1999), logic yields:

$$F_f(x^*) = \frac{p - c}{p - s} \rightarrow F(e^{(r_m-r_f)(T-t)}x^*) = \frac{p - c}{p - s}$$

or

$$x^* = e^{-(r_m-r_f)(T-t)} F^{-1} \left( \frac{p - c}{p - s} \right).$$
Implications for Flexibility

Resources

(Aytekin/JRB 2004)

• Suppose firms can invest in capacity in multiple locations to take advantage of market fluctuations (exchange rates/demand)

• Implication:
  – Can identify limited set of possible configurations
  – Can develop closed-form expressions of value with computable bounds
Alternative Operations

- Production Distribution

Domestic

Foreign

Advantage of foreign operations:
When cost (exchange rate) is advantageous, can shift production.

Excess capacity in D and F provide an option to shift production to the favorable location.
Valuing the Alternatives

- If sufficient flexible capacity, produce in the market with favorable exchange rate.
- Set thresholds for production shifts to overcome setup and changeover costs.
- Shift production when limits are exceeded.
- Gain: natural balance.
- Cost: additional capacity and transaction.
Value of Flexible Capacity

• Can evaluate the capacity as a perpetual option using only correlation to the market for the elimination of risk

• Value also increasing in the volatility of the exchange rate but reaches a limit:

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Markets Imperfections and Operations-Finance

• Without market imperfections, operational and financial can be separated (Miller/Modigliani)
• Market imperfections make it less possible to create perfect hedges
• Result is that operations and finance cannot be separated
Operations-Finance Links: Implications for the Firm

- Imperfections:
  - Tax advantage of debt
  - Cost of financial distress (e.g., loss in default)


\[
\begin{align*}
\max \quad V(x, D) &= \int_x^\infty \left[ px - \tau(px - cx - rD) \right] f(q) dq \\
&+ \int_x^{q^*} \left[ ps - \tau(ps - cx - rD) \right] f(q) dq \\
&+ \int_{q^*}^{q_b} pqf(q) dq + \alpha \int_0^{q_b} pqf(q) dq - cx(1 + r_f) \\
\text{s.t.} \quad D(1 + r_f) &= D(1 + r)[1 - F(q^b)] + \alpha \int_0^{q_b} pqf(q) dq \\
0 &\leq D \leq cx
\end{align*}
\]
Joint Decision Making in an Imperfect Market
Interactive Effects between Production and Financial Decisions

- Separate operational and financial decision making is sub-optimal
- Production decision is negatively related with the production cost
- Debt decision is positively related with the production cost
- Optimal production decision is a decreasing function of financial leverage
The Effects of Decision Misspecification

Key Observations:

- Firm’s value is a convex function of financial leverage
- The effect of over-leverage is more severe than under-leverage
- Low-margin companies especially exposed to misspecifying decisions
- The effect of production decision misspecification is more severe
Production Margin and Capital Structure

Tradeoff-Theory

An lower profit margin results in higher leverage (Fama & French 2002)

Model results

Leverage ratio is convex and U-shaped in production cost

Empirical Results

For very high margin, leverage ratio appear to increase
Additional Empirical Evidence (JRB 2011)

• With fixed costs in this model, leverage should first increase and then decrease in operating margin

• Leverage/Operating Margin:
Implications for the Supply Chain
(Yang/JRB 2011)

• Trade credit provides a risk-sharing mechanism between firms
• By borrowing from a supplier, a buyer induces the supplier to share in the risk
• Chain coordination can then be enhanced
• Policies should favor junior credit
• Empirical evidence:
  – Firms use trade credit then short-term when needed
  – Making suppliers senior seems to hurt trade credit
Summary Observations

• Operational decisions should be consistent with financial realities
• Operational and financial decisions are interdependent in practical markets
• Inter-dependencies extend throughout the supply chain
• Operational analyses (particularly the role of commitment) can explain observed behavior and guide policy
• Much more research is needed at this interface
Thank you to MSOM!