How Does Variance of Product Ratings Matter?

Monic Sun
Stanford University
Amazon’s New Look

Customer Rating:

Average customer rating based on 6 comments:

Customer Reviews

1,792 Reviews

<table>
<thead>
<tr>
<th>Rating</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 star</td>
<td>(792)</td>
</tr>
<tr>
<td>4 star</td>
<td>(254)</td>
</tr>
<tr>
<td>3 star</td>
<td>(161)</td>
</tr>
<tr>
<td>2 star</td>
<td>(130)</td>
</tr>
<tr>
<td>1 star</td>
<td>(455)</td>
</tr>
</tbody>
</table>

Average Customer Review

★★★★☆ (1,792 customer reviews)

new chart!
Research Questions

1. How does price change with the variance?

2. How does demand change with the variance?

3. How does profit change with the variance?
Literature Review

- POSITIVE IMPACT: Clemons, Gao and Hitt (2006)
- NEGATIVE IMPACT: Meyer (1981)
- NO IMPACT: Zhang (2006)
- HELPS GOOD PRODUCTS: Martin, Barron and Norton (2007)
- HELPS BAD PRODUCTS: West and Broniarczyk (1998)

no consensus, little modeling, focus on demand
Anchored Model

- A seller and many risk-neutral consumers
- Consumers have different tastes

- each consumer knows his own taste $x$
- common knowledge: $x$ is uniformly distributed on $[0,1]$
$U(x) = v - t \cdot x - P$

- $v$ and $t$ are random variables
Example: Cartoon Films
Product Life Cycle

Period 1

Product is born
Seller chooses price
Early consumers make purchase decisions
Rating & updating

Period 2

Seller chooses new price
Late consumers make purchase decisions

ratings are functions of product attributes
late consumers back out product attributes
Product Ratings

Rating formula: $S(x) = v - t \cdot x$

highest score: $v$

lowest score: $v - t \cdot D_i$

marginal consumer

perfectly matched consumer

marginal consumer
Equilibrium Outcomes

**Period 1 Solution**

\[ \text{Max } P_1 \cdot D_1 \]
\[ \text{s.t. } E(v) - E(t) \cdot D_1 - P_1 = 0 \]

\[ P_1^* = \frac{E(v)}{2}; \quad D_1^* = \frac{E(v)\cdot E(t)}{2E(t)}; \quad \Pi_1^* = \frac{E(v)^2}{4E(t)} \]

**Period 2 Solution**

\[ \text{Max } P_2 \cdot D_2 \]
\[ \text{s.t. } v - t \cdot D_2 - P_2 = 0 \]

\[ P_2^* = \frac{v}{2}; \quad D_2^* = \frac{v}{2t}; \quad \Pi_2^* = \frac{v^2}{4t} \]

**Consumer Updating**

\[ M = v - \frac{1}{2} t \cdot D_1; \]
\[ V = \frac{1}{12} (t \cdot D_1)^2 \]

\[ v = M + \sqrt{3V}; \quad t = \frac{2\sqrt{3V}}{D_1} \]
Ratings’ Impact: what we already know

\[ P_2^* = \frac{M + \sqrt{3V}}{2}; \quad D_2^* = \frac{D_1}{4} \left( \frac{M}{\sqrt{3V}} + 1 \right); \quad \Pi_2^* = \frac{D_1}{4} \left( \frac{M^2}{\sqrt{3V}} + \sqrt{3V} + 2M \right). \]

1. Price increases over time for high-variance products
   (Bergemann & Välimäki 2006)

2. Higher average rating increases price, demand, and profit
   (Elberse & Eliashberg 2003; Chevalier & Mayzlin 2006; Cao & Gruca 2004; Bruce, Haruvy & Rao 2004)
Ratings’ Impact: what we did not know

FOR A GIVEN, HIGH, AVERAGE RATING

- **mainstream**: high return to advertising
- **flops**: low return to advertising
- **niche products**: high return to advertising

Variance
Test I: Motion Pictures

Test how first day box office responds to variance of pre-release critic ratings

Why movies?

– billion dollar industry
– differentiated consumer tastes
– fixed price
– disagreement often a salient cue
403 wide-release movies in 2002-2006

- sources: boxofficemojo.com & metacritic.com
- # of ratings 21.3; average score 55.1 points
- SD 15.1 points; SD of SD 3.7 points
- first day BO $7.9m
Incorporating Fixed Price

\[ D_2 = C_1 \cdot \left( \frac{M - P}{2\sqrt{3V}} + \frac{1}{2} \right) \]

- **P1** First day BO increases with average rating
- **P2** First day BO increases with variance iff M<P
## Impact of Critic Ratings

### Dependent Variable: Log (first day BO)

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<thead>
<tr>
<th></th>
<th>BO</th>
<th>BO</th>
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<tbody>
<tr>
<td>Average Rating</td>
<td>0.007**</td>
<td>0.025***</td>
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<td>SD of Ratings</td>
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<td>0.057*</td>
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<tr>
<td>AR * SD</td>
<td>-0.001**</td>
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<tr>
<td>No. of Ratings</td>
<td>0.016</td>
<td>0.017*</td>
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</table>

Observations: 403

- BO $\uparrow$ with SD iff AR < 57, true for 57% movies
- BO $\uparrow$ with AR iff SD < 25, true for 99% movies
Test II: Books

Test how book sales respond to variance of consumer ratings

Why books?
- ratings and reviews are proven to be considered
- DID approach: Chevalier & Mayzlin 06
- public data source
892 random books from the bestseller section of Global Books in Print

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Observations: 892
Difference-in-Differences

One Fifth Avenue
by Candace Bushnell
(Paperback - Reprint)

Reader Rating: ★★★★☆ (54 ratings)

Detailed Rating:
"Book Cover" See All

- Pub. Date: June 2009
- 464pp
- Sales Rank: 4,301

Available in eBook

More Formats
- Hardcover: $20.76
- Paperback - Bargain: $4.98
- Compact Disc - Abridged, 7 CDs, 8 hrs.: $14.99
- MP3 Book - Abridged: $7.46

Write a Review
DID: Books with <30 reviews

- **pleasantly surprised**
  - **Rating:** ★★★☆☆
  - By: penname96
  - Date: August 28, 2009
  - Review:
    - The book has been in my pile for a while. It was like a movie you really don't want to go see, but are dragged to, then you are pleasantly surprised. No, this is not a "Sex In the City" book. This is a fresh story about people who live at One Fifth Ave and how their everyday lives are entangled. I enjoyed and recommend.
  - Helpfulness: 0 out of 0 people found this review helpful.

- **Fun Read**
  - **Rating:** ★★★★☆
  - By: penname96
  - Date: July 11, 2009
  - Review:
    - Full of interesting and very real characters. I thought the plot was focused and even though I have never lived in New York I was able to appreciate the setting and life style of the characters. I understood and could relate to each character as an individual. I also appreciate that the story line came back around. There were several characters introduced throughout the story and it was clear how each character was related to the story and had significance to each other. I loved the book and was happy I took the time to read it!
Summary Stats of 87 books

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<tr>
<td># Reviews</td>
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<td>4.8</td>
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<td>Amazon (\Delta) Average Rating</td>
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<td>1.599***</td>
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<td>-2.784***</td>
<td>-2.926***</td>
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<td>Amazon (\Delta) ln(No. of Ratings)</td>
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<td>-0.062</td>
<td>-0.246</td>
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<td>0.456</td>
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<td>Amazon (\Delta) Average Rating</td>
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<td>0.655</td>
<td>-1.191*</td>
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<td>-5.424**</td>
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<td>Amazon (\Delta) AR*SD</td>
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<tr>
<td>BN (\Delta) AR*SD</td>
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</tr>
</tbody>
</table>

R square: 0.29, 0.31, 0.39

Sales ↑ with SD if AR < 4.19, true for 56% books
Test III: Computer Products

Goals

– how does price change when chart appears?
– when does seller show the chart?

– Newegg pioneered the chart
– both are leading sellers of computer products
Price Comparison

**Price difference increases with SD of ratings**

<table>
<thead>
<tr>
<th>Dependent Variable: Newegg Price – TigerDirect Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newegg SD of Ratings</td>
</tr>
<tr>
<td>Average Rating</td>
</tr>
<tr>
<td>Average No. of Ratings</td>
</tr>
<tr>
<td>Observations</td>
</tr>
</tbody>
</table>
Newegg sells higher fractions of mainstream & niche products
Contributions

1. First model on consumer disagreement
   (U shape helps unify mixed evidence)

2. First empirical analysis on rating distribution
   (interaction term is crucial)

3. New rules of thumb for managers
   (pricing, advertising, chart)
Thank You!

monic@stanford.edu
• demand always increases with variance if \( \alpha < \frac{1}{4} \frac{E(v)}{\bar{v}} \frac{t}{E(t)} \)

• demand always decreases with variance if \( \alpha > \frac{1}{4} \frac{E(v)}{\bar{v}} \frac{t}{E(t)} \)

\( U(x) = v - (t \cdot x)^\alpha - P \)

\( \text{Rating} = v - t \cdot x \)
71% online shoppers seek out product reviews

Model change: d, n

Higher variance leads to higher price iff n>1

Lower first-period price (even lower with high d)
Duopolistic Competition

• Competition may overturn effect of ratings

• Model change: Firms A & B located at each end

• **When does high variance help?**
  – low average rating
  – competitor has high average rating and low SD
Contradict Empirical Results

- $v$ with probability $p$, rating is $v$
- $0$ with probability $1-p$, rating is $0$, inconvenience cost is $c$
- expected utility $p \cdot v - (1-p) \cdot c$ decreases in variance

Comments with One-Star Reviews

- I gave it one not because the board cannot perform. Mainly want to warn others if you are going to install win2k avoid this board…

- Panda 2007 is a good product, IF.. you never need tech support.
User Ratings

235 wide-release movies in Jan 2002-Sept. 2004

- source: Yahoo! Movies
- # of ratings 4,097; SD of 6,048
- average score 9.1/13 points
- SD 3.7 points; SD of SD 0.7 points
## Impact of User Ratings

<table>
<thead>
<tr>
<th>Dependent Variable: Log (first day BO)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Critic Rating</td>
<td>0.018*</td>
<td>0.019*</td>
</tr>
<tr>
<td>SD of Critic Ratings</td>
<td>0.084***</td>
<td>0.083***</td>
</tr>
<tr>
<td>AR * SD Critic Ratings</td>
<td>-0.002***</td>
<td>-0.002***</td>
</tr>
<tr>
<td>No. of Critic Ratings</td>
<td>0.069***</td>
<td>0.069***</td>
</tr>
<tr>
<td>Average User Rating</td>
<td>0.072</td>
<td>0.578***</td>
</tr>
<tr>
<td>SD of User Ratings</td>
<td>-0.039</td>
<td>1.231**</td>
</tr>
<tr>
<td>AR * SD User Ratings</td>
<td>-0.124***</td>
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<tr>
<td>No. of User Ratings</td>
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Observations: 235