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   - The Experiment and Data Collection
   - Advertising Campaigns and Search Keywords
   - Summary Statistics

3 Empirical Analysis and Results
   - Econometric Model
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   - Robustness Checks

4 Discussion of Results
   - Display and Search Advertising Complementarities
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Introduction

- The purpose of this paper is to understand how display advertising affects consumers’ online search behaviors.
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We hypothesize that display ads cause consumers to search for the advertised brand.

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- We hypothesize that display ads cause consumers to search for the advertised brand.
- We also hypothesize that display ads cause consumers to search for competitors’ brands because the ad also primes the product category.
- We use our findings to explore the economic impacts of advertising spillovers display advertising market on the search advertising market and on firms’ investment in advertising.
Related Literature

Research on Advertising and Online Searching

• Mayzlin and Shin (2011): separating equilibrium in which high quality firms opt invite the consumer to search.

• Swasy and Rethans (1986): found in the lab that advertising for new products creates curiosity among consumers with high product category knowledge.

• Menon and Soman (2002): advertising that cued curiosity increased time spent and attention on gathering information but did not increase the number of clicks on links for more information.

Research on Effects Across Media Channels

• Alba and Chattopadhyay (1985): cueing a brand inhibited recall of other category and related brands.

• Nedungadi (1990): priming of a minor brand increases retrieval and consideration of major brand, but not vice versa.
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Research on Display Advertising Effectiveness

- Dreze and Hussherr (2003): users avoid looking at display ads, but frequency increased unaided brand recall.
- Lewis (2010): click-through rates modestly decline in the number of impressions shown a user.
- Goldfarb and Tucker (2011a,b): limits on targeting reduce, but match and obtrusiveness increase ad effects on surveyed purchase intent.

Research using Search to Measure Ad Effectiveness

- Joo, Wilbur, and Zhu (2011): consumers' exposure to branded TV ads is correlated with online searches for these brands.
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Yahoo! sells the primary ad unit on Yahoo!’s front page, www.yahoo.com, to one advertiser for the whole day or splits the day between two advertisers.
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• Users who arrive on “even” seconds see one advertiser’s ad while those who arrive on “odd” seconds see the other ad.
The Natural Experiment

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- This provides a natural experiment to analyze the effects of advertising.
• We use ad splits where the target and control ads were from unrelated product categories.
Treatment v. Control

- We use ad splits where the target and control ads were from unrelated product categories.
- We record the anonymous user’s searches on Yahoo! for ten minutes after the ad is delivered.
Treatment v. Control

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• The delivery of each target (control) ad impression marks the start of a treatment (control) period.
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• Each period ends either after ten minutes or when another impression is delivered to the same user, whichever comes first.
  ▶ Ten minutes should be long enough for users to act upon the ad and short enough to avoid misattributing activities to the wrong ad impression.
  ▶ A ten minute window also yields the most statistical power.
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# The Ad Campaigns

<table>
<thead>
<tr>
<th>Date of Ad Split</th>
<th>Target Ad</th>
<th>Control Ad</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 January 2011</td>
<td><img src="image1.jpg" alt="Target Ad" /></td>
<td><img src="image2.jpg" alt="Control Ad" /></td>
</tr>
<tr>
<td>10 February 2011</td>
<td><img src="image3.jpg" alt="Target Ad" /></td>
<td><img src="image4.jpg" alt="Control Ad" /></td>
</tr>
<tr>
<td>29 June 2011</td>
<td><img src="image5.jpg" alt="Target Ad" /></td>
<td><img src="image6.jpg" alt="Control Ad" /></td>
</tr>
</tbody>
</table>
• We recorded searches that had the advertiser’s or competitors’ brands as search terms.
The Search Keywords

- We recorded searches that had the advertiser’s or competitors’ brands as search terms.
- Lists of competitors’ brands were collected online.

Progressive’s Competitors’ Brands
- 14 brands.
- Examples: State Farm, Allstate, Geico, and USAA.
- Source: Dec. 2009 Mintel auto insurance industry report.

Acura’s Competitors’ Brands
- 36 brands.
- Examples: Audi, BMW, Ford, and Lexus.
- Source: Autobytel.com.

Samsung Galaxy Tab’s Competitors’ Brands
- 15 brands.
- Examples: Apple iPad, Blackberry Playbook, and Motorola Xoom.
- Source: “CNET looks at current and upcoming tablets” (July 29, 2011).
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# Data Summary

<table>
<thead>
<tr>
<th>Variables and Statistics</th>
<th>Progressive Auto Insurance</th>
<th>Acura TSX</th>
<th>Samsung's Galaxy Tab</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date of Ad Split</strong></td>
<td>2011/01/11</td>
<td>2011/02/10</td>
<td>2011/06/29</td>
</tr>
<tr>
<td><strong>Sample Sizes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Unique Visitors</td>
<td>40,673,687</td>
<td>41,313,836</td>
<td>37,620,318</td>
</tr>
<tr>
<td>Total Number of Visits</td>
<td>171,953,331</td>
<td>171,593,781</td>
<td>161,460,200</td>
</tr>
<tr>
<td>Total Number of Exposures to the Target Ad</td>
<td>86,152,779</td>
<td>85,684,914</td>
<td>80,866,903</td>
</tr>
<tr>
<td><strong>Percentage of Users Who Searched for Relevant Keywords</strong></td>
<td>0.06%</td>
<td>0.80%</td>
<td>0.04%</td>
</tr>
<tr>
<td><strong>Total Number of Visits per User</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>4.23</td>
<td>4.15</td>
<td>4.29</td>
</tr>
<tr>
<td>Median</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td><strong>Total Number of Exposure to the Target Ad per User</strong></td>
<td>2.12</td>
<td>2.07</td>
<td>2.15</td>
</tr>
<tr>
<td>Mean</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Median</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Distribution of Total Number of Exposures to the Test Ad

Number of Impressions Delivered

Number of Users

Progressive Auto Insurance
Acura TSX
Samsung Galaxy Tab
Distribution of Total Number of Exposures to the Target Ad for Users Who Visited the Front Page 10 times
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Measuring the Search Lift

\[ \text{Search}_{ijt} = \alpha_j + \beta_j AD_{it} + \epsilon_{ijt} \]
Measuring the Search Lift

\[ \text{Search}_{ijt} = \alpha_j + \beta_j \text{AD}_{it} + \epsilon_{ijt} \]

- \( \text{Search}_{ijt} \) is an indicator variable equal to one if user \( i \) searched for brand \( j \) during period \( t \).
$\text{Search}_{ijt} = \alpha_j + \beta_j AD_{it} + \epsilon_{ijt}$

- $\text{Search}_{ijt}$ is a indicator variable equal to one if user $i$ searched for brand $j$ during period $t$.
- $AD_{it}$ is a indicator variable equal to one if user $i$ is delivered the target ad at time $t$. 
Measuring the Search Lift

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- \( \epsilon_{ijt} \) is the residual which we cluster at the individual level in estimation.
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- \( \text{AD}_{it} \) is a indicator variable equal to one if user \( i \) is delivered the target ad at time \( t \).
- \( \epsilon_{ijt} \) is the residual which we cluster at the individual level in estimation.

Using OLS, we estimate \( \beta_j \) to obtain the average increase in searches for product \( j \) caused by the display ad.
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Significant Lift in Searches for the Advertiser

<table>
<thead>
<tr>
<th>Advertiser</th>
<th>Extra Searches (1)</th>
<th>Percentage Lift in Searches (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressive</td>
<td>1,135*</td>
<td>30.0%</td>
</tr>
<tr>
<td>Acura</td>
<td>1,555*</td>
<td>45.0%</td>
</tr>
<tr>
<td>Samsung Galaxy Tab</td>
<td>424*</td>
<td>42.0%</td>
</tr>
</tbody>
</table>

Table

Notes:
(1) * indicates statistical significance.
(2) Percentage lift calculated as (extra searches / baseline searches) * 100%.
Significant Lift in Searches for the Competitors

Table

<table>
<thead>
<tr>
<th>Brand</th>
<th>Extra Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressive's Competitors' Brands</td>
<td>327</td>
</tr>
<tr>
<td>Acura's Competitors' Brands</td>
<td>12,035*</td>
</tr>
<tr>
<td>Samsung Galaxy Tab's Competitors' Brands</td>
<td>994*</td>
</tr>
</tbody>
</table>
No Significant Decrease in Searches for Any Competitors: Progressive’s Competitors

<table>
<thead>
<tr>
<th>Percentage Lift in Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>21st Century</td>
</tr>
<tr>
<td>State Farm</td>
</tr>
<tr>
<td>Farmer’s</td>
</tr>
<tr>
<td>American Family</td>
</tr>
<tr>
<td>Travelers</td>
</tr>
<tr>
<td>Erie</td>
</tr>
<tr>
<td>Liberty Mutual</td>
</tr>
<tr>
<td>USAA</td>
</tr>
<tr>
<td>Geico</td>
</tr>
<tr>
<td>Allstate</td>
</tr>
<tr>
<td>Nationwide</td>
</tr>
<tr>
<td>AIG</td>
</tr>
<tr>
<td>Safeco</td>
</tr>
</tbody>
</table>

Significant at 5% Level
Insignificant
No Significant Decrease in Searches for Any Competitors: Acura’s Competitors

| Percentage Lift in Searches | Lincoln | Mini | Ford | Toyota | Jeep | Audi | Smart | Porsche | Scion | Dodge | Buick | Kia | Fiat | Honda | Lotus | Cadillac | Nissan | GMC | Infiniti | Suzuki | BMW | Mercedes | Jaguar | Mitsubishi | Chrysler | Mazda | Volkswagen | Land Rover | Hyundai | Lexus | Subaru | Rolls Royce | Tesla | Saab | Volvo |
|-----------------------------|--------|------|------|--------|-----|-----|-------|---------|-------|-------|-------|-----|-----|-------|-------|----------|--------|-----|---------|--------|-----|---------|--------|-------|--------|----------|--------|-----|-------|----------|------|------|-----|
No Significant Decrease in Searches for Any Competitors: Samsung Galaxy Tab’s Competitors
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Limiting the sample to just first impressions and to users who visit only once.
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- Pros: Eliminates concerns about misattributing.
Limiting the sample to just first impressions and to users who visit only once.

- Pros: Eliminates concerns about misattributing.
- Cons: Misses out on the majority of impressions, obtains a different average effect for a different composition of impressions, weaker results due to smaller sample sizes.
Limiting the sample to just first impressions and to users who visit only once.

- **Pros**: Eliminates concerns about misattributing.
- **Cons**: Misses out on the majority of impressions, obtains a different average effect for a different composition of impressions, weaker results due to smaller sample sizes.

Decompose the branded search counts into words, queries, and domains clicked.
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- Pros: Provides a much richer view of the effects of the advertising.
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Decompose the branded search counts into words, queries, and domains clicked.

- **Pros:** Provides a much richer view of the effects of the advertising.
- **Cons:** False discovery risks require higher levels of statistical significance to avoid spurious conclusions.
Robustness Checks Limiting the Sample to the First Impressions

<table>
<thead>
<tr>
<th></th>
<th>Full Sample</th>
<th>Limited to the first impression</th>
<th>Limited to users who were delivered one impression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daily Total Search Lift</td>
<td>Daily Total Search Lift</td>
<td>Lower Bound 95% CI</td>
</tr>
<tr>
<td><strong>Samsung Galaxy Tab Advertising Campaign</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samsung Galaxy Tab</td>
<td>424</td>
<td>503</td>
<td>190</td>
</tr>
<tr>
<td>All Competitors</td>
<td>994</td>
<td>257</td>
<td>-964</td>
</tr>
<tr>
<td><strong>Acura Advertising Campaign</strong></td>
<td></td>
<td></td>
<td></td>
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<td>Acura</td>
<td>1,555</td>
<td>1,037</td>
<td>466</td>
</tr>
<tr>
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<td>12,035</td>
<td>10,161</td>
<td>4,259</td>
</tr>
<tr>
<td><strong>Progressive Auto Insurance Advertising Campaign</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Progressive</td>
<td>1,135</td>
<td>433</td>
<td>-234</td>
</tr>
<tr>
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<td>327</td>
<td>326</td>
<td>-1,225</td>
</tr>
</tbody>
</table>
• As expected, there were statistically significant increase in clicking on the Brands’ URLs.

• There were statistically significant increase in clicking and searching for sales channels’ websites.
  ▶ For example, Samsung Galaxy Tab increased clicking to Best Buy, Staple’s, Target, Apple’s Store website, and ebay.

• There were significant increase in clicking to review websites.
  ▶ Acura ad increase clicking to Motortrend.com, caranddriver.com, edmunds.com, and autobytel.com.
  ▶ Samsung ad increase clicking to reviews.cnet.com and besttablet2011.com.
• As expected, there were statistically significant increase in clicking on the Brands’ URLs.

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Search Composition Robustness Checks

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• Increase in searches leads to a greater expected number of clicks on a search ad.
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• The increase in clicks may make entry into advertising on new keywords cost-effective.
Increasing Searches Decreases Costs for Search Advertiser

- Increase in searches leads to a greater expected number of clicks on a search ad.

- The increase in clicks may make entry into advertising on new keywords cost-effective.

- More directly, it can also decrease the CPC for a fix expected number of clicks by the nature of the generalized second price (GSP) auction.
Decreasing CPC for a fixed expected number of clicks

- In the GSP auction, CPC is increasing with CTR on a given search result page.
  - In equilibrium of the GSP auction, CPC for ads at the top page of the page, a higher CTR spot, is more than that for ads at the bottom of the page.
Decreasing CPC for a fixed expected number of clicks

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  ▶ In equilibrium of the GSP auction, CPC for ads at the top page of the page, a higher CTR spot, is more than that for ads at the bottom of the page.

- Because the increase of searches increases the expected number of clicks, holding the expected number of clicks constant permits an advertiser to bid for a lower CTR ad position, lowering the CPC.
Decreasing CPC for a fixed expected number of clicks

- In the GSP auction, CPC is increasing with CTR on a given search result page.
  - In equilibrium of the GSP auction, CPC for ads at the top page of the page, a higher CTR spot, is more than that for ads at the bottom of the page.

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- As a result, display advertising increases the marginal profitability of a click for both the display advertiser and its competitors by increasing the number of searches.
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Display advertising is both a strategic complement and complement to search advertising
CPC Increases with CTR

* CTRs for the four search ad positions are averages for a sample of queries with at least four ads from Reiley, Li, and Lewis (2010).
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• We find:
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  ▶ Profits are increasing in spillovers.
Advising investment decreases in the magnitude of spillovers.

- Diagram shows a line graph with the x-axis labeled "Spillovers" and the y-axis labeled "Equilibrium Level of Advertising".
- The graph illustrates a downward trend, indicating that as the magnitude of spillovers increases, the equilibrium level of advertising decreases.
Prices are increasing and decreasing in spillovers over different ranges of spillovers.
Profits are increasing in spillovers.
Outline

1. Introduction & Related Literature
2. Methodology
   - The Experiment and Data Collection
   - Advertising Campaigns and Search Keywords
   - Summary Statistics
3. Empirical Analysis and Results
   - Econometric Model
   - Advertiser and Competitor Search Lifts
   - Robustness Checks
4. Discussion of Results
   - Display and Search Advertising Complementarities
   - Advertising Investment and Competitive Spillovers
5. Conclusion
6. Appendix
• Display ads increased searches for both the advertiser’s brand as well as its competitors’ brands.
Conclusion

- Display ads increased searches for both the advertiser’s brand as well as its competitors’ brands.
  - Advertiser’s branded searches increased by 30% to 45%.
    - "iPad" received twice as many incremental searches as "Galaxy Tab."
Conclusion

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  - Advertiser’s branded searches increased by 30% to 45%.
  - Competitors’ brands increased by as much as 23%.
  - Total increase in competitor-branded searches was 2 to 8 times the increase for the advertiser’s brand.
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- The extra searches create a cost-complementarity between display and search advertising.
- The presence of positive spillovers may reduce advertising investment relative to no spillovers.
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Future Research

Positive advertising spillovers raise many questions:

• Will researchers find proportional effects on sales and profits?
• Are there similar spillovers from all other forms of advertising?
• Are the spillovers illustrated in online search a proxy for customer search behavior more generally?
• Are online search queries a proportional representation of causal attention induced by the ad?

Smart phones and tablets provide mobile access to online search allowing customers to inquire about people, locations, products, and services.

We hope to see future research explore these and other related questions, leveraging these new technologies, to help advertisers and publishers improve the effectiveness of advertising and the efficiency of advertising marketplaces.
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6 Appendix
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<td>Percentage Lift</td>
<td>Competitor/Own</td>
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## Table: Percentage Lift in Searches for Samsung Galaxy Tab’s Competitors

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<th>Searches</th>
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<th>Percentage Lift</th>
<th>Competitor/Own</th>
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<td>Cluster T-stat</td>
<td>Estimate</td>
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<td>Samsung Galaxy Tab</td>
<td>958</td>
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<td>20.57</td>
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<td>68.64</td>
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<td>16.74</td>
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<td>317</td>
<td>11.92</td>
<td>11.34</td>
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</table>
A Stylized Model of the Complements

Let

- $A_d$ - Quantity of Display Ad Impressions
- $A_s$ - Quantity of Expected Number of Search Ad Clicks
- $\nu_s$ - Marginal Revenue for a Search Click
- $\nu_d$ - Marginal Revenue for a Display Ad Impression
- $P_s(\cdot)$ - GSP Auction’s Equilibrium CPC as a function of CTR.
  - $P_s'(\cdot) > 0$
- $Q_s(\cdot)$ - Quantity of Searches as a function of $A_d$.
  - $Q_s'(\cdot) > 0$. 
A Stylized Model of Complements

Profit Function

\[ \Pi(A_d, A_s) = A_d v_d + A_s v_s + A_d P_d(A_d) + A_s P_s(A_s) Q_s(A_d) \]

Marginal Profit w.r.t. \( A_s \)

\[ \frac{\partial \Pi}{\partial A_s} = v_s - P_s(A_s) Q_s(A_d) - A_s Q_s(A_d) P''_s(A_s) Q_s(A_d) \]

Change in Marginal Profit w.r.t. \( A_d \)

\[ \frac{\partial^2 \Pi}{\partial A_s \partial A_d} = Q'_s(A_d) Q_s(A_d)^2 (1 + A_s A_s Q_s(A_d) P'_s(A_s) Q_s(A_d)) + A_s Q_s(A_d) P''_s(A_s) Q_s(A_d) \]

This implies that

\[ \frac{\partial^2 \Pi}{\partial A_s \partial A_d} > 0 \] if

\[ P''_s(A_s) Q_s(A_d) > -1 + A_s A_s Q_s(A_d) P'_s(A_s) Q_s(A_d) \]
A Stylized Model of Complements

Profit Function

\[ \Pi(A_d, A_s) = A_d v_d + A_s v_s + A_d P_d(A_d) + A_s P_s \left( \frac{A_s}{Q_s(A_d)} \right) \]
# A Stylized Model of Complements

## Profit Function

\[ \Pi(A_d, A_s) = A_d \nu_d + A_s \nu_s + A_d P_d(A_d) + A_s P_s \left( \frac{A_s}{Q_s(A_d)} \right) \]

## Marginal Profit w.r.t. \( A_s \)

\[ \frac{\partial \Pi}{\partial A_s} = \nu_s - P_s \left( \frac{A_s}{Q_s(A_d)} \right) - \frac{A_s}{Q_s(A_d)} P_s' \left( \frac{A_s}{Q_s(A_d)} \right) \]
A Stylized Model of Complements

**Profit Function**

\[ \Pi(A_d, A_s) = A_d \nu_d + A_s \nu_s + A_d P_d(A_d) + A_s P_s \left( \frac{A_s}{Q_s(A_d)} \right) \]

**Marginal Profit w.r.t. \( A_s \)**

\[ \frac{\partial \Pi}{\partial A_s} = \nu_s - P_s \left( \frac{A_s}{Q_s(A_d)} \right) - \frac{A_s}{Q_s(A_d)} P_s' \left( \frac{A_s}{Q_s(A_d)} \right) \]

**Change in Marginal Profit w.r.t. \( A_d \)**

\[ \frac{\partial^2 \Pi}{\partial A_s \partial A_d} = \frac{Q_s'(A_d)}{Q_s(A_d)^2} \left( (1 + A_s) P_s' \left( \frac{A_s}{Q_s(A_d)} \right) + \frac{A_s}{Q_s(A_d)} P_s'' \left( \frac{A_s}{Q_s(A_d)} \right) \right) \]
### Profit Function

\[
\Pi(A_d, A_s) = A_d v_d + A_s v_s + A_d P_d(A_d) + A_s P_s \left( \frac{A_s}{Q_s(A_d)} \right)
\]

### Marginal Profit w.r.t. \( A_s \)

\[
\frac{\partial \Pi}{\partial A_s} = v_s - P_s \left( \frac{A_s}{Q_s(A_d)} \right) - \frac{A_s}{Q_s(A_d)} P'_s \left( \frac{A_s}{Q_s(A_d)} \right)
\]

### Change in Marginal Profit w.r.t. \( A_d \)

\[
\frac{\partial^2 \Pi}{\partial A_s \partial A_d} = \frac{Q'_s(A_d)}{Q_s(A_d)^2} \left( (1 + A_s) P'_s \left( \frac{A_s}{Q_s(A_d)} \right) + \frac{A_s}{Q_s(A_d)} P''_s \left( \frac{A_s}{Q_s(A_d)} \right) \right)
\]

This implies that

- \( \frac{\partial^2 \Pi}{\partial A_s \partial A_d} > 0 \) if \( P''_s \left( \frac{A_s}{Q_s(A_d)} \right) > - \frac{1+A_s}{A_s} Q_s(A_d) P'_s \left( \frac{A_s}{Q_s(A_d)} \right) \)
Ad Awareness Investment and Spillovers

We adapt Grossman and Shapiro (1984) to the setting with advertising spillovers. Given

- a unit mass of consumers, uniformly distributed on unit line
- two firms, located on opposite ends of the line
- that if a consumer is aware of a product, he is also knows its price
- that consumers know of a firm if they receive an ad
- that receiving an advertiser’s ad also makes the consumer aware of the competitor’s product with a certain probability
Ad Awareness Investment and Spillovers

Let

- $\phi_i$ - Fraction of consumers to receive firm $i$’s ad
- $\delta$ - Spillover of awareness to competitor from receiving an ad
- $\tau$ - Transportation cost
- $R$ - Reservation price
- $D(\cdot), P,$ and $c$ - Quantity demanded, unit price, and unit cost, respectively.
Demand Curve for Firm $i$'s Product

$$D_i(P_i, P_i', \phi_i, \phi_i') = (\phi_i + \delta\phi_i') \left( (1 - (\phi_i' + \delta\phi_i)) + (\phi_i' + \delta\phi_i) \frac{P_i' - P_i + \tau}{2\tau} \right)$$

Equilibrium Prices and Profits

$$P^e = c + \tau \frac{2 - (1 + \delta)\phi^e}{(1 + \delta)\phi^e}$$

$$\Pi^e = \tau \left( \frac{2 - (1 + \delta)\phi^e}{2} \right)^2 - \frac{a}{2} \left( \phi^e \right)^2$$

Equilibrium Advertising Level

$$\phi^e = \frac{(2 + \delta) - \sqrt{(2 + \delta)^2 - 4 \left[ \frac{(1+\delta)^2-2\frac{a}{\tau}}{1+\delta} \right]}}{(1 + \delta)^2 - 2\frac{a}{\tau}}.$$