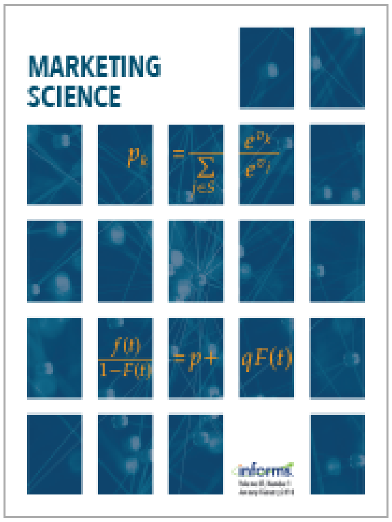


Marketing Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Costly Collusion in Differentiated Industries

Raphael Thomadsen, Ki-Eun Rhee,

To cite this article:
Raphael Thomadsen, Ki-Eun Rhee, (2007) Costly Collusion in Differentiated Industries. Marketing Science 26(5):660-665.
https://doi.org/10.1287/mksc.1060.0255

MARKETING SCIENCE
Vol. 26, No. 5, September–October 2007, pp. 660–665
ISSN 0732-2399 | EISSN 1526-548X | 07 | 2605 | 0660

DOI 10.1287/mksc.1060.0255

Costly Collusion in Differentiated Industries

Raphael Thomadsen
UCLA Anderson, 110 Westwood Plaza, Suite B411, Los Angeles, California 90095,
raphael.thomadsen@anderson.ucla.edu

Ki-Eun Rhee
KDI School of Public Policy, 207-43 Cheongnyangri-dong, Dongdaemun-gu, Seoul, Korea 103-868,
krhee@kdischool.ac.kr

This paper demonstrates that increased product differentiation will make it more difficult to sustain collusion when it is costly to coordinate or maintain collusion. This result holds for a wide range of models, including all those commonly used to model competition between differentiated products. This contrasts with the previous theoretical literature, which shows that, in the absence of these costs, greater differentiation can help foster collusion under some common models of product differentiation but is consistent with the empirical literature, which suggests that collusion tends to occur most among homogeneous firms.

Key words: game theory; product differentiation; competition; collusion
History: This paper was received January 24, 2006, and was with the authors 2 months for 2 revisions; processed by Greg Shaffer.

1. Introduction

This paper demonstrates that under relatively unrestrictive assumptions, tacit collusion becomes more difficult to sustain as the level of product differentiation increases when there are high enough costs associated with collusion. This lack of ambiguity contrasts with the previous theoretical literature on tacit collusion and product differentiation, which finds that the direction of the relationship between product differentiation and collusive stability depends on the particular model of product differentiation that is used.

At the heart of this issue is a simple trade-off: While firms selling homogeneous products have the most to gain from tacit collusion, they also have the most to gain from cheating on the collusive agreement. The result is that the exact demand specification determines which effect dominates (Tyagi 1999). In contrast with the mixed results in the theoretical literature,[1] empirical studies consistently find that collusion occurs more frequently among firms selling homogeneous products. For example, Levenstein and Suslow (2006) examine the cartel literature and conclude that price fixing occurs more frequently in homogeneous product markets.[2] These observations match the general findings among empirical papers testing for collusion: Those looking at homogeneous firms generally find tacit collusion, while those examining heterogeneous firms generally cannot reject that firms are competing using static Nash outcomes.[3]

This paper proposes a general reason why it might be easiest to support tacit collusion among homogeneous firms—that there is a cost to maintaining or coordinating collusion. Costs of maintaining collusion could include monitoring costs, communication costs, or the continual potential of being caught and punished for illegally colluding. Costs of coordinating collusion could include costs of building collusion-specific infrastructure or the cost of negotiating the collusive outcome. We show that the presence of these costs increases the difficulty of sustaining collusion more for firms that are more differentiated.

To see the intuition behind this result, note that the ease of collusion is based upon the patience required to balance short-term gains from cheating with long-term benefits from colluding. Introducing costs of maintaining collusion increases the short-run gains from cheating (because the firm no longer has to incur the costs of colluding) and reduces the long-run benefits from colluding (by the amount of the costs of collusion), making collusion more difficult to support.

[1] Chang (1991) and Ross (1992) find that differentiation makes collusion easier, while Rothschild (1992) and Häckner (1994) find the opposite. Deneckere (1983) shows that the relationship can be nonmonotonic.

[2] While we focus on tacit collusion, our model also applies to cartels because cartels need to create self-enforcing incentives due to their illegal nature (which makes enforcing the agreement in court impossible).

[3] Collusion was found in studies of coffee roasting (Gollop and Roberts 1979), banking (Spiller and Favaro 1984), retail gasoline (Slade 1992, Borenstein and Shepard 1996), sugar (Genesove and Mullin 1998), and electricity (Wolfram 1999). Collusion was not found in studies of cereal (Nevo 2001) or beer (Slade 2004).

The degree to which collusion becomes more difficult is higher when the products are more differentiated because the sizes of both the short-run gain from cheating and the long-run benefit from collusion are smaller, so the percentage change of each effect from costs of collusion are larger. The effect of these costs is strong enough that collusion becomes monotonically harder to sustain as products grow more heterogeneous when these costs are large enough.

2. Costs of Collusion

The premise of this paper is that there are costs to coordinating and maintaining collusion. In this section, we discuss the sources of these costs along with empirical evidence of their existence. The costs that we focus on are costs of negotiating collusive outcomes, costs of building social and institutional structures needed to sustain collusion, costs of monitoring the other firms' actions, and costs from the risk of prosecution.

Numerous studies have demonstrated that the costs of negotiating a collusive outcome are generally large. One reason is that there is often no focal point for the firms to select as the equilibrium when the firms are asymmetric. This lack of a focal point is reflected in the different choices academic researchers have made in selecting which collusive outcome they believe is most reasonable: Donsimoni (1985) and Athey and Bagwell (2001) use joint profit maximization, Jehiel (1992) uses the Nash bargaining solution, while Friedman and Thisse (1993) assume that collusive profits will be proportional to the ratio of the profits without collusion.

Knittel and Stango (2003) show that the lack of focal collusive outcomes can inhibit tacit collusion. They find that collusion is more prevalent in credit card markets where price ceilings have been enacted than in markets without such regulations because the price ceilings act as focal points for what the collusive outcome should be. Other studies of collusion have found that coordinating collusion requires face-to-face meetings, which cost money, time, effort, and—because these meetings are illegal—a probability of prosecution. For example, Connor (2001) discusses the difficulties in setting up overt collusion in the lysine and citric acid markets. Even once a collusive outcome is determined, many authors have shown that collusion can be maintained only with constant communication and frequent meetings to coordinate each period's actions.[4]

It has also been shown that collusion flourishes best when the interactions between firms have a social context, which requires an investment on the part of the firms.[5] In addition to building social infrastructure, firms often need to make institutional investments to support collusion. For example, firms participating in the lysine cartel had to figure out how to adhere to their quota without alerting either the middle managers or their salesforce that such restrictions existed.[6] Externally, collusion has often involved creating trade associations that coordinate the collusive schemes, and publish and verify the output of cartel members to facilitate punishing firms that violate the agreements. These trade associations also provide a forum for discussion and renegotiation.

Monitoring can be a significant cost of collusion. In cases of tacit collusion, monitoring can involve directly examining competitors' actions. For example, store managers might visit nearby stores to see their prices, or airlines might watch competitor's prices on a large search engine like Orbitz.[7] Connor (2001) notes that monitoring for some formal cartels has involved opening up facilities and inventories to on-site inspections by competitors. Other common forms of monitoring involve using a trade association or third-party auditor to collect and verify prices or output, or, for some formal cartels, using a joint sales agency (Levenstein and Suslow 2006).[8]

Finally, because collusion is generally illegal, setting up collusion involves indirect costs from the risk of prosecution. This risk increases as the collusion lasts longer, and as it involves more phone calls, communication, and documentation. This is both because of the increased risk of a mole or a leak of documentation and because the government is more likely to notice the collusion the longer it continues.

[4] See Levenstein and Suslow (2006), Hay and Kelly (1974), Connor (2001), and Scherer and Ross (1990).

[5] Levenstein and Suslow (2006) discuss these costs with the diamond and rayon industries. Connor (2001) talks about Archer Daniels Midland Companies (ADM) use of social context in the citric acid cartel.

[6] Mishra and Prasad (2005) show that constraints on how a firm can reward its salesforce can lead to a shift where the firms are best off switching to centralized decision making.

[7] The U.S. Department of Justice examined whether this actually led to collusion and determined that they could not prove that this was the case. However, the events of September 11, 2001 three months after Orbitz's launch made a comparison of pre- and post-Orbitz pricing more difficult. See the U.S. Department of Justice press release at http://www.usdoj.gov/atr/public/press_releases/2003/201208.htm (accurate as of May 20, 2006).

[8] Some readers might be concerned about whether costly monitoring can be a credible equilibrium outcome. However, it is possible to work out a game-theoretic model where both players always abide by the agreement and yet pay to monitor on the equilibrium path. The essential kernel of the model is that a firm choosing not to monitor is effectively a signal to end collusion. We present the model in Technical Appendix 1 at http://mksci.pubs.informs.org.

3. Costly Collusion and Product Differentiation

In this section we demonstrate that it is more difficult to support tacit collusion as product differentiation increases when the costs of collusion are high enough. We limit our analysis by considering only the difficulty of sustaining full collusion between firms.[9] Also, we focus on punishments using Nash reversion grim trigger strategies (Friedman 1971).[10] Under this scheme, firms collude as long as no firm has deviated in the past. However, if a deviation ever occurs, then firms forever revert to playing the Nash equilibrium of the stage game. This punishment structure is commonly used, and there are reasons to believe it is reasonable in our context. First, implementing other punishments could require many of the same costs as collusion, while Nash reversion punishments are self-enforcing. Also, a firm could have the unilateral ability to get out of punishments that are more severe by notifying the government about the price-fixing scheme and demanding that the government investigate whether the actions of the other firm are consistent with competitive behavior. This is made credible by laws in many countries that grant amnesty to the first firm that confesses to a price-fixing scheme.[11]

The model we use is very basic. For notational simplicity, we assume that firms are symmetric, although the model can easily be modified to handle asymmetric firms. Let d be an index that captures the level of differentiation. Denote the (assumed stationary expected value of) collusive profits of each firm as $\pi^C(d)$, the static Nash equilibrium profits as $\pi^N(d)$, and the profit that a firm derives from unilaterally deviating from a collusive agreement as $\pi^D(d)$. Let δ be the discount factor, which we, like Lal (1990), define as "the net present value of \$1 received at the end of each period." We assume that $\pi^C(d)$, $\pi^D(d)$, and $\pi^N(d)$ are continuous and once differentiable at all but a finite number of levels of differentiation. Note that $\pi^D(d) \geq \pi^C(d) \geq \pi^N(d)$.

Given this, collusion can then be sustained under Nash reversion if $(1/(1-\delta))\pi^C(d) \geq \pi^D(d) + (\delta/(1-\delta)) \cdot \pi^N(d)$, or equivalently, if

$$\delta \geq \hat{\delta}(d) \equiv \frac{\pi^D(d) - \pi^C(d)}{\pi^D(d) - \pi^N(d)}. \tag{1}$$

Note that $\hat{\delta}(d)$ will be continuous and differentiable at all but a finite number of levels of differentiation, given the assumptions on $\pi^D(d)$, $\pi^C(d)$, and $\pi^N(d)$. We say that collusion is easier to support as the discount factor required to sustain it becomes smaller.

We make two assumptions:[12]

$$\frac{\partial(\pi^C - \pi^N)}{\partial d} < 0, \tag{A1}$$

$$\frac{\partial(\pi^D - \pi^C)}{\partial d} < 0. \tag{A2}$$

Assumption (A1) states that the gain from colluding is highest among homogeneous products and decreases with the level of product differentiation. Using collusion over price as an example, this is reasonable on an intuitive level because competition tempers prices less when products are more differentiated. Assumption (A2) states that the gain from deviating from a collusive agreement is also greatest among homogeneous products. Returning to the example with price, the intuition here is that a firm will gain fewer consumers from undercutting a competitor's price under greater levels of differentiation, so the one-time gain from cheating is smaller. These assumptions hold for the most common models of product differentiation—including all those cited in this article—and do not imply that collusion will be either easier or harder to sustain with increased product differentiation.[13]

Now suppose that there is a recurring cost, C, of maintaining collusion. The profit accrued in each period under collusion becomes $\pi^{C^*} = \pi^C - C$. Collusion is then more difficult to sustain as the level of product differentiation increases whenever the costs of maintaining collusion are high enough. To see this, note that the critical discount factor becomes

$$\hat{\delta}^* = \frac{\pi^D - \pi^C}{\pi^D - \pi^N} + \frac{C}{\pi^D - \pi^N}$$

with these costs. The first term tends to determine the effect of differentiation on collusion when these costs are small; the direction of the effect is then ambiguous and dependent on the functional form of the model. However, when C is sufficiently large, the effect of the

[9] Defined as selecting an outcome lying on the Pareto-optimal frontier (from the firms' points of view).

[10] All our results also hold under optimal punishment schemes, ala Abreu (1986, 1988), with a similar set of assumptions as those presented below. We present these proofs in Technical Appendix 3.

[11] One weakness of Nash reversion is that it is not renegotiation-proof; this is a problem that applies to repeated games in general and is not specific to our analysis. One might believe that the Nash reversion is more renegotiation-proof if firms adjust their internal structure to become more competitive after collusion breaks down. Bhardwaj (2001) analyzes the link between firm structure and competition.

[12] These assumptions need only to hold at levels of differentiation where these functions are differentiable. For notational simplicity, we suppress the dependence of the profits on the level of differentiation hereafter.

[13] That is, (A1) and (A2) do not constrain $\partial\hat{\delta}/\partial d$ to be either positive or negative.

second term dominates, and the fact that the denominator shrinks with product differentiation causes the critical discount factor to increase. When the costs of collusion are large enough, collusion is monotonically more difficult to sustain as the level of differentiation increases.

Proposition 1. *Assume that* (A1) *and* (A2) *hold. Then there exists a level of costs for sustaining collusion,* $\widehat{C}$, *such that collusion is* (*weakly*) *monotonically more difficult to sustain under Nash reversion as the level of differentiation increases for any* $C > \widehat{C}$.[14]

Proof. Collusion is monotonically more difficult to sustain if $\partial\hat{\delta}^*/\partial d > 0$, which holds if and only if $\partial(\ln\hat{\delta}^*)/\partial d > 0$. Note that

$$\frac{\partial \ln(\hat{\delta}^*)}{\partial d} = \frac{\partial \ln(\pi^D - \pi^C + C)}{\partial d} - \frac{\partial \ln(\pi^D - \pi^N)}{\partial d}$$
$$= \frac{[\partial(\pi^D - \pi^C)/\partial d]}{(\pi^D - \pi^C + C)} - \frac{[\partial(\pi^D - \pi^N)/\partial d]}{(\pi^D - \pi^N)}, \quad (2)$$

where the second equality holds because of the chain rule.

Assumptions (A1) and (A2) jointly imply that

$$\frac{\partial(\pi^D - \pi^N)}{\partial d} = \frac{\partial(\pi^D - \pi^C)}{\partial d} + \frac{\partial(\pi^C - \pi^N)}{\partial d}$$
$$< \frac{\partial(\pi^D - \pi^C)}{\partial d} < 0. \quad (3)$$

Thus, Equation (2) is positive whenever C is large enough. A sufficient condition for this is that $\pi^D - \pi^C + C \geq \pi^D - \pi^N$. This implies that $\widehat{C} < \pi_0^C - \pi_0^N$, where π_o denotes the profit levels that arise when $d = 0$, because $\pi^D - \pi^C + (\pi_0^C - \pi_0^N) \geq \pi^D - \pi^N$ for any level of differentiation by (A1), with equality only at $d = 0$.[15] Q.E.D.

Figures 1–3 illustrate this result. Figures 1 and 2 demonstrate this relationship for Deneckere's (1983) model under Bertrand and Cournot competition, respectively.[16] Figure 3 plots the critical discount factor against different levels of product differentiation for a Hotelling-style model, as detailed in Chang

Figure 1 Deneckere's Model with Bertrand Competition

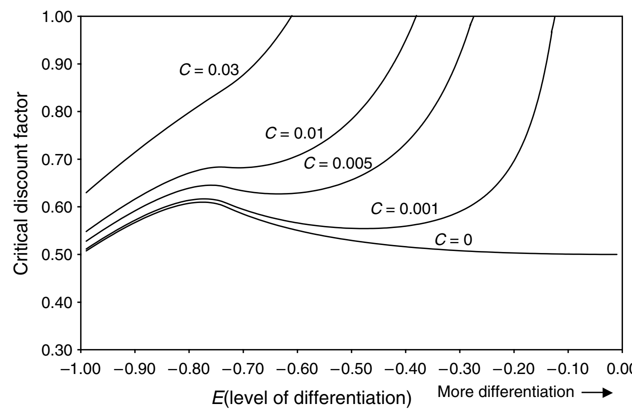


Figure 2 Deneckere's Model with Cournot Competition

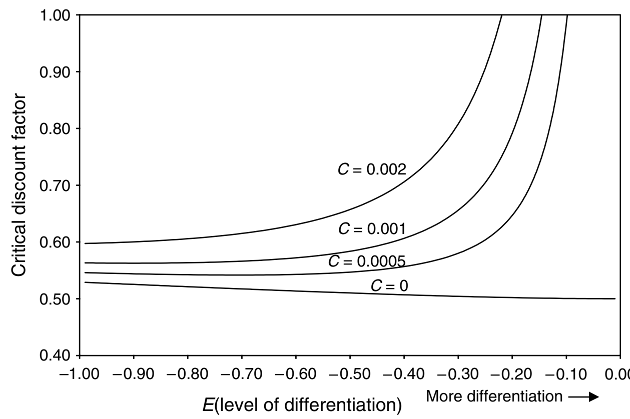
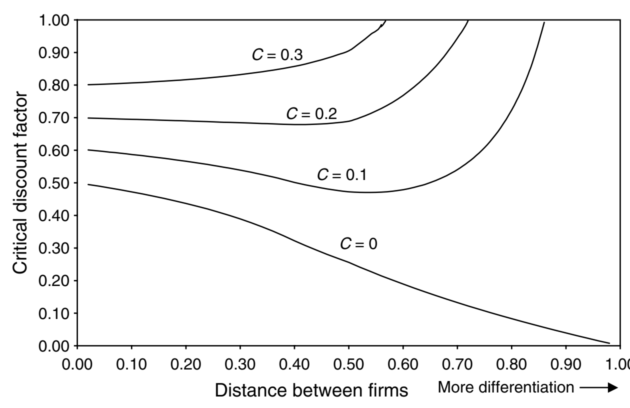


Figure 3 Hotelling Model a la Chang



[14] This relationship will be strictly monotonic over the range of differentiation where collusion is feasible (i.e., $\hat{\delta}^*(d) < 1$), but for high levels of differentiation collusion is impossible for any δ.

[15] The area editor pointed out that this sufficient condition is knife edged, with the condition that tacit collusion be preferred to the stage Nash outcome: $\pi^C - C \geq \pi^N$. Thus, if the sufficient condition is binding, the only cost where collusion could be supported and where the monotonic relationship would hold would be $\pi_0^C - \pi_0^N$, and the region where collusion could be supported at this cost would collapse to $d = 0$ (no differentiation). However, in practice, this sufficient condition is far from binding for commonly used models of product differentiation, as illustrated in the next paragraph. Thus, the result usually holds for a wide range of costs, and the monotonicity applies over a wide range of product differentiation.

[16] Demand for product i is characterized as $P_i = 1 - q_i + Eq_j$, where $E \in [-1, 0]$. Note that the level of product differentiation increases as E is closer to zero. For simplicity, marginal costs are assumed to be zero.

(1991).[17] In Figure 1 we see that the relationship between the level of product differentiation and the ease of tacit collusion is nonmonotonic. However, once a cost of collusion is introduced, it is apparent that the difficulty of colluding increases dramatically when products are differentiated, but that this difficulty changes only a little bit when the products are homogeneous. If costs are high enough, then a monotonic relationship between the level of product differentiation and the critical discount factor emerges. Figures 2 and 3 show similar effects for the other models. In these models, the ease of collusion increases with product differentiation in the absence of costs of maintaining collusion, but once the costs of collusion are large enough, the result of Proposition 1 is restored, and collusion becomes more difficult among firms selling products that are more heterogeneous. It is evident in these figures that the results for Proposition 1 generally hold for a wide range of costs and product differentiation, as noted in Footnote 15.

Proposition 1 demonstrates that collusion is most easily supported among firms selling homogeneous products when maintaining tacit collusion involves recurring costs. It turns out that onetime setup costs of collusion have the same effect, although the mechanism is different. If it is sufficiently expensive to coordinate collusion, then firms will choose to compete through Nash competition and avoid this cost. Because the gains from collusion will decrease with greater product differentiation, this will affect firms selling heterogeneous products more than those selling homogeneous products.[18]

4. Conclusion

Despite the result in the theoretical literature that the functional form of demand dictates whether tacit collusion is easiest to sustain for homogeneous or heterogeneous products, empirical studies have shown that collusion generally occurs among firms selling homogeneous goods. This paper bridges these results by noting that theory predicts that collusion will be easiest to support among homogeneous firms, regardless of the shape of demand, when there are large enough costs associated with collusion.[19]

In this paper, we assume that the costs of collusion are constant across levels of differentiation. However, this might not always be true. For example, monitoring costs could increase with the level of differentiation because it might be more difficult to observe prices or detect secret defections at outlets that are far away. Similarly, costs of setting up collusion may increase with the level of product differentiation because greater asymmetry between firms might increase the cost of negotiations. For example, when products are homogeneous, firms can agree on a single price or output level for the product; but when products are more heterogeneous it is possible that the firms would have to set a schedule of prices and output levels.[20] While endogenizing these costs is beyond the scope of this paper, we note that the monotonicity of Proposition 1 is reinforced when these costs increase in the level of differentiation.

Acknowledgments
The authors thank Kyle Bagwell, Pradeep Bhardwaj, Bjorn Jorgenson, Mike Riordan, and Margaret Slade for their helpful comments.

References

Abreu, D. 1986. Extremal equilibria of oligopolistic supergames. *J. Econom. Theory* **39** 191–228.

Abreu, D. 1988. On the theory of infinitely repeated games with discounting. *Econometrica* **56** 383–396.

Ailawadi, K., P. Kopalle, S. Neslin. 2005. Predicting competitive response to a major policy change: Combining game theoretic and empirical analyses. *Marketing Sci.* **24**(1) 12–24.

Athey, S., K. Bagwell. 2001. Optimal collusion with private information. *RAND J. Econom.* **32** 428–465.

Bhardwaj, P. 2001. Delegating pricing decisions. *Marketing Sci.* **20**(2) 143–169.

Borenstein, S., A. Shepard. 1996. Dynamic pricing in retail gasoline markets. *RAND J. Econom.* **27**(3) 429–451.

Chang, M.-H. 1991. The effects of product differentiation on collusive pricing. *Internat. J. Indust. Organ.* **9** 453–469.

Connor, J. M. 2001. *Global Price Fixing: Our Customers Are the Enemy*. Kluwer Academic Publishers, Boston, MA.

Deneckere, R. 1983. Duopoly supergames with product differentiation. *Econom. Lett.* **11** 37–43.

Donsimoni, M. P. 1985. Stable heterogeneous cartels. *Internat. J. Indust. Organ.* **3** 451–467.

Dubé, J. P., P. Manchanda. 2005. Differences in dynamic brand competition across markets: An empirical analysis. *Marketing Sci.* **24**(1) 81–95.

Friedman, J. 1971. A non-cooperative equilibrium for supergames. *Rev. Econom. Stud.* **38** 1–12.

Friedman, J., J.-F. Thisse. 1993. Partial collusion fosters minimum product differentiation. *RAND J. Econom.* **24** 631–645.

[17] In this model, consumers are located uniformly on the interval $[0, 1]$ and firms are located symmetrically at x and $(1-x)$. For simplicity, marginal costs are assumed to be zero.

[18] A full proof of this statement appears in Technical Appendix 2 at http://mktsci.pubs.informs.org.

[19] This result, along with evidence that advertising (Dubé and Manchanda 2005) and pricing (Sudhir 2001, Ailawadi et al. 2005) are best described by dynamic game-theoretic models, is suggestive of the intriguing result that it might be most important to consider dynamic behavior in analyzing relatively homogeneous products. Soberman and Gatignon (2005) note that such competitive dynamics can affect firms' marketing-mix decisions, as well as market evolution. However, analyzing these questions is beyond the scope of this paper.

[20] A referee pointed out that an exception to this could occur if products become so differentiated that the products appeal to different well-defined segments.

Genesove, D., W. Mullin. 1998. Testing static oligopoly models: Conduct and cost in the sugar industry, 1890–1914. *RAND J. Econom.* **29**(2) 355–377.

Gollop, F. M., M. J. Roberts. 1979. Firm interdependence in oligopolistic markets. *J. Econometrics* **1** 313–331.

Häckner, J. 1994. Collusive pricing in markets for vertically differentiated products. *Internat. J. Indust. Organ.* **12** 155–177.

Hay, G., D. Kelley. 1974. An empirical survey of price fixing conspiracies. *J. Law Econom.* **17** 13–38.

Jehiel, P. 1992. Product differentiation and price collusion. *Internat. J. Indust. Organ.* **10** 633–641.

Knittel, C., V. Stango. 2003. Price ceilings as focal points for tacit collusion: Evidence from the credit card market. *Amer. Econom. Rev.* **93** 1703–1729.

Lal, R. 1990. Price promotions: Limiting competitive encroachment. *Marketing Sci.* **9**(3) 247–262.

Levenstein, M., V. Suslow. 2006. What determines cartel success? *J. Econom. Lit.* **44**(1) 43–95.

Mishra, B., A. Prasad. 2005. Delegating pricing decisions in competitive markets with symmetric and asymmetric information. *Marketing Sci.* **24** 490–497.

Nevo, A. 2001. Measuring market power in the ready-to-eat cereal industry. *Econometrica* **69** 307–342.

Ross, T. 1992. Cartel stability and product differentiation. *Internat. J. Indust. Organ.* **10** 1–13.

Rothschild, R. 1992. On the sustainability of collusion in differentiated duopolies. *Econom. Lett.* **40** 33–37.

Scherer, F. M., D. Ross. 1990. *Industrial Market Structure and Economic Performance*, 3rd ed. Houghton Mifflin Company, New York.

Slade, M. E. 1992. Vancouver's gasoline-price wars: An empirical exercise in uncovering supergame strategies. *Rev. Econom. Stud.* **59** 257–276.

Slade, M. E. 2004. Market power and joint dominance in UK brewing. *J. Indust. Econom.* **52** 133–163.

Soberman, D., H. Gatignon. 2005. Research issues at the boundary of competitive dynamics and market evolution. *Marketing Sci.* **24** 165–174.

Spiller, P. T., E. Favaro. 1984. The effects of entry regulation on oligopolistic interaction: The Uruguayan banking sector. *RAND J. Econom.* **15** 244–254.

Sudhir, K. 2001. Competitive pricing behavior in the auto market: A structural analysis. *Marketing Sci.* **20**(1) 42–60.

Tyagi, R. 1999. On the relationship between product substitutability and tacit collusion. *Managerial Decision Econom.* **20** 293–298.

Wolfram, C. 1999. Measuring duopoly power in the British electricity spot market. *Amer. Econom. Rev.* **89** 805–826.