Manufacturing & Service Operations Management

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

OM Forum—Supply Chain Contracting: Doughnuts to Bubbles

Martin A. Lariviere

To cite this article:
Martin A. Lariviere (2016) OM Forum—Supply Chain Contracting: Doughnuts to Bubbles. Manufacturing & Service Operations Management 18(3):309-313. http://dx.doi.org/10.1287/msom.2015.0567

M&SOM MANUFACTURING & SERVICE OPERATIONS MANAGEMENT
Vol. 18, No. 3, Summer 2016, pp. 309–313
ISSN 1523-4614 (print) | ISSN 1526-5498 (online)

informs

http://dx.doi.org/10.1287/msom.2015.0567

OM Forum

Supply Chain Contracting: Doughnuts to Bubbles

Martin A. Lariviere
Kellogg School of Management, Northwestern University, Evanston, Illinois 60208,
m-lariviere@kellogg.northwestern.edu

This paper discusses the origins of the supply chain contracting literature as well as its current state. It argues that its origins go back further than many scholars realize. It also makes the case that the field expanded rapidly, creating a bubble that has largely burst. However, there have been lasting implications that affect both how we teach supply chain management and the kind of research that is done under the heading of operations management.

Keywords: supply chain management; incentives and contracting
History: Received: July 15, 2015; accepted: September 15, 2015. Published online in *Articles in Advance* December 21, 2015.

1. Introduction

I want to start by saying that I am greatly honored to be named a distinguished fellow of the Manufacturing and Service Operations Management Society of INFORMS. The society has been a large part of my professional life, and I very much appreciate the recognition.

Consequently, I was delighted when I received the news that I had been named a fellow. After a bit, however, that excitement met the realization that I was now obligated to put together a talk I was unlikely to give a second time. So I began with the obvious—looking at what my predecessor had done. I found that the talks of past fellows fall into two groups: some talk about the research they know best; others give philosophical presentations on the nature of research and the process of discovery. I was not feeling philosophical and so decided to go with the former approach and speak about supply chain contracting. My aim here is not to give a detailed literature review. Rather, I plan on giving a little history and then how I see the field today. That is, I will speak about how the supply chain contracting field goes from doughnuts to bubbles.

2. Why Doughnuts?

Where does the supply chain contracting literature begin? What is the most seminal of its seminal papers? People familiar with the field may suggest several candidates, but I strongly suspect that everyone would agree that Pasternack's *Marketing Science* paper on pricing and returns policies for perishable products belongs in the conversation (Pasternack 1985). For those unfamiliar with this paper, it considers a supplier selling to a retailer facing a newsvendor problem. It shows that a partial returns policy can coordinate the supply chain. If the supplier is willing to take back part of the retailer's order after demand is realized and refund part of the wholesale price, the retailer can be induced to order the optimal quantity of the centralized supply chain (i.e., one in which a single firm produces at the supplier's marginal cost to serve the retailer's market). Further, it is possible to arbitrarily divvy up the resulting profit so both the retailer and supplier can be made better off regardless of whatever contract they are currently using.

There is no question that Pasternack's paper has been hugely influential. It provides the template that many subsequent papers follow. It is built around a classical operations model and explores how a real-world contract can influence an agent's decisions. It also establishes that a properly chosen contract can keep decentralization from harming supply chain performance.

But what are its origins? In 2008, *Marketing Science* celebrated its 25th anniversary by republishing many of its early, most-cited articles along with brief commentaries by the relevant authors. As one of the 10 most cited papers in history of the journal, Pasternack (1985) made the cut (even if most marketing scholars would be hard-pressed to explain why). In his commentary on the article, Pasternack (2008) notes that his famous work was influenced by a consulting engagement he had several years earlier with a chain of doughnut shops.

That engagement is actually the basis of a separate *Interfaces* article (Pasternack 1980). The chain in question owned all its stores and hired managers. The managers, however, functioned more or less as if they were franchisees. A manager had to buy flour, sugar,

and other ingredients from the chain and then give the chain a percentage of the store's revenue but was otherwise the residual claimant to the store's profit. That is, the doughnut chain governed its relationship with its managers by a revenue sharing contract as studied by Cachon and Lariviere (2005).

Pasternack reports that the chain earned its money both from selling ingredients and skimming revenue. The ingredient prices managers faced were higher than the chain's acquisition costs, and the chain took a strictly positive share of revenue. He modeled the manager as facing a newsvendor problem for a single product and for which a single ingredient was required. Noting that it is "difficult" to generate closed form solutions for the ingredient markup and revenue share, he employed a numerical study to determine what terms could increase the chain's profit without reducing the managers' earnings. He found that the chain would be better off eliminating the markup on the ingredients while boosting its share of revenue. Indeed, he notes in passing that the chain could do even better if it were willing (it was not) to sell ingredients below cost.

This is a fun paper to read, but it has largely been ignored. As of November 2015, it had all of 13 citations according to Google Scholar. In some ways, this is unfortunate. The late 1970s and early 1980s were the heyday of research on principal-agent problems within economics. Many classics that defined the field appeared around this time (e.g., Holmström 1979, 1982, and Grossman and Hart 1983). And here was a real-world principal-agent problem with some details on how the firm actually managed the incentives of its workers.

However, it is somewhat understandable why economic theorists have ignored the paper. It may offer a real-world case study, but it is light on theory. The focus is on a numerical analysis that may have been insightful for the doughnut chain but offers little guidance on how the results would generalize to other settings.

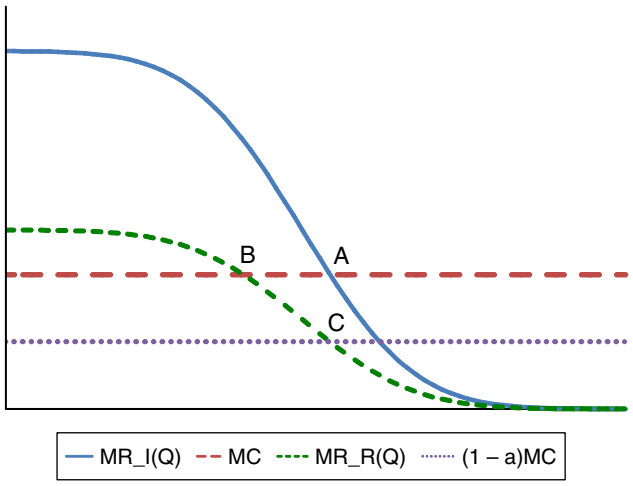
I knew of Pasternack (1980) before preparing this article. Indeed, I am responsible for 2 of those 13 citations. However, there was one paper citing Pasternack (1980) that I had never heard of.[1] Whitin (1981) appeared in *Interfaces* as a response to Pasternack (1980).[2] Whitin takes a theoretical approach that boils down to the following observation: The integrated channel faces a newsvendor problem for which the optimal solution can be characterized by a critical fractile. Under the contract offered by the doughnut chain, managers also face a newsvendor problem, and their optimal fraction of demand to serve depends on the contract terms. Consequently, the contract terms can be tweaked so that the managers choose the same fractile of the demand distribution as a central planner would. Decentralization can thus be implemented without any reduction in supply-chain profits.

For those familiar with the supply chain contracting literature, Whitin's analytical approach will sound familiar. It is the basic trick that underlies a large number of contracting papers built around selling to a newsvendor. Indeed, Whitin likely deserves credit for introducing one of the most important means of analysis for supply chain contracting models.

There was one issue with Whitin's proposal that he openly acknowledges: It requires selling the ingredients to the store managers below cost. The intuition to this finding is fairly straightforward and shown in Figure 1. For a supply chain facing demand distribution $F(x)$ and selling at fixed retail price r, the expected marginal revenue for the integrated supply chain from stocking quantity Q is $MR_I(Q) = r(1-F(Q))$ and profits are maximized when expected marginal revenue equals the constant marginal cost MC (point A in the figure). However, a retailer who must give a fraction a of his revenue to the supplier has his expected marginal revenue $MR_R(Q)$ scaled downward. Specifically $MR_R(Q) = r(1-a)(1-F(Q))$ and $MR_R(Q)$ will cross MC at value less than the system optimal quantity (point B). In order to induce the retailer to take the right quantity, the wholesale price must also be lowered by $(1-a)$, and the supplier sells at a loss (point C).

Whitin (1981) has received even less attention than Pasternack (1980). According to Google Scholar, it has

Figure 1 **(Color online) Marginal Revenue and Cost as a Function of Order Quantity**



[1] Let me remind you of the guidance my advisor gave in his MSOM fellow talk: "I suggest that you avoid doing a big literature review before embarking on a research project," www.informs.org/Community/MSOM/Fellows/Evan-Porteus.

[2] In case you were wondering, yes, that is the Whitin of the Wagner-Whitin lot-sizing algorithm (Wagner and Whitin 1958).

only been cited once. That honor, in fact, goes to Pasternack who published a reply to Whitin's response in the same issue of *Interfaces* (Pasternack 1981). Its general tone is captured in the following quote.

> Whitin mathematically derives the "optimal" solution for this problem. Whitin's "optimal" solution, however, requires the company to sell ingredients to managers below cost. Such a solution was dismissed by the company (not by myself as Whitin claims but with my concurrence) as infeasible. The practical reason for this is obvious. (1981, p. 84)

Note that the quotation marks around "optimal" appear in the original.

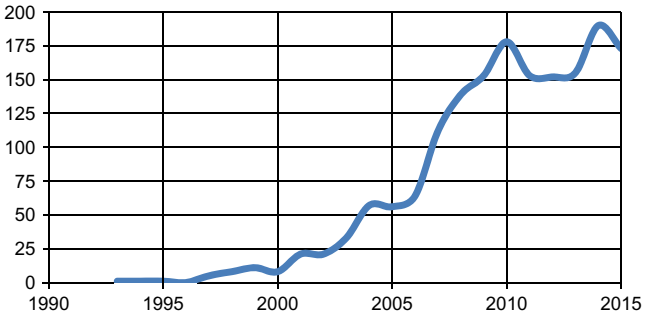
This triptych of papers really is the foundation of the supply chain contracting literature. Together they demonstrate the arc of nearly every topic in the field. It begins with someone describing a real-world practice and offering some insight on how contract terms can influence the behavior of the relevant players. Next, a mathematical model is developed which offers more general intuition. Finally, a curmudgeon complains that the proposed model is useless in practice.[3]

3. Why Bubbles?

Having explained why the field begins with doughnuts, let me turn to why it ends in a bubble. Consider Figure 2. Glancing at the rapid rise shown in the figure, it could easily represent a frothy index of tech stocks or a commodity in tight supply. In fact, it represents the number of publications containing "supply chain" and "contract" in the title, abstract, or key words in a search of the relevant part of the Scopus citation database. From a lone paper in 1993, the total climbs to 11 in 1999, to 56 in 2005, and peaks at 190 in 2014.

Whereas the quick expansion might be characteristic of a bubble, the figure does not necessarily demonstrate a bubble's other defining feature: a catastrophic collapse. As I write this, we are in late 2015. With 173 documents so far in 2015, this year's total may ultimately eclipse last year's. However, there is significant evidence that the bubble has already burst. For example, it has largely left our INFORMS journals. *Management Science* has only three articles on supply chain contracting in 2015 according to Scopus, whereas *M&SOM* has just one. Of the 173 documents the Scopus database captures for this year, nearly 40% come from just three journals: *International Journal of Production Economics* (25 documents), *International Journal of Research* (22), and *European Journal of Operational Research* (20). To me this suggests that whereas the volume of supply chain contracting articles may still be high, the days of supply chain contracting as a hot topic on the cutting edge of the field have passed.[4]

Figure 2 **(Color online) Publications Captured by the Scopus Citation Database for Social Science and Humanities Having "Supply Chain" and "Contract" in Their Title, Abstract, or Key Words as of November 5, 2015**



If the bubble has burst, there are two questions worth asking. First, why did the bubble form and second, what do we have to show for it? I think there were several factors behind the rise of supply chain contracting as a field. One is simply developments in commerce. The 1990s saw a growing use of outsourcing as many corporations sought to focus on core competencies. General Motors, for example, spun off its parts division Delphi in 1999. That gave it greater freedom to buy from a wider set of firms, but it also meant that transactions that once were completely in-house now had to be governed by formal contracts.

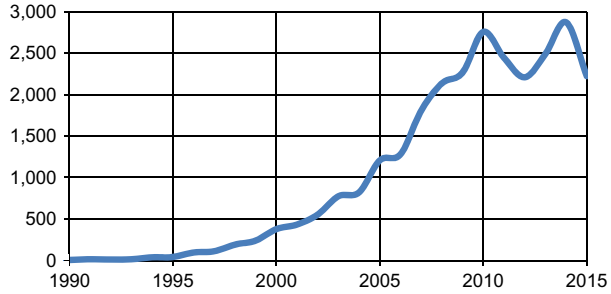
There was also, over the years, a formalization of supply chain management as an academic field. Figure 3 replicates the search from Figure 2 but drops "contract." Prior to the 1990s, supply chain as a concept was not really on the radar of academics. There was relevant research going on (just as there were firms facing supply chain issues in practice), but it was not called supply-chain management. For example, Clark and Scarf's classic work on multiechelon inventory does not use the phrase (Clark and Scarf 1960).

But that changed rather rapidly. In 1995 (the year I finished graduate school), Scopus captures 42 papers referencing supply chains. By 2000, that is 378 and then we are off to the races with 1,207 documents

[3] There is actually a missed opportunity here: One can use Whitin's model to analytically demonstrate that the policy Pasternack found numerically is, in fact, optimal for the constrained problem in which the supplier does not sell below cost. Further, one can show that if the supplier must assure that the retailer's profit does not fall, the stocking quantity must increase.

[4] Interestingly, the physical locus of this work has also shifted. Looking at the years 1999 to 2004, the top three schools producing this work were University of Pennsylvania, Duke University, and Stanford University. Jump forward a decade, the top schools from 2009 to 2014 were Hong Kong Polytechnic University, University of Science and Technology of China, and Tsinghua University.

Figure 3 **(Color online) Publications Captured by the Scopus Citation Database for Social Science and Humanities Having "Supply Chain" in Their Title, Abstract, or Key Words as of November 5, 2015**



in 2005 and more than twice that (2,755) in 2010. Arguably, my original search on "supply chain" and "contract" is an artifact of the explosive growth in supply chainrelated research. One could engage in a game of academic Mad Libs, pairing supply chain and random nouns to generate similar figures.[5]

Research in the broader area of supply chain management had implications for the subfield of supply chain contracting. Work by Hau Lee and others (e.g., Lee and Billington 1992, Lee et al. 1997) highlighted the interconnected nature of supply chains and how misaligned incentives could lead to poor performance. That called for formal modeling of incentives and contracts.

At the same time, it was never easier to start doing this work. As I noted above, work on the principal-agent problem was in vogue in economics in the late 1970s and early 1980s. Consequently, by the time I was in graduate school in the early 1990s, that work had moved from being showcased in upper level economic seminars to being part of core microeconomic sequences. Further, standard assumptions and models had been codified, and it was pretty clear what the complications could araise when you deviated from tried and true.

Finally, the tie to operations in general and to the basic newsvendor mode in particular was hard to resist. A basic model of selling to the newsvendor was easy to present as part of operations management, since it was tied to such a bedrock part of the field. Graduate students and junior faculty could push the boundaries of the field by bringing in economic reasoning while being able to demonstrate clearly to advisors and senior colleagues their link to conventional operations.

The aftermath of a bubble always brings questions of what was a fleeting fad and what has some permanence. One can fairly ask whether the supply chain contracting as an academic endeavor has produced any Amazons that stand the test of time or merely Webvans that stand as cautionary tales. I would argue that there are several ways in which work on supply chain contracting has had lasting impact.

First, it has changed how we teach supply chain management. Contracting and coordination have made it into managerial publications (e.g., Cachon and Lariviere 2001, Narayanan and Raman 2004) and textbooks (e.g., Chopra and Meindl 2015, Van Mieghem and Allon 2015). Spending at least some time in an undergraduate or master's class on how different terms can affect behavior is nearly de rigueur. The contracting literature has some clear lessons (e.g., contingent payments spread the risk and can improve supply chain outcomes) that can be demonstrated with simple models. As a consequence, I would argue that more of this work has found its way into entry-level courses than other recent innovations in supply chain management.

The second, lasting, outcome has been laying the foundation for new research areas. Supply chain contracting's 15 minutes of fame may be over, but there is still active work on the broader area of operations economics (Van Mieghem 2013). Work on supply chain contracts has brought a broad appreciation for economic modeling into operations management, and that has given researchers an interest in related areas as well as the skill to pursue this work. Work on strategic consumers (e.g., Lariviere and Van Mieghem 2004, Su and Zhang 2009) has been a hot topic in the last several years, and now we see papers in which workers act in their own interest (e.g., Gurvich et al. 2015, Gopalakrishnan et al. 2015). Neither of these areas would be developing as quickly as they are without the prior work in supply chain contracting.

The relation of operations economics to supply chain contracting is partly methodological; exposure to economic modeling is now a routine part of training in operations management Ph.D. programs, which certainly facilitates researchers branching out to new areas. But there is also a cultural aspect. The bubble in supply chain contracting research has helped redefine what is an appropriate topic and methodology for an OM paper. This has had a wide impact on the field that goes beyond just modeling work. The legacy of supply chain contracting has influenced empirical research (e.g., Guajardo et al. 2012) and behavioral research (Kremer and Van Wassenhove 2014). Indeed, it is this cultural shift that is likely to be the most significant lasting impact of supply chain contracting research.

[5] Try it! It works for "automobile" or "chemicals" but not for "cantaloupe."

References

Cachon GP, Lariviere MA (2001) Turning the supply chain into a revenue chain. *Harvard Bus. Rev.* 79(3):20–21.

Cachon GP, Lariviere MA (2005) Supply chain coordination with revenue-sharing contracts: Strengths and limitations. *Management Sci.* 51(1):30–44.

Chopra S, Meindl P (2015) *Supply Chain Management, Strategy, Planning and Operations*, 6th ed. (Prentice-Hall, Upper Saddle River, NJ).

Clark AJ, Scarf H (1960) Optimal policies for a multi-echelon inventory problem. *Management Sci.* 6(4):475–490.

Gopalakrishnan R, Doroudi S, Ward AR, Wierman A (2015) Routing and staffing when servers are strategic. Working paper, University of Southern California, Los Angeles.

Grossman SJ, Hart OD (1983) An analysis of the principal-agent problem. *Econometrica* 51(1):7–45.

Guajardo J, Cohen M, Netessine S, Kim S-H (2012) Impact of performance-based contracting on product reliability: An empirical analysis. *Management Sci.* 58(5):961–979.

Gurvich I, Lariviere MA, Moreno A (2015) Operations in the on-demand economy: Staffing services with self-scheduling capacity. Working paper, Northwestern University, Evanston, IL.

Holmström B (1979) Moral hazard and observability. *Bell J. Econom.* 10(1):74–91.

Holmström B (1982) Moral hazard in teams. *Bell J. Econom.* 13(2): 324–340.

Kremer M, Van Wassenhove LN (2014) Willingness to pay for shifting inventory risk: The role of contractual form. *Production Oper. Management* 23(2):239–252.

Lariviere MA, Van Mieghem JA (2004) Strategically seeking service: How competition can generate Poisson arrivals. *Manufacturing Service Oper. Management* 6(1):23–40.

Lee HL, Billington C (1992) Managing supply chain inventory: Pitfalls and opportunities. *Sloan Management Rev.* 33(3):65–73.

Lee HL, Padmanabhan V, Whang S (1997) Information distortion in a supply chain: The bullwhip effect. *Management Sci.* 43(4): 546–558.

Narayanan VG, Raman A (2004) Aligning incentives in supply chains. *Harvard Bus. Rev.* 82(11):94–103.

Pasternack BA (1980) Filling out the doughnuts; The single period inventory model in corporate pricing policy. *Interfaces* 10(5): 96–100.

Pasternack BA (1981) Seeing the doughnut from the whole: A response to "Watching the Whole Doughnut." *Interfaces* 11(4): 84–85.

Pasternack BA (1985) Optimal pricing and return policies for perishable commodities. *Marketing Sci.* 4(2):166–176.

Pasternack BA (2008) Commentary—Optimal pricing and return policies for perishable commodities. *Marketing Sci.* 27(1): 131–132.

Su X, Zhang F (2009) On the value of commitment and availability guarantees when selling to strategic consumers. *Management Sci.* 55(5):713–726.

Van Mieghem JA (2013) OM forum—Three Rs of operations management: Research, relevance, and rewards. *Manufacturing Service Oper. Management* 15(1):2–5.

Van Mieghem JA, Allon G (2015) *Operations Strategy: Principles and Practice*, 2nd ed. (Dynamic Ideas, Belmont, MA).

Wagner HM, Whitin TM (1958) Dynamic version of the economic lot size model. *Management Sci.* 5(1):89–96.

Whitin TM (1981) Watching the whole doughnut. *Interfaces* 11(4): 80–83.