# Competition and Innovation: Did Arrow Hit the Bull's Eye?

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**Draft: 28 September 2010**

> "The only ground for arguing that monopoly may create superior incentives to invent is that appropriability may be greater under monopoly than under competition. Whatever differences may exist in this direction must, of course, still be offset against the monopolist's disincentive created by his preinvention monopoly profits." Arrow (1962), p. 622.

> "As soon as we go into details and inquire into the individual items in which progress was most conspicuous, the trail leads not to the doors of those firms that work under conditions of comparatively free competition but precisely to the doors of the large concerns … and a shocking suspicious dawns upon us that big business may have had more to do with creating that standard of life than with keeping it down." Schumpeter (1946), p. 82.

## 1. Introduction

The 50th anniversary of the publication of NBER *Rate and Direction of Inventive Activity* volume is an opportune time to revisit what is arguably the most important question in the field of industrial organization: what organization of business activity best promotes innovation?

Needless to say, this question has received intense attention by economists and other social scientists, especially since the middle of last century, when the critical importance of innovation to economic growth became more widely appreciated.[1] Hence, I wade into this topic with considerable trepidation. So, let me state at the outset that this essay is intended to be somewhat

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[1] I make no attempt to survey the huge theoretical and empirical literature that explores the relationship between competition and innovation, and I apologize in advance to those who have made important contributions yet are not explicitly cited here. I rely heavily on Gilbert (2006) and Cohen (2010). See also Sutton (1998) and (2007). Aghion and Griffith (2005) and Aghion and Howitt (2009) discuss the relationship between competition and growth.

speculative: an audacious attempt to distill lessons from the huge and complex literature on competition and innovation that are simple and robust enough to inform competition policy.

My ambitious task is made somewhat more manageable because I confine myself to a narrower question: how can *competition policy* best promote innovation. I do not attempt to address broader questions regarding innovation policy or business strategy. Within the realm of competition policy, I focus on the assessment of proposed mergers. Even in this more limited area, I am not the first to attempt to distill robust principles suitable for competition policy. To the contrary, I follow closely in the footsteps of Baker (2007), Gilbert (2006), and Katz and Shelanski (2005 and (2007), and borrow unabashedly from their work. Baker (2007) is closest in spirit to this paper: he identifies four principles relating competition and innovation and argues strongly that antitrust fosters innovation.

Before putting forward my central thesis – hypothesis, really – let us review the bidding.

Arrow (1962) famously argued that a monopolist's incentive to innovate is less than that of a competitive firm, due to the monopolist's financial interest in the status quo. This fundamental idea comports with common sense: a firm earning substantial profits has an interest in protecting the status quo and is unlikely to be the instigator of disruptive new technology. In Arrow's words: "The preinvention monopoly power acts as a strong disincentive to further innovation."[2] Consciously over-simplifying, the Arrow position can be summarized in this principle:

**Arrow: "Product market competition spurs innovation**."

Schumpeter (1942), by contrast, even more famously emphasized that a great deal of innovation is attributable to large firms operating in oligopolistic markets, not to small firms operating in atomistic markets. "The firm of the type that is compatible with perfect competition is in many cases inferior in internal, especially technological, efficiency."[3] Schumpeter argued that larger

[2] Arrow (1962), p. 620. Put differently, the secure monopolist's incentive to achieve a process innovation is less than that of a competitive firm because the monopolist with lower costs will merely replace itself, while the competitive firm will (by assumption) take over the market, in which it previously earned no economic profits. Tirole (1997), p. 392, dubbed this the "replacement effect."

[3] Schumpeter (1942), p. 106. Schumpeter also argued that large established firms operating in oligopolistic markets are better able to finance R&D than are small firms operating in atomistic markets. In the light of today's highly developed capital markets, including venture capital markets, this argument has much less salience today.

firms have greater incentives and ability to invest in R&D. He dismissed perfect competition as the ideal market structure, stressing the importance of temporary market power as a reward to successful innovation: "A system – any system, economic or other – that at *every* point in time fully utilizes its possibilities to the best advantage may yet in the long run be inferior to a system that does so at *no* given point in time, because the latter's failure to do so maybe a condition for the level or speed of long-run performance."[4] Consciously over-simplifying, the Schumpeter position can be summarized in this principle:

**Schumpeter:** "**The prospect of market power and large scale spurs innovation**."

Let the battle be joined. Arrow vs. Schumpeter, in the super-heavyweight class.

Wait a minute. Are the Arrow and Schumpeter positions really incompatible? This essay advances the claim that they are *not*, at least so far as competition policy is concerned.

What do we actually *need* to know about the relationship between competition and innovation for the purposes of competition policy? For merger enforcement, we need a framework to evaluate the effects of a proposed merger on innovation. In practice, the relevant mergers are those between two of a small number of firms who are best place to innovate in a given area. For other areas of antitrust enforcement, we typically seek to evaluate the impact on innovation of a specific business practice, such as the package licensing of a group of patents or the decision to keep an interface proprietary rather than open. For these purposes, I argue here that we do not need a universal theory of the relationship between competition and innovation. I also argue that the Arrow and Schumpeter perspectives are fully compatible and mutually reinforcing.

Consciously over-simplifying yet again, I offer two guiding principles. These principles work in tandem, weaving together the Arrow and the Schumpeter perspectives:

**Contestability: "The prospect of gaining or protecting profitable sales spurs innovation."**

**R&D Rivalry:** "**R&D rivalry generally spurs innovation.**"

Note that neither of these principles refers directly to "product market concentration."

[4] Id., p. 83.

The Contestability principle focuses *the impact of innovation at the level of the firm*. Sales are contestable in the relevant sense if profitable sales shift towards the successful innovator, in the sense that successful innovation increases the firm's sales and price/cost margins. This in turn depends on the nature of *ex post product market competition* along with conditions of appropriability. If market shares are sticky, e.g., because consumers have strong brand preferences or high switching costs, relatively few sales are contestable and innovation incentives will be muted. If imitation is rapid, so a firm that successfully innovates is unable to differentiate its products or achieve a significant cost advantage over its rivals, *ex post* profit margins will be low and innovation incentives again will be muted. In my lexicon, low appropriability can lead to low contestability.

The Arrow principle fits well with the Contestability principle: for a given level of *ex post* sales, a firm with few *ex ante* sales has more to gain from innovation. Put differently, a firm that will make substantial sales even if it does not innovate, Arrow's incumbent monopolist, has muted incentives to innovate.

The Schumpeter principle also fits well with the Contestability principle: one cannot expect substantial innovation (from commercial firms, at least) if *ex post* competition is so severe that a successful innovator earns little profit. And companies making major innovations often are rewarded with large market shares, leading to high *ex post* market concentration.

The R&D Rivalry principle focuses on *the process of innovation competition at the level of the industry*. More specifically it focuses on the *ex ante* competition *to* innovate. The R&D Rivalry principle states that, at least as a general tendency, the more firms are engaged in R&D, and the more capable they are, the more innovation will tend to occur, *ceteris paribus*. The R&D Rivalry principle is not about each individual firm devoting more resources to R&D in the fact of stronger R&D rivalry; it is concerned about industry-wide innovation.

Oddly enough, these intuitive notions of what we mean by "competition" – sales contestability and R&D rivalry – are not the ones typically used to define "competition" in the literature on competition and innovation. But they can take us a long way in competition policy.

This paper advances the hypothesis that the Contestability principle and the R&D Rivalry principle are sufficiently robust – both theoretically and empirically – to inform competition policy. I sketch out the argument that these two principles provide the conceptual and empirical basis for a rebuttable presumption that a merger between two of a very few firms who are important, direct R&D rivals in a given area to is likely to retard innovation in the area. Furthermore, I suggest, somewhat tentatively, that we have a pretty good understanding of the circumstances under which that presumption is rebutted and innovation is furthered by allowing two important, direct R&D rivals to merge. I also suggest that these two principles can usefully guide competition policy in other areas.

Perhaps you already are convinced that innovation is generally spurred by sales contestability and R&D rivalry. If so, you may want to stop right here, or skip to the discussion below where I apply these two principles to competition policy. But as someone actively involved in antitrust enforcement, it appears to me that a rather different "complexity proposition" has taken root and threatens to become the conventional wisdom, namely:

**Complexity #1: "The relationship between competition and innovation is so complex and delicate that there should be no presumption that the elimination of product market or R&D rivals will diminish innovation."**

A version of this complexity proposition specific to mergers has also gained currency:

**Complexity #2: "The relationship between competition and innovation is so complex and delicate that there should be no presumption that a merger between two of a very few firms conducting R&D in a given area is likely to diminish rather than spur innovation."**

These propositions echo various more general statements from the literature on competition and innovation, where it has become *de rigueur* to emphasize that "competition" has ambiguous effects on innovation. For example, Gilbert (2006) states that the incentives to innovate

> "depend upon many factors, including: the characteristics of the invention, the strength of intellectual property protection, the extent of competition before and after innovation, barriers to entry in production and R&D, and the dynamics of R&D. *Economic theory does not offer a prediction about the effects of competition on innovation that is robust to all of these different market and technological conditions.* Instead, there are many predictions and one reason why empirical studies have not generated clear conclusions about the relationship between competition and innovation is a failure of many of these studies to account for different market and technological conditions." (p. 162, emphasis supplied)

In a similar vein, Motta (2004), writes: "Both theoretical and empirical research on the link between market structure and innovation is not conclusive, even though a 'middle ground' environment, where there exists some competition but also high enough market power coming from the innovative activities, might be the most conducive to R&D output."[5]

Certainly, the overall cross-sectional relationship between firm size or market structure and innovation is complex. Just think of all the variations we often see in the real world.

On the Arrow side of the ledger, i.e., in praise of innovation by firms without a strong incumbency position, we have:

- Disruptive entrants are a potent force. They can shake up a market, bringing enormous value to customers. The mere threat of disruptive entry can stir inefficient incumbent firms from their slumber.
- Firms without a significant incumbency position may have a freer hand to innovate because they are not tied to an installed base of customers.[6]
- Firms with strong incumbency positions often resist innovations that threaten those positions. Such resistance can even take the form of exclusionary conduct that violates the antitrust laws.
- Start-up firms often play the role of disruptive entrants, introducing new products or processes.
- Firms with suitable capabilities entering from adjacent markets often play the role of disruptive entrants.

On the Schumpeterian side of the ledger, i.e., in praise of innovation by large firms with an established incumbency position, we have:

- Some highly concentrated markets exhibit rapid innovation, and some atomistic markets seem rather stuck in their ways. One suspects that these differences are not simply the result of differences in technology opportunity.
- Large firms often are closer to the cutting edge in technology than their smaller rivals.

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[5] Motta (2004), p. 57. Writing to antitrust practitioners, Davis (2003), states (p. 695-696) that there is a "consensus or near-consensus" that "the relation of market structure to market conduct and performance in innovation is far more problematic than in the case of price competition."

[6] For an insightful and influential study along these lines, see Christenson (1997).

- Larger firms can have greater incentives to achieve process improvements because they can apply these improvements to a larger volume of production. In contrast, a smaller firm that that cannot grow significantly, even if it successfully innovates, and cannot license out its innovation, has a lower incentive to lower its costs.

- Large firms often acquire innovative start-up firms, or enter into other arrangements such as licenses or joint ventures with them, thereby accelerating the adoption and diffusion of those firms' inventions.

On top of all this, we know that appropriability matters a great deal for innovation incentives.

So, let me be clear: nothing in this essay should be read to question the proposition that the overall relationship between product market structure and innovation is complex. The relationship between firm size and innovation is also complex. General theoretical or empirical findings about these relationships remain elusive, in part because a firm's innovation incentives depend upon the *difference* between its pre-innovation and post-innovation size. This difference depends upon the *ex ante* market structure and reflects the *ex post* market structure.

But we are not totally at sea. Yes, the world is complex, but my aim here is to suggest some general lessons for competition policy when evaluating innovation effects. Even stating these lessons requires that one be quite careful in defining our terms. Implementing them requires that one be willing and able to distinguish different settings based on a few key, observable characteristics. This approach is similar to the one advocated by Gilbert (2006), who writes:

> "The many different predictions of theoretical models of R&D lead some to conclude that there is no coherent theory of the relationship between market structure and investment in innovation. That is not quite correct. The models have clear predictions, although they differ in important ways that can be related to market and technological characteristics. It is not that we don't have a model of market structure and R&D, but rather that we have many models and it is important to know which model is appropriate for each market context." (p. 164-5)

The argument developed here is that competition policy can be usefully and substantially guided by the Contestability principle and the R&D Rivalry principle. Let me illustrate how that might work, by way of a real-world example.

In 2003-04, the Federal Trade Commission (FTC) reviewed the merger between Genzyme and Novazyme, the only two firms pursuing enzyme replacement therapies to treat Pompe disease, a rare genetic disorder. FTC Chairman Timothy Muris, explaining the Commission's decision not to challenge the merger, explicitly relied on the proposition that "economic theory and empirical

investigations have not established a general causal relationship between innovation and competition."[7] This statement, taken alone, is unobjectionable. As noted above and discussed more below, much of the theoretical and empirical literature on the relationship between market structure and innovation emphasizes complexity while seeking to explain how different factors affect that relationship, recognizing that both market structure and innovation are endogenous. Nonetheless, I ask here whether we know enough to warrant a presumption that a merger between the only two firms pursing a specific line of research to serve a particular need is likely to diminish innovation rivalry, absent a showing that the merger will generate R&D synergies that will enhance the incentive or ability of the merged firm to innovate.

Applying the Contestability and R&D Rivalry principles might well have led to a different outcome in the Genzyme/Novazyme merger. Since these two companies were the only ones with research programs for enzyme replacement therapies to treat Pompe disease, the merger evidently eliminated R&D rivalry in that area. Furthermore, successful innovation in this case clearly offered the prospect of gaining significant, profitable sales: the first innovator would establish a new market, and the second innovator could capture profitable sales from the first if its treatment was sufficiently superior. Invoking a presumption that a merger between the only two R&D rivals in a given area reduces competition, the merger would have been challenged absent a showing that it led to innovation synergies sufficient to offset the reduced inventive to innovate resulting from the merger. See below for more on this case.

The Genzyme and Novazyme merger is just one (prominent) example of how the "complexity perspective" on competition and innovation has taken root. As Katz and Shelanski (2007) note, some observers "argue that innovation provides a rationale for a more permissive merger policy. One argument advanced in support of this line of reasoning appeals to what is known as 'Schumpeterian competition,' in which temporary monopolists successively displace one another through innovation."[8] While not going as far as Chairman Muris, Katz and Shelanski are sufficiently swayed by these arguments to write: "In brief, we recommend that merger review proceed on a more fact-intensive, case-by-case basis where innovation is at stake, with a

[7] Statement of Chairman Timothy J. Muris in the Matter of Genzyme Corporation/Novazyme Pharmaceuticals, Inc., January 13, 2004, at http://www.ftc.gov/opa/2004/01/genzyme.shtm, citing FTC (1996) Vol. I, Chapter 7, at 16.

[8] Katz and Shelanski (2007), p. 4, footnote omitted.

presumption that a merger's effects on innovation are neutral except in the case of merger to monopoly, where there would be a rebuttable presumption of harm." While merger analysis tends to be highly fact-intensive, whether or not innovation effects are at issue, the standard proposed by Katz and Shelanski appears to be markedly more lenient than the one antitrust law usually applies to horizontal mergers, where there is a rebuttable presumption of harm from a merger that substantially increases concentration and leads to a highly concentrated market.[9]

Here I ask whether such a lenient standard is appropriate for evaluating the impact of mergers on innovation. Yet I do not want to direct too much attention to presumptions and burdens of proof, which are more the stuff of lawyers than economists. Nor do I want to overstate the differences between my approach and that of Katz and Shelanski.[10] The key operative question is whether one can obtain reasonable accuracy in merger enforcement, in cases involving innovation, by focusing the inquiry on (1) the extent of R&D rivalry between the two merging firms, including consideration of the innovative abilities, efforts, and incentives of other firms, and (2) any merger-specific efficiencies that will enhance the ability or incentive of the merged firm to engage in innovation.[11]

Section 2 shows that the emerging conventional wisdom – that there is no reliable relationship between competition and innovation – results in part from the peculiar way that the notion of "more competition" has been defined in the industrial organization and endogenous growth literatures. Section 3 defines two notions of competition that can be assessed in practice and

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[9] The "structural presumption" in antitrust law has declined in recent decades, but not nearly to the point where only mergers to monopoly are presumed to substantially lessen competition. See Baker and Shapiro (2008). The 2010 Horizontal Merger Guidelines issued by the Department of Justice and the Federal Trade Commission state in Section 5.3: "Mergers resulting in highly concentrated markets [HHI greater than 2500] that involve an increase in the HHI of more than 200 points will be presumed to be likely to enhance market power. The presumption may be rebutted by persuasive evidence showing that the merger is unlikely to enhance market power."

[10] See the discussion below of the FTC's 2009 challenge to the proposed merger between Thoratec and Heartware. Shelanski was Deputy Director of the Bureau of Economics at the time of that challenge. See also the discussion of the 2010 Horizontal Merger Guidelines. Shelanski was closely involved in developing these new guidelines (as was this author).

[11] Likewise, in evaluating the impact of specific conduct by a dominant firm on innovation, the operative question for competition policy is not whether large firms innovate more than small ones, or whether concentrated market structures are associated with more or less innovation than atomistic market structures. After all, competition policy, at least as practiced in the U.S. today, is not about engineering market structures or the size distribution of firms. The operative question is whether the specific conduct at issue which allegedly excludes a rival, such as a refusal to open up an interface, will benefit customers by spurring innovation or harm them by retarding innovation, either by excluding an innovative rival or reducing the competitive pressure placed on the dominant firm.

arguably spur innovation: sales contestability and R&D rivalry. Section 4 gives a brief summary of the relevant empirical literature, which generally supports the Contestability and R&D Rivalry principles. Sections 5 applies these principles to merger enforcement policy, and Section 6 concludes.

## 2. Competition and Innovation: What Went Wrong?

Much of the literature on the relationship between competition and innovation has, unfortunately, given policy makers a clouded picture of what we really know about this relationship that is not as helpful as it could be. The problem stems in large part from the way the term "competition" has been used in that literature.

### *A. Equating "More Competition" With "Less Product Differentiation"*

In the theoretical industrial organization literature on competition and innovation, "more competition" frequently is modeled as "less product differentiation." If the products offered by the various competing firms are close substitutes, price competition is more intense. So, "less product differentiation" is not an unreasonable way to define "more competitive pressure," at least in a static oligopoly setting. However, this has resulted in numerous statements in the literature that can be misleading and unhelpful for the purpose of competition policy, especially merger enforcement. In particular, while merger enforcement can directly affect the number of independent firms competing in an industry, it does not directly affect the extent of product differentiation among the products offered by those firms.

The danger can be illustrated by the discussion in Aghion and Griffith (2005). They begin in Chapter 1, "A Divorce Between Theory and Empirics," with what they label as the "dominant theories of the early 1990s." These are static models of product differentiation in which an increase in product market competition is modeled as a reduction in the extent of product differentiation, such as lower transportation costs in a model of spatial differentiation. Innovation is then measured by the equilibrium number of firms in the market, where entry involves a fixed cost. With weaker product differentiation, price/cost margins are smaller, and fewer products are supplied in the free entry equilibrium. This simple and uncontroversial

proposition about product *variety* is characterized (p. 11) as a "Schumpeterian effect of product market competition." Aghion and Griffith go on to state (p. 12) "we again obtain an unambiguously negative Schumpeterian effect of product market competition on innovation."[12]

I am not disputing the results in these simple models of product differentiation. Nor am I disputing that innovation incentives are low if successful innovation merely places a firm in a market where its product is only slightly differentiated from other products and where the firm has no cost advantage. What I am disputing is that such a proposition is helpful for competition policy, or innovation policy more generally. Meaningful product innovation involves the development of new products that are superior to, or at least significantly distinct from, existing products. Meaningful process innovation involves the development or adoption of production processes (broadly defined to include business methods) that significantly reduce costs. These static models of oligopoly do not involve anything I recognize or credit as innovation. They may help us understand how many brands of toothpaste will be introduced, but they cannot help us understand how firms choose to invest to develop new products that are markedly superior to current offerings. Nor do these models capture R&D rivalry or significant sales contestability. The effect of changing a parameter measuring the degree of differentiation among products is not directly relevant to competition policy.[13]

For Aghion and Griffith, this discussion is merely a launching pad, and I do not mean to suggest that they base any of their conclusions or policy recommendations on these simple static oligopoly models. Indeed, they immediately (p. 13) go on to note two important and powerful forces missing from these models: "the interplay between rent dissipation and preemption incentives, and the differences between vertical (i.e., quality improving) and horizontal innovations." Nonetheless their framing of the issues is indicative of how the conversation has developed, and how research findings are translated and conveyed to policy makers. They summarize (p. 3-4) the "early theoretical and empirical literatures" as follows: "theory pointed to

[12] Similarly, Aghion, et. al. (2005), summarizing the "main existing theories of competition and innovation," states: "The leading IO models of product differentiation and monopolization … deliver the prediction that more intense product market competition reduces postentry rents, and therefore reduces the equilibrium number of entrants." (p. 710, footnoted omitted)

[13] Baker (2007) puts this nicely: "antitrust is not a general-purpose competition intensifier. Rather, antitrust intervention can be focused on industry setting and categories of behavior where enforcement can promote innovation. (p. 589, footnote omitted)

a detrimental effect of competition on innovation and growth, while the empirical literature instead suggested that more competitive market structures are associated with greater innovative output, an idea that had much support in policy circles."

These passages from Aghion and Griffith (2005) accurately reflect a strand of the theoretical literature that equates the concept of "more competition" with "less product differentiation." See, for example, Boone (2000) and (2001), and Aghion, et. al. (2001). Vives (2008), "Innovation and Competitive Pressure," surveys and synthesizes this literature.[14] Schmutzler (2010) defines a generalized "competition parameter." By definition, increases in this parameter lead to lower equilibrium profit margins and a greater sensitivity of a firm's equilibrium output to that firm's cost level. Schmutzler explores the relationship between "more competition," as defined by increases in this parameter, and the level of R&D investment. While there is nothing inherently incorrect or misleading about modeling "more competitive pressure" as "less product differentiation," defining "more competition" this way can lead to statements about competition and innovation that are unhelpful or even misleading for merger enforcement policy.

In particular, the statement that "more competition discourages innovation" can be misused or misunderstood in the context of competition policy, or innovation policy more broadly. The statement "innovation incentives are low if *ex post* competition is so intense that even successful innovators cannot earn profits sufficient to allow a reasonable risk-adjusted rate of return on their R&D costs" seems more defensible and far more accurate. I doubt these conditions are common, except perhaps when appropriability is low, in which case the root problem is one of low appropriability, not excessive competition. But at least this statement is not misleading.

Clarity and precision in defining "competition" can reduced perceived complexity regarding the impact of competition on innovation.

[14] In a oligopoly model with restricted entry, Vives also studies the relationship between the number of firms and innovation. This measure of competition is more relevant to merger enforcement policy, as discussed below in Section 5.

## *B. Equating "More Competition" with "More Imitation"*

The endogenous growth literature also explores the relationship between competition and innovation, albeit from a different perspective. See Aghion and Griffith (2005) and Aghion and Howitt (2009), especially Chapter 12, "Fostering Competition and Entry," and the references therein.[15] The paper by Aghion, et. al. (2005), "Competition and Innovation: An Inverted-U Relationship," has been especially influential. The model used by Aghion, et. al. (2005) is far better for considering innovation than are the static oligopoly models just discussed, because it is a dynamic model in which firm invest to develop new and superior products.

However, as I now explain, this strand of literature typically equates "more competition" with "more imitation." This has led to the unfortunate sound bite, typically paired with a reference to Schumpeter, that "greater competition discourages innovation." Aghion, et. al. (2005) write:

> "increased product market competition discourages innovation by reducing postentry rents. This prediction is shared by most existing models of endogeneous growth …. where an increase in product market competition, or the rate of imitation, has a negative effect on productivity growth by reducing the monopoly rents that reward new innovation." (p. 711, footnote omitted)

The standard growth-theoretic models that explore the competition/innovation relationship model "more competition" as a parameter that shifts downward the *ex post* demand function facing the innovator. They do not model "more competition" as an increase in the magnitude of contestable sales, or as an increase in R&D rivalry. In fact, "more competition," meaning more imitation, involves *reduced* sales contestability due to lower profit margins for the innovator.

To see how this literature models competition, consider the benchmark model of innovation and productivity growth presented by Aghion and Griffith (2005).[16] In that model, "competition" is measured by the cost advantage of an innovator over a competitive fringe of imitators. I regard this as a measure of the strength of intellectual property protection, or as a measure of the spillovers associated with innovation. It is certainly not a measure of R&D rivalry or sales contestability. It is entirely unsurprising that imitation reduces innovation incentives. Unfortunately, Aghion and Griffith interpret this finding as follows:

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[15] In Aghion and Howitt (2009), see especially Chapter 12, "Fostering Competition and Entry," and the references therein. For a recent survey on this literature, see Scopelliti (2010).

[16] See pp. 16-19. "This serves as a basis for the theoretical extension we will present in later chapters of this book."

> "However, pro-competition policies will tend to discourage innovation and growth by reducing $\chi$ [the cost advantage of the innovator over the imitators], thereby forcing incumbent innovators to charge a lower limit price." (p. 18)

So far as I can tell, these "pro-competition policies" involve weaker intellectual property rights, or perhaps mandatory licensing or price controls, neither of which can properly be called "competition policies" at least in the United States today.[17] But the idea sticks: "competition" and "pro-competition policies" discourage innovation and growth.

Aghion and Griffith do not rest at this point and conclude that competition discourages growth. To the contrary, they press forward, seeking to reconcile theory and evidence, emphasizing what they call the "escape competition effect." In my lexicon, this is a form of contestability: a firm that fails to innovate will find its margins squeezed, while innovating preserves these margins. However, their extension models also equate "more competition" with more complete imitation of a process innovation. For that reason, their analysis strikes me as far more relevant for policies that influence the strength of intellectual property rights than for competition policy.[18]

Let me be clear: there is nothing inherently incorrect or misleading about modeling "more competition" as "more imitation." Imitation does reduce the demand facing an innovator, and it certainly constitutes "more competition" from that firm's perspective. Furthermore, imitation can be a very important consideration when firms make R&D investment decisions, especially for product or process innovations that are difficult to protect using patents or trade secrets.[19]

Nonetheless, the statement that "more competition discourages innovation" can all too easily be misunderstood or misused in the context of competition policy, not to mention innovation policy

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[17] The impact of imitation on innovation and economic growth is certainly important for policies governing the design and strength of patent rights, as well as policies affecting the protection and enforcement of trade secrets. That discussion is beyond the scope of this paper. Shapiro (2007) discusses the relationship between the reward to a patent holder and the patent holder's contribution.

[18] Of course, imitation, spillovers and appropriability can be very important in antitrust analysis. In particular, a merger that internalizes significant spillovers may promote innovation, as discussed below.

[19] Patents and trade secrets are the most relevant forms of intellectual property for the product and process innovations I have in mind here. However, the same argument can be made for creative works, where copyrights typically are the most relevant form of intellectual property. A similar point can be made for trademarks as well, but the link between trademarks and innovation is more tenuous.

more broadly.[20] The statement "more rapid and complete imitation tends to discourage innovation" seems more reasonable and far more accurate.

Clarity and precision in defining "competition" can reduced perceived complexity regarding the impact of competition on innovation.

## *C. Equating "More Competition" with "Lower Market Concentration"*

Industrial organization economists have long used product market concentration as a proxy for competition, with higher concentration indicating less competition on price and output. We place less weight on this proxy than we did fifty years ago, but it certainly still has value, at least in properly defined relevant markets. The recently revised Horizontal Merger Guidelines continue to use HHI thresholds, with adverse competitive effects viewed as unlikely in markets with a post-merger HHI less than 1500 and presumed likely for mergers that raise the HHI more than 200 and lead to a post-merger HHI greater than 2500.

The link between product market concentration and R&D rivalry has always been weaker than the link between product market concentration and rivalry to win current sales. A firm's current sales may not be a good proxy for that firm's R&D incentives and abilities. Plus, R&D expenditures normally have the character of a fixed cost, leading to scale economies. If those fixed costs are large relative to sales, significant market concentration is inevitable in equilibrium, as shown by Sutton (1998). Furthermore, as Schumpeter emphasized, the reward to successful innovation is some degree of market power in the technical sense – price above marginal cost – for a sufficient volume of sales to earn a risk-adjusted return on the fixed and sunk R&D costs. So, if we measure the post-innovation market structure – which we will inevitably do if innovation is ongoing – we should not expect to see atomistic market structures in industries that have experienced significant technological progress.[21]

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[20] Aghion and Griffith (2005) clearly believe their work is relevant to competition policy. In the conclusion to Chapter 3, they state (p. 64): "These predictions have important policy implications for the design of competition policy."

[21] We may seen an atomistic market structure at some levels of the industry, but not at the level where large R&D expenditures (as a fraction of sales) are required to achieve the observed technological progress.

The empirical literature on product market structure and competition has come to recognize all of these points, and recent work (see below) attempts heroically to account for them. Cohen (2009) summarizes (p. 29): "Regarding measures, there can be little here can be little disagreement with Gilbert's contention that the commonly employed measure of market structure, market concentration, does not accurately reflect the nature or intensity of competition." Yet there remains some tendency to equate "more competition" with "lower product market concentration." Thus, a finding that unconcentrated markets (or markets where firms earn low operating profits relative to sales) are not the ones where we see the most experience significant innovation may be interpreted incorrectly as "too much competition discourages innovation," or as implying that "an intermediate amount of competition is best for promoting innovation."

Framing the relationship between competition and innovation as one between product market concentration and competition is not dissimilar to the view in the 1950s and 1960s that atomistic markets were the ideal and best promote (pricing and output) competition. That view gave way long ago to a more nuanced one, which recognizes that when individual firms differ greatly in their efficiency (as they normally do), and when there are significant economies of scale (as there typically are in markets where antitrust enforcement takes place), robust competition is likely to lead to a market structure in which some firms have substantial market shares. This very same principle applies with even greater force to innovation: we know there are significant economies of scale, because R&D is a fixed cost, and it would be surprising indeed if firms did not differ substantially in their ability to innovate. Accounting for the inherent uncertainty associated with innovation only strengthens the point: even if several firms have comparable *ex ante* ability to innovate, *ex post* some will strike gushers and others just dry wells.

Again, there is nothing inherently wrong with observing and reporting that many of the most innovative industries do not have atomistic market structures: it is helpful to know not to expect, or strive for, atomistic market structures in those industries.[22] But there is no tension between established competition policy principles and the Schumpeterian observation that successful

[22] Even in concentrated industries, start-up firms can play a very positive and powerful role in spurring innovation. If they are rapidly acquired by large incumbents, or if their ideas are copied by large incumbents, their role may never be reflected in a decline in market concentration. Even if antitrust does not stand in the way of mergers that cause moderate increases in concentration, it may need still to intervene to protect customers from unilateral conduct by dominant firms that stifles disruptive innovation by start-up firms.

innovators often are able to price well above marginal cost and often gain substantial market shares. U.S. antitrust law has understood for a very long time that the market power resulting from successful innovation is an important and inevitable part of the competitive process. As Judge Learned Hand famously observed: "the successful competitor, having been urged to compete, must not be turned upon when he wins."[23] Furthermore, of course, merger enforcement policy does not strive for atomistic markets: under the recently revised Horizontal Merger Guidelines, merger adverse competitive effects are considered unlikely if the post-merger HHI is less than 1500, and the merger enforcement statistics show that the DOJ and the FTC often allow horizontal mergers leading to more concentrated markets to proceed without challenge.

## 3. Competition and Innovation: Towards Robust Principles

When considering the impact of competition on innovation, rather than equating "more competition" with "less product differentiation," "more imitation," or "lower product market concentration," I suggest that the term "more competition" be reserved for market characteristics that correspond greater *rivalry*. This is how the concept of "more competition" is generally applied in the area of competition policy: the competitive process is working well if there is healthy rivalry, on the merits, to serve the needs of consumers. Effective competition is about the *competitive process*, not the outcome. More important than terminology, assessing competition based on rivalry allows us to articulate and employ principles that are theoretically and empirically robust.

Arguing from first principles, we can distinguish *rivalry to make sales* from *rivalry to innovate.* The contestability principle focuses on the former concept, and the R&D Rivalry principles focuses on the latter. Critically, in actual practice both types of rivalry can be assessed by the antitrust agencies and courts when they are enforcing the antitrust laws. These two types of rivalry are distinct but work together. Sales may be contestable even without R&D rivalry, e.g., when a disruptive entrant is developing a new product that may capture substantial sales from an incumbent lacking its own R&D program.

[23] U.S. v. Aluminum Company of America, 148 F.2d 416 (1945).

Any analysis of competition and innovation needs to pay close attention to the conditions of appropriability, i.e., the extent to which innovators can appropriate the benefits of the advances attributable to them. The conditions of appropriability greatly affect innovation incentives. Appropriability is heavily influenced by the strength of intellectual property rights. Appropriability is reduced by spillovers to non-innovating firms, e.g., through imitation. While some causal factors, such as low entry barriers, can lead to both more competition and more imitation, our analysis should not conflate "low appropriability" with "more competition."

## *A. Contestability*

A given market is highly contestable – in the sense relevant for innovation – if a firm's operating profits are highly sensitive to whether or not that firm innovates. Contestability in this sense depends upon the nature of product market competition, along with the conditions of appropriability. In particular, low appropriability typically leads to low contestability. The Contestability Proposition states that greater contestability, by providing stronger incentives to innovate, spurs innovation.

An unconcentrated market is highly contestable if an innovator can gain substantial market share at a healthy margin by offering a better product or by exploiting a cost advantage. In contrast, for product innovations, an unconcentrated market is not highly contestable if customers exhibit strong brand preferences, or have high switching costs, so any one firm that develops an improved product will gain few sales from its rivals. Likewise, for process innovations, an unconcentrated market is not highly contestable if an innovating firm's rivals will quickly imitate its innovation or if an innovating firm will not expand much, e.g., due to capacity constraints or because rivals will rapidly respond to price cuts it initiates. Many readers will recognize some of these themes from Sutton (1998). Cohen (2009) refers (p. 21) to the two factors stressed by Sutton as "technological opportunity and submarket homogeneity."

Contestability asks about an individual firm's incentive to innovate. Consider the impact on a given firm's operating profits if that firm achieves a given innovation.[24] This can be a product or process innovation. For simplicity, suppose the firm produces a single product, whether or not it innovates, although the firm will offer an improved product if it succeeds in achieving a product innovation. Denote the product's price by $P$, its output by $X$, and its (constant) marginal cost by $C$, so the profit margin on incremental units is given by $M \equiv P - C$.[25] The firm's profits gross of R&D expenses and other costs that are fixed with respect to its output level are $\pi = (P - C)X = MX$. Whether or not the firm in question successfully innovates, that firm sets its price to maximize its operating profits.

Let the subscript "0" denote the situation in which the firm does not successfully innovate, and the subscript "1" denote the situation in which the firm does successfully innovate. The "no innovation" state will typically not be the pre-innovation status quo, since other firms may well innovate even if the firm in question does not. This allows us to account for the added competitive pressure faced by the firm in question if it fails to innovate and its rivals succeed: $X_0$ and/or $M_0$ may be small.

This setup allows us to examine the innovation incentives facing this one firm, given the actions and reactions of other firms in terms of their own R&D investments and pricing. Innovation increases the firm's profits by $\Delta\pi = \pi_1 - \pi_0 = M_1X_1 - M_0X_0$, which can be written as $\Delta\pi = (M_1 - M_0)X_1 + M_0(X_1 - X_0)$ or

$$\Delta\pi = X_1\Delta M + M_0\Delta X .$$

The $\Delta X$ term here can incorporate rivals' reactions to the firm's innovation or to changes in the price set by the firm. This expression is simple, and not deep, but it does serve to remind us of the basic factors at play, which determine the level of sales contestability for a given firm.

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[24] My focus is largely on the incentive to innovate rather than the ability to innovate. However, the latter arises in assessing possible innovation synergies as part of merger review, e.g., if the merging parties are combining assets that complement each other for performing innovation, such as skilled personnel and valuable patents.

[25] Generalizing to multiple products affected by the innovation is straightforward.

The first term represents the extra margin the firm earns on the sales it would make even without the innovation. This extra margin can come from lower costs (for a process innovation) or from a higher price (for a product innovation). This term encompasses the "escape competition" effect in the literature. This term is scaled by the firm's post-innovation output level. If the innovation will do little to increase the firm's unit sales (so $X_1$ is not much more than $X_0$, making the second term small), we have $\Delta\pi \approx X_0 \Delta M$. Under these conditions, initially larger firms have greater incentives to innovate. This is a standard observation in the literature: the benefit of lowering marginal cost is proportional to output.[26]

The second term represents the extra sales the firm makes by innovating. These sales are valued at the firms pre-innovation margin. Other things equal, a firm that would make few sales without innovating will have a larger sales boost from innovating, $\Delta X$, and thus a larger incentive to innovate. This reflects the Arrow replacement effect at work. If demand is sticky, so one firm cannot gain many sales even as a result of successful innovation, $\Delta X$ is small, reducing the incentive to innovate. Likewise, if rivals react strongly to the firm's improved product, e.g., by lowering their prices, the firm may gain few sales. Rapid imitation operates similarly.

One can easily write down the continuous version of the firm's boost to operating profits due to innovation. Denote by $\theta$ the level of innovation achieved by the firm. Innovation can affect the firm's demand and/or cost. Write the firm's demand as $D(P,\theta)$, with $D_\theta(P,\theta) > 0$, and the firm's marginal cost as $C(\theta)$, with $C'(\theta) < 0$, so the firm's profits are given by $\pi(P,\theta) = D(P,\theta)(P - C(\theta))$. Applying the envelope theorem, achieving marginally more innovation raises operating profits by $\pi_\theta(P,\theta) = D(P,\theta)\left|C'(\theta)\right| + (P - C(\theta))D_\theta(P,\theta)$. The first term here is the margin boost, and the second term is the sales boost.[27] The $D_\theta(P,\theta)$ term can incorporate rivals' reactions to the firm's innovation or to changes in the price set by the firm.

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[26] My simple formulation does not include licensing revenues. Licensing breaks the connection between the firm's own sales and the base on which higher margins can be earned

[27] The margin boost in this continuous version results entirely from cost savings, since we can hold the firm's price fixed using the envelope theorem. For discrete changes in $\theta$, we would need to integrate this expression with respect to $\theta$, accounting for changes in price and output along the way.

The Arrow "replacement effect" is driven by contestability: in his model, innovation allows a firm initially operating in a highly competitive market to take over the entire market at a margin reflecting its cost advantage. In contrast, an incumbent monopolist has far fewer sales to gain from innovation (and only the monopolist can innovate) so sales contestability is lower.[28]

The robustness of the Contestability principle is nicely illustrated by seeing how it fares in the model of continual process innovation used by Aghion, et. al. (2005). They use this model to argue for an inverted-U shaped relationship between competition and innovation. Such a non-monotonic relationship would appear to defy the Contestability principle. It does not.

In the Aghion, et. al. model, each industry is a duopoly, with no possibility of entry. The two firms sell a homogeneous product, so the only possible source of competitive advantage is a cost advantage. The duopolists can invest in R&D to lower their costs; such process innovations come in discrete steps. At any point in time, if the two firms have equal costs, the industry is said to be "neck-and-neck." Aghion, et. al. assume that spillovers allow a firm falling two steps behind immediately and costlessly to narrow the gap to one step, so the only other possible state of the market is for one firm to be the leader and the other the laggard, one step behind. This assumption also implies that the leader never invests in R&D, since it cannot extend its lead and since the leader's profits only depend upon the cost gap between the two firms, not on their absolute cost levels.

Aghion, et. al. state (p. 713): "We define the degree of product market competition inversely by the degree to which the two firms in a neck-and-neck industry are able to collude." A neck-and-neck firm has a stronger incentive to innovate, the greater the degree of product market competition. They call this the "escape the competition" effect, which I think of as the flip side of the Arrow replacement effect. In contrast, a laggard firm has a *weaker* incentive to innovate, the greater the degree of product market competition, since successful innovation leads to the less profitable neck-and-neck state. They call this a Schumpeterian effect. Aghion, et. al. cleverly exploit these mixed effects to obtain an inverted-U shaped relationship between equilibrium steady-state innovation rates (aggregated across many sectors) and the degree of

[28] In Arrow's model, only a single firm can innovate, so the incumbent monopolist faces no danger of losing its monopoly if it is the designated innovator. If the monopolist can be dethroned, it may well have more profits at

product market competition (degree of collusion). The model is elegant and instructive – major virtues in my view – but it is worth noting some of the strong assumptions underlying its prediction of the inverted-U shaped relationship between competition and innovation: there are only two firms in each industry, with no possibility of entry; the two firms sell a homogeneous product; the laggard firm cannot innovate in a different direction, e.g., to differentiate its product, or take a riskier approach that might leapfrog the leader; and (due to imitation) the leader does not benefit at all from further lowering its costs.

Whether or not these conditions are realistic, the basic forces modeled by Aghion, et. al. (2005) fit comfortably with the Contestability principle.[29] In particular, the inverted-U shaped relationship they uncover between "competition" and innovation does *not* correspond to a non-monotonic relationship between contestability and innovation. In their model, "more competition" means less effective collusion when the duopolists are neck-and-neck. Their notion of "more competition" translates to *less* contestability when the firms are neck-and-neck: each firm has *less* to gain from pulling ahead, the more effectively the two firms are colluding. Their notion of "more competition" translates to *more* contestability when the firms are in the leader/laggard state: the laggard earns zero profits regardless of the degree of competition and *more* profits by catching up, the more effectively the firms collude when neck-in-neck. Their model thus is perfectly consistent with the Contestability principle.

This is a good point to draw the connection between the notion of "more competition" and the operation of competition policy. Taking the Aghion, et. al. (2005) model at face value, it suggests that allowing some degree of collusion is desirable to spur innovation because it provides greater incentives to laggard firms to catch up so they can collude with their rival, while allowing a great deal of collusion is undesirable for innovation because the duopolists would then be content to rest comfortably once they are neck-and-neck and effectively colluding. I am not aware of anyone actually proposing such a policy towards collusion, and for good reason. Among other problems, if the firms were given latitude to communicate and collude, they might

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stake than an entrant; this is the central point in Gilbert and Newbery (1982).

[29] The R&D Rivalry principle is not directly applicable to their model, since the number of R&D rivals in a given industry is always fixed at two and since they do not consider the impact of shifts in the firm's R&D capabilities, e.g., by shifting the R&D cost function. Presumably, a downward shift in the R&D cost function would lead to faster innovation for any given level of competition.

find a way to maximize joint profits by agreeing to stop spending money on R&D. In any event, a more relevant question for competition policy is whether reducing competition by allowing the two firms to *merge* would accelerate or retard innovation. In the Aghion, et. al. model, a merger between the two firms would be disastrous for innovation. Assuming that knowledge spillovers continue to limit the merged firm's competitive advantage to one step, the merged firm would immediately cease all innovation and coast along with a one-step advantage over the imitating fringe.

### *B. R&D Rivalry*

R&D rivalry occurs when multiple firms devote resources to improving their ability to meet a specific need. R&D rivalry to serve a given need is greater, by definition, the more firms are conducting R&D aimed at serving that need and the more capable those firms are at innovating in that area.

The R&D Rivalry principle states that greater R&D rivalry generally spurs industry-wide innovation. Put slightly differently, greater R&D rivalry in a given area generally leads to more aggregate innovation in that area, *ceteris paribus*, so there is generally a monotonic relationship between R&D rivalry and innovation. I argue in this paper that the R&D rivalry principle has a sound basis, both theoretically and empirically.

Patent races are a vivid form of R&D rivalry: one firm wins the patent and the others cannot practice the patented technology, even if they independently invent it later. In the context of a patent race, the R&D Rivalry principle states that discovery is accelerated by adding more participants in the race or by increasing their capabilities.[30] To illustrate with one special case, consider a patent race between an incumbent monopolist and a single would-be entrant. Gilbert and Newbery (1982) identify a tendency for the incumbent monopolist to preempt the entrant in order to protect its profits and avoid competition. This finding is perfectly consistent with the R&D rivalry principle: the threat of entry pushes the incumbent monopolist to spend more on R&D, accelerating discovery. Empirically, if preemption incentives are powerful, we might well

[30] For the purposes of competition policy, what is relevant issue is changing the number of R&D rivals when there are only a few or several such rivals.

see continued dominance over time by a single firm. We might also see rapid innovation in a market that remains highly concentrated. These observations are perfectly consistent with the R&D rivalry principle (as well as the Contestability principle), even though they might lead us to reject the hypothesis that less concentrated product markets are associated with more innovation.

In putting forth the R&D Rivalry principle, I am not suggesting that economic theory offers a *theorem* to that effect. In particular, my argument is not based on a general monotonicity theorem relating R&D rivalry to R&D expenditures or to the pace of innovation; even to state such a theorem would require metrics for the concepts "R&D rivalry" and "innovation." (One could do this in a high-level, reduced-form level model, but I am not sure how far that would get us in practice.) The principle can be useful for competition policy, despite the existence of counterexamples, so long as we understand the conditions giving rise to those counterexamples and are able to assess in a given case whether those conditions are likely to be met.[31]

The theoretical literature on cost-reducing investments in oligopoly illustrates how some of these nuances can be handled. That literature recognizes a tension between *ex ante* rivalry and R&D investment incentives: a single firm's incentives to invest in R&D to reduce its own costs depend in part on the firm's expected output from innovating (as captured in the margin term above, $X_1 \Delta M$ ). The firm's expected output from innovating, $X_1$, typically is reduced by the presence of numerous, capable rivals. As the Contestability principle tells us, this effect can be overcome if the presence of more rivals implies that innovation boosts the firm's unit sales by more, elevating $\Delta X$ , not an implausible situation. This ambiguity arises in part because these models conflate R&D rivalry with current product market competition: the set of rivals investing in R&D is assumed to be the coextensive with the set of current product market competitors. In my lexicon, greater product market competition reduces sales contestability if unit sales are sticky, but this does not violate the R&D rivalry principle. If we equate the number of product market rivals with the number of R&D rivals, Vives (2008) (p. 428-430) finds that an increase in the number of firms tends to decrease each firm's *ex post* output, and thus decrease its equilibrium

[31] Adding an R&D rival could slow innovation by reducing contestability, e.g., if the non-innovating firm would easily imitate the innovating firm. I would regard this fact pattern as one in which the Contestability principle and the R&D Rivalry principle point in opposite directions, not as contradicting either principle.

R&D investment level. Nonetheless, increasing the number of firms tends to increase *industrywide* R&D investment and the industrywide R&D to sales ratio.

Looking ahead to merger analysis, the (Schumpeterian) lesson from this line of analysis is that a merged firm may have greater incentives to achieve a process innovation than either merging party alone, because the merged firm will have a larger base of sales on which it can to apply that innovation. In the language of the Horizontal Merger Guidelines, the possibility that the larger scale of the merged firm will lead to merger-specific R&D synergies should be considered. However, as discussed below, the magnitude of this effect depends upon how much an individual merging firm achieving the same innovation would expand its production, and how much of this expansion would come at the expense of the other merging firm.

Empirically, testing the R&D rivalry principle requires measuring R&D rivalry and innovation and teasing out a casual relationship between them, either in a cross-section or over time. For this purpose, innovation should be broadly defined to include the adoption and diffusion of new products and processes, not just the invention of new technologies. Preferably, one would measure innovation using an "output" measure, such as productivity growth, rather than an input measure, such as R&D expenditures or an intermediate measure such as patent counts.

In practice, the R&D rivalry principle needs to be used carefully, giving proper attention to conditions of appropriability, in conjunction with the Contestability principle. Below, in Section 5, I show how this might be (and is) done in the area of merger enforcement.

## 4. What Does the Empirical Evidence Really Tell Us?

There is a substantial body of empirical evidence supporting the general proposition that "more competition," meaning greater sales contestability, spurs firms to be more efficient.

Detailed case studies of businesses operating in diverse settings almost invariably conclude that companies insulated from competition – i.e., firms operating in environments in which relatively few sales are contestable – are rarely at the cutting edge in terms of efficiency and can be woefully inefficient. Porter (1990) assembles a raft of evidence showing that companies protected from international competition tend to fall behind and lose their ability to compete in

export markets. Porter has long emphasized the importance of competition in spurring innovation, as in this passage from Porter (2001):

> "Innovation provides products and services of ever increasing consumer value, as well as ways of producing products more efficiently, both of which contribute directly to productivity. Innovation, in this broad sense, is driven by competition. While technological innovation is the result of a variety of factors, there is no doubt that healthy competition is an essential part. One need only review the dismal innovation record of countries lacking strong competition to be convinced of this fact. Vigorous competition in a supportive business environment is the only path to sustained productivity growth, and therefore to long term economic vitality." p. 923

In another wide-ranging international study, Lewis (2004) concludes that competitive markets are the key to economic growth. His central conclusion is that competition drives innovation:

> Most economic analysis ends up attributing most of the differences in economic performance [across countries] to differences in labor and capital markets. *This conclusion is incorrect. Differences in competition in product markets are much more important.* (p. 13, emphasis in original)

In a similar vein, numerous studies show that increasing competitive pressure by lowering regulatory entry barriers generally enhances productivity and accelerates innovation.

In discussing the relationship between competition and innovation, it is important to bear in mind the very large differences across firms, even firms in the same industry, in their efficiency. Bartelsman and Doms (2000) survey the literature on firm-level productivity, writing:

> "Of the basic findings related to productivity and productivity growth uncovered by recent research using micro-data, perhaps most significant is the degree of heterogeneity across establishments and firms in productivity in nearly all industries examined." (p. 578)

In a more recent survey, Syverson (2010) starts by stating: "Economists have shown that large and persistent differences in productivity levels across businesses are ubiquitous." He reports studies (pp. 35-48) showing how competition acts to improve productivity both through a Darwinian selection effect and by inducing firms to take costly actions to raise their productivity. He also reports studies showing how additional competition arising from trade liberalization enhances productivity. These are first-order effects which serve to remind us that the relevant notion of "innovation" is quite broad, encompassing the adoption and diffusion of best practices. Innovation is not confined to the invention of new products or new methods of production.

Syverson (2004) is a especially instructive regarding the relationship between competitive pressure and firm-level efficiency. Studying the concrete industry, he shows that average

productivity is higher, and productivity differences across firms are smaller, in local markets that are more competitive. Here "more competitive" means that the producers are more densely clustered, increasing spatial substitutability. Syverson shows that relatively inefficient firms in the concrete industry find it more difficult to operate in the more competitive local markets.

In contrast to Syverson's in-depth study of one industry, Bloom and Van Reenen (2007) examine management practices across a wide range of industries by surveying managers from over 700 medium-sized firms. They find very large differences in productivity across firms and conclude that "poor management practices are more prevalent when product market competition is weak." (p. 1351) They explain that

> "higher levels of competition (measured using a variety of different proxies, such as trade openness) are strongly associated with better management practices. This competition effect could arise through a number of channels, including the more rapid exit of badly managed firms and/or the inducement of greater managerial effort."

Similarly, Bloom and Van Reenen (2010) observe (pp. 204-205) that "firms with 'better' management practices tend to have better performance on a wide range of dimensions: they are larger, more productive, grow faster, and have higher survival rates." They report that strong product market competition appears to boost average management practices through a combination of eliminating the tail of badly managed firms and pushing incumbents to improve their practices.

In addition to these studies, there is a very large empirical literature examining the relationship between (a) firm size and innovation, and (b) product market concentration and innovation. Cohen (2009) surveys this literature.[32]

Regarding business unit size and innovation, Cohen writes:

> Thus, the robust empirical patterns relating to R&D and innovation to firm size are that R&D increases monotonically - and typically proportionately - with firm size among R&D performers within industries, the number of innovations tends to increase less than proportionately than firm size, and the share of R&D effort dedicated to more incremental and process innovation tends to increase with firm size. (p. 8-9)

As Cohen explains (p. 10) these findings are consistent with the view that larger business units expect to be able to apply process innovations over a larger scale of output, because firms chiefly

exploit their process innovations internally and often anticipate limited growth due to innovation. In contrast, Cohen writes (p. 10) that "the returns to more revolutionary (i.e. substitute) innovations are less tied to a firm's prior market position."

Regarding the connection between market power and innovation, Cohen observes (p. 12): "The empirical literature has focused principally on the effects of market concentration on innovative behavior. The literature has thus directly tested Schumpeter's conjectures about the effects of *ex ante* market structure." Cohen further notes (p. 12) that "the potential for achieving *ex post* market power through innovation has been characterized under the general heading of appropriability conditions and measured by survey-based indicators of appropriability." Cohen is thus careful to avoid conflating "more competition" with "more imitation."

Lee (2005) offers this view of a key stylized factoid that has long captured the imagination of industrial organization economists:

> "The conventional wisdom from the literature postulates an inverted-U relationship between market structure, measured by seller concentration on the horizontal axis, and industry R&D intensity (i.e., R&D-to-sales ratio) on the vertical axis. The inverted-U hypothesis says that moderately concentrated industries engage more intensively in R&D activity than either atomistically competitive or highly concentrated industries." (p. 101)

This inverted-U shaped relationship between market concentration and innovation has not held up well under scrutiny, especially after correcting for industry differences in technological opportunity and for the endogeneity of product market structure. I do not intend to wade into that debate, which I do not expect to be resolved definitely one way or the other during my lifetime, either theoretically or empirically, for the reasons given above. Meanwhile, the message received by non-specialists and policy makers is that we know rather little about the relationship between "competition" and innovation.

Lee (2005) distinguishes industries based on appropriability and emphasizes that the notions of "more competition" and "more imitation" are very different:

> "the concentration-R&D relationship differs depending on the strength of the link or simply the appropriability of R&D in terms of market share: A positive relationship is predicted for low-appropriability industries, where market concentration supplements low R&D appropriability, while a negative or an inverted U-shaped relationship for high-appropriability industries. An

[32] See Cohen and Levin (1989) and Cohen (1995) for earlier surveys of this literature.

> empirical analysis of data, disaggregated at the five-digit SIC level, on R&D and market concentration of Korean manufacturing industries provides supportive evidence for the predictions." (p. 101)

Attempting to move the debate forward, and recognizing the limitations of market concentration as a proxy for the intensity of competition, the empirical literature has made progress in using measures other than market concentration as a proxy for the intensity of competition. Notably, Nickell (1996) uses a modified Lerner Index as a proxy for competition.[33] Nickell states (p. 724): "I present evidence that competition, as measured by increased numbers of competitors or by lower levels of rents, is associated with a significantly higher rate of total factor productivity growth."[34] More recently, Aghion, et. al. (2005), also using a modified Lerner index as their measure of competition, have challenged Nickell's conclusions. They find instead an inverted-U shaped relationship between product market competition and innovation.

> "This paper investigates the relationship between product market competition and innovation. We find strong evidence of an inverted-U relationship using panel data. We develop a model where competition discourages laggard firms from innovating but encourages neck-and-neck firms to innovate." (p. 701)

Aghion, et. al. (2005) look at two-digit SIC industries. They measure innovation using the number of citation-weighted patents. Their measure of the Lerner Index averages four percent, and generally falls between zero and ten percent, with the peak of the inverted-U occurring at a Lerner Index of around five percent. Whatever one makes of these findings, they do not challenge the Contestability principle or the R&D Rivalry principle, and they are not directly relevant to analyzing the effects of proposed mergers on innovation.

Cohen reports a number of other studies that support the general proposition that greater competitive pressure spurs firms to innovate to get ahead of their rivals. For example, he notes (p. 16) that "Lee (2009), using World Bank survey data for nine industries across seven

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[33] Nickell also uses results from a one-time survey in which management was asked whether it had more than five competitors in the market for its product. He discusses (p. 732) the limitations of his proxies for competition. Nickell also uses a measure of market share, with three-digit industry sales in the denominator. Nickell notes that "the three digit industry does not represent anything like a 'market,'" and thus has little value as a cross-section measure of market power, but he argues that it is useful as a time-series measure.

[34] Blundell, Griffith, and Van Reenen (1999) state (p. 529): "We find a robust and positive effect of market share on observable headcounts of innovations and patents although increased product market concentration in the industry tends to stimulate innovative activity." They measure innovation by counting the number of technologically significant and commercially important innovations. They define an industry at the three digit level. Their metrics

countries, finds that intensity of competition may stimulate more capable firms to invest more heavily in R&D, while less capable firms may invest less." Of special relevance for competition policy, Cohen reports (p. 16) work suggesting that entry causes innovation. However, this is a tricky area empirically, since high technological opportunity in an industry tends to cause both more entry and faster innovation in that industry. In summarizing the literature on market structure and innovation, Cohen (2009) states (p. 28). "Moving on to our consideration of the relationship between market structure and R&D, the empirical patterns are mixed, and not terribly informative." Again, this is unsurprising, given what we can measure, given the endogeneity of market structure, and given that increased market concentration may or may not go along with greater contestability or more R&D rivalry.

Of particular interest here, Gilbert (2006) provides an extensive discussion of what this empirical literature implies for competition policy. As he points out (p. 187), product market concentration is "a commonly used, but highly imperfect, surrogate for competition." I note in particular that relevant antitrust markets do not match up well with the publicly available sales data, making the measurement of meaningful market shares difficult or impossible for academic researchers. Likewise, academic researchers often have difficulty measuring true operating profits or price/cost margins using publicly available accounting data.

Gilbert concludes that these studies have failed to establish a general and robust relationship between product market concentration and innovation, once one controls for the underlying technological environment.

> "Empirical studies that use market concentration as a proxy for competition fail to reach a robust conclusion about the relationship between market concentration and R&D when differences in industry characteristics, technological opportunities, and appropriability are taken into account" (p. 206).

Gilbert notes several reasons for these negative results: limited data on innovative activity and market concentration, including the high level of aggregation at which market concentration is usually measured; failure to distinguish exclusive from non-exclusive property rights and between product and process innovations; differences in technological opportunities across industries and over time; and failure to control for other confounding factors.

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for competition are the proportion of industry sales made by the five largest domestic firms and the value of imports

The lack of robust results in this particular line of empirical work is understandable, given the measurement difficulties and conceptual complexities already discussed. However, given the extensive empirical evidence showing that competitive pressure forces firms to be more efficient, and given the robust theoretical points relating innovation incentives to sales contestability and R&D rivalry, the negative results in this particular area should not be interpreted as implying that "we just don't know anything about the relationship between competition and innovation." To the contrary, the empirical evidence overall gives reasonably good support to the Contestability and R&D Rivalry principles.

## 5. Merger Enforcement

We are now ready to see what all of this implies for merger enforcement in cases where innovation effects are involved. This is no small matter, since merger enforcement is central to the work of the antitrust agencies and since many and FTC merger investigations and enforcement actions over the past fifteen years have involved innovation.[35] Here I follow in the footsteps of Katz and Shelanski (2005) and (2007), who offer an extensive and thoughtful discussion of how merger enforcement does, and should, take account of innovation.[36]

Merger analysis involves predicting the effects of a specific, discrete change in industry structure, namely the joining of two former rivals under common ownership. As a practical matter, most mergers that receive serious antitrust scrutiny based on a theory of innovation effects involve two of a small number of companies with products, R&D programs or capabilities in a given area. Usually, but not always, the two merging firms are also important pre-merger rivals in the product market. The merger cases of greatest interest in which innovation effects are important typically fit into one of the following fact patterns:

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in proportion to home demand.

[35] Katz and Shelanski (2005) and Gilbert (2006) note the growing importance of innovation in merger analysis. Katz and Shelanski (2005) also discuss a number of specific merger cases in which innovation has been an important factor. Gilbert and Tom (2001) discuss the rising importance of innovation in DOJ and FTC antitrust enforcement more generally during the 1995-2000 time period. The 2010 Horizontal Merger Guidelines include, for the first time, a section on innovation.

[36] Katz and Shelanski (2007) make the useful distinction between "innovation impact" and "innovation effects." My focus here is on "innovation effects."

- **Two Product Market Rivals:** The merging firms are rivals in the relevant product market. One or both of them is investing in R&D to strengthen its position in the market.

- **Incumbent and Potential Entrant:** One merging firm has a strong position in the product market. The other merging firm has no current offering in the product market but is investing in R&D and will enter the product market if the R&D is successful.

- **Pure Innovation Rivals:** Neither merging firm has a current offering in the product market, but both are developing products to serve the market.

When examining a horizontal merger with possible innovation effects, we generally are interested in some version of this question:

> "Will a merger between two rivals significantly reduce their *incentive* to innovate? If so, will the merger enhance their *ability* to innovate sufficiently to offset the reduced incentive?"

The overall relationship between market structure and innovation is not especially relevant to this inquiry, especially since merger enforcement only takes place in moderating or highly concentrated markets. In particular, since merger analysis is not about a generalized increase in "competition," such as a reduction in the extent of product differentiation or an increase in imitation, much of the literature relating the (exogenous) degree of product differentiation to innovation is of little or no relevance to merger analysis. The Schumpeterian proposition that an *ex post* atomistic market structure is not conducive to innovation also is not directly relevant to merger enforcement, which involves a discrete change, usually a substantial increase in concentration, in *ex ante* market structure.

The empirical literature on firm size and R&D is somewhat more relevant, to the extent that it can inform us about the merger-specific efficiencies relating to innovation that are likely to arise when two competing business units are combined to form a larger business unit. However, the analysis of merger synergies tends to be highly fact-specific. So far at least, general findings about firm size and innovation have not proven helpful for assessing merger-specific R&D efficiencies.

In Subsection A, I briefly explain what the recently revised Horizontal Merger Guidelines say about innovation effects. The Guidelines reflect the Contestability and R&D Rivalry principles. Subsections B and C apply these principles to two merger cases in which innovation effects where central. Section D muses about innovation diversity.

## *A. Innovation Effects Under the Merger Guidelines*

The recently revised Horizontal Merger Guidelines contain Section 6.4, "Innovation and Product Variety." Innovation effects had not been explicitly addressed in the predecessor 1992 Horizontal Merger Guidelines. Section 6.4 begins this way:

> "Competition often spurs firms to innovate. The Agencies may consider whether a merger is likely to diminish innovation competition by encouraging the merged firm to curtail its innovative efforts below the level that would prevail in the absence of the merger. That curtailment of innovation could take he form of reduced incentive to continue with an existing product-development effort or reduced incentive to initiate development of new products."

A central question in this analysis is "whether one firm is engaging in efforts to introduce new products that would capture substantial revenues from the other merging firm."

The Contestability principle is directly applicable to this question. Consider how the two firms are affected if Firm A introduces a new and improved product. The new product will increase Firm A's operating profits (measured gross of its R&D expenditures). If Firm B offers products that compete against Firm A's new product, the introduction of Firm A's new product will lower Firm B's operating profits. We can ask what fraction of Firm A's extra profits come at the expense of Firm B's profits. Farrell and Shapiro (2010) call this the "innovation diversion ratio." Applying the contestability principle, Firm A's incentive to introduce this new product are higher, the more profitable sales Firm A gains from Firm B as a result.

How will this change if Firm A acquires Firm B? Post-merger, sales gained at the expense of Firm B's products are no longer incremental to the merged firm: they cannibalize Firm B's profits. Put differently, the merger internalizes what had been a pecuniary externality. The merger turns the lost profits on Firm B's products into an opportunity cost borne by the merged firm when introducing Firm A's new product. The magnitude of the resulting "tax" on the profits from Firm A's new product is, by definition, the innovation diversion ratio. While the innovation diversion ratio is not typically amenable to precise measurement, because it involves products not yet introduced, marketing and financial documents of merging firms and other evidence sometimes indicates the products from which a new product is expected gain sales. Even when the innovation diversion ratio is not amenable to measurement, it is still conceptually central to evaluating the impact of the merger on Firm A's incentive to introduce its new

product. When the innovation diversion ratio is high, the merger significantly reduces the contestability associated with the new product (or other innovation) in question.

The Guidelines reflect these ideas, along with the possibility of offsetting innovation synergies:

> "The Agencies evaluate the extent to which successful innovation by one merging firm is likely to take sales from the other, and the extent to which post-merger incentives for future innovation will be lower than those that would prevail in the absence of the merger. The Agencies also consider whether the merger is likely to enable innovation that would not otherwise take place, by bringing together complementary capabilities that cannot be otherwise combined or for some other merger-specific reason."

As an example of merger-specific efficiencies relating to innovation, suppose that Firm A is considering investing in R&D to develop an improved process that will lower its unit costs. Suppose also that Firm A does not expect to expand its unit sales much as a result of these lower costs.[37] If the merger will enable the process innovation to be applied to Firm B's output, and if Firm A would not license its process innovation to Firm B in the absence of the merger, the merger can enhance Firm A's incentives to develop this process innovation. Of course, any such merger synergy must be weighed against the innovation diversion effects discussed above. In terms of the Contestability principle, the merger can increase $\Delta\pi = X_1\Delta M + M_0\Delta X$ if it increases the base of sales on which the lower costs are achieved, $X_1$, enough to offset the decline in contestable sales, $\Delta X$ resulting from diversion from Firm B's products to Firm A's products.[38] This reflects the robust idea in the literature that smaller firms have lower incentives to engage in process innovations.

Similar ideas can be used to evaluate the longer-term impact of a merger on innovation. The Guidelines state:

> The second, longer-run effect is most likely to occur if at least one of the merging firms has capabilities that are likely to lead it to develop new products in the future that would capture substantial revenues from the other merging firm. The Agencies therefore also consider whether a merger will diminish innovation competition by combining two of a very small number of firms with the strongest capabilities to successfully innovate in a specific direction.

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[37] As discussed above, this can occur because the firm faces binding capacity constraints or because consumers have strong brand preferences and the firm will gain relatively few sales even if it lowers its price to fully pass through its lower costs.

[38] The relevant gain in unit sales for the merged firm, $\Delta X$, is the gain in unit sales of Firm A's products net of the unit sales lost on Firm B's products.

This line of inquiry is directly related to the R&D Rivalry principle. These effects can arise even if the merging firms are not pre-merger product market rivals, as in the Genzyme/Novazyme case.

Evaluating a firm's innovation capabilities is inherently difficult, and the importance of the R&D rivalry between the merging firms can be very difficult to assess if the attributes of the products likely to result from their R&D projects are unknown. Katz and Shelanski (2005) note that many of the merger cases in which R&D rivalry was central have involved pharmaceutical mergers. The FDA approval process often makes it possible to know well in advance which firms are in the best position to introduce drugs or medical devices soon in a specific therapeutic area.

Often, the firms with the greatest ability to innovate in a given area are those that have successfully innovated in similar areas in the past, or who own the complementary assets necessary to commercialize innovations. Such firms often have a strong *ex ante* market position. Historical R&D successes and current market position are thus two common indicators of a firm's innovation capabilities. Of course, a merger also can enable merger-specific efficiencies by combining complementary capabilities within a single firm. As the Guidelines note in the section on efficiencies, the internalization of spillovers can be a cognizable efficiency.

### *B. Genzyme/Novazyme*

[This case will be further developed as a short case study. The merger involved pure R&D rivalry, in that neither firm had a product on the market at the time of the merger.]

[The statement by Chairman Muris relies heavily on economic arguments. The dissent by Commissioner Thompson and the statement by Commissioner Jones Harbor provide further very useful raw material. The fact pattern in this case, as described in these FTC statements, is quite clear, and mostly not disputed, which facilitates analysis. In particular, there appears to be agreement that Genzyme was well ahead of Novazyme and would be first-to-market if its product gains approval, while Novazyme's product would most likely be significantly superior if it gains approval. Their R&D rivalry occurs under the Orphan Drug Act, which establishes certain exclusivity rights for the first-to-market but also rights to a second product if is superior. Katz and Shelanski (2007) also discuss this case.]

[The arguments made by Chairman Muris can be evaluated using the Contestability and R&D Rivalry principles. The bottom line, evaluating the arguments mounted by the Commissioners, but without reaching the merits of the case itself (since there are some disputed facts and I am just taking the various factual representations at face value): Muris explicitly relies on some version of the "complexity" principle, and the Muris statement contains a number of dubious propositions which appear to violate the Contestability principle and the R&D rivalry principle.]

### *C. Thoratec/HeartWare*

[In this 2009 case, the FTC challenged the Thoratec's proposed acquisition of HeartWare.[39] According to the complaint, HeartWare was "poised to seriously challenge Thoratec's monopoly of the U.S. left ventricular assist device ("LVAD") market." Thoratec had the only FDA approved devices, and HeartWare was one of a very few companies permitted to sell limited number of these devices pursuant to Investigational Device Exemptions. (par. 2) The FTC alleged that competition from HeartWare had already forced Thoratec to innovate and that the merger would eliminate innovation competition (par. 23e).]

[This case seems relatively straightforward, based on the FTC complaint. The case follows the fact pattern in which one merging firm has a product on the market and both are conducting R&D to improve their offerings.]

[The Contestability and R&D Rivalry principles appear to work well here and to support the enforcement action taken by the FTC. While the case appears relatively simple, it still illustrates why general propositions about product market concentration and innovation are typically not very helpful for merger analysis where innovate is at stake.]

### *D. Innovation Diversity*

[Innovation diversity seems terribly important. Especially since we are honoring the 1962 volume on the rate and *direction* of inventive activity.]

[39] See http://www.ftc.gov/opa/2009/07/thoratec.shtm

[In general, we have no reason to believe that the portfolio of R&D projects undertaken by private firms is socially optimal when the reward to innovation comes in the form of market power. As usual, there are two wedges between social and private incentives when it comes to allocating resources across a portfolio of risky R&D projects: external effects on other firms and external effects on consumer surplus. In Shapiro (2006), I study how rewards based on patents can lead to a bias in the R&D approaches pursued by private firms.]

[When thinking about the effects on other firms, we often have in mind business stealing effects. In the presence of market power, these are not merely pecuniary negative externalities. But there also are positive external effects, e.g., on the suppliers of complements or in the presence of network effects.]

[Merger analysis would benefit from greater knowledge of the circumstances under which individual firms are capable of pursuing multiple, diverse approaches in the same area. No doubt a single firm can have incentives to pursue diverse approaches internally. But this can be hard to accomplish organizationally. Intuitively, one suspects that diversity is more difficult within a single organization than across multiple organizations with different leaders. Grove (1996) explains that Intel found it very hard to pursue both CISC and RISC internally. Christensen (1997) discusses the importance and limitations of "skunk works."

[For the purpose of merger analysis, it is very important to assess whether the merger will augment the *ability* of the merged entity to conduct R&D. For example, a merger can enable cross-fertilization between the research teams of the two merging firm. Likewise, a merger can enable valuable information sharing between the regular operations of one merging firm and the researchers at the other firm. Similarly, a merger can combine complementary assets such as a new product by a small start-up firm and the existing manufacturing or distribution assets of a larger, more established firm. However, these merger synergies are easier to claim than to verify. The Guidelines require that efficiencies be merger-specific and verified to be credited.]

[Another consideration is that the ability of start-up firms to pursue an exit strategy by selling to an incumbent can be important for initially obtaining venture capital. In fact, merger enforcement almost never stands in the way of large firms from acquiring innovative start-ups.

The rare exceptions arise when the start-up has already grown into a clear threat to the acquiring firm in an area where that firm has a powerful incumbency position.]

[All in all, considerations of innovation diversity are highly fact-intensive and case-specific, because they tend to involve innovation synergies more than innovation incentives.]

## 6. Conclusions

Yes, Arrow *did* hit the bull's eye: a firm with a vested interest in the status quo has a smaller incentive to develop or introduce new technology that disrupts the status quo.

In this paper, I have attempted to generalize the Arrow "replacement effect" in a practical manner with the Contestability principle.

Schumpeter was also quite correct: market power is a necessary reward to innovation.

Indeed, Schumpeter's point may be the more important one when it comes to the antitrust evaluation of unilateral conduct by a dominant firm. While antitrust enforcement of this type can enhance *ex post* competition, it must also be mindful of longer-term innovation incentives. Antitrust law has recognized this for many years, in no small part due to Schumpeter's influence.

But Arrow's point is the more salient one for merger enforcement. Way to go, Ken!

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