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# Innovation Matters

## Competition Policy for the High-Technology Economy

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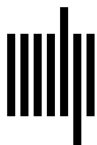
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### 3 Competition and Innovation Basics: Arrow versus Schumpeter

What we have got to accept is that [the large-scale establishment or unit of control] has come to be the most powerful engine of [economic] progress and in particular of the long-run expansion of total output... In this respect, perfect competition is not only impossible but inferior, and has no title to being set up as a model of ideal efficiency. It is hence a mistake to base the theory of government regulation of industry on the principle that big business should be made to work as the respective industry would work in perfect competition.

—Joseph A. Schumpeter, *Capitalism, Socialism, and Democracy* (1942)

The incentive to invent is less under monopolistic than under competitive conditions, but even in the latter case it will be less than is socially desirable.

—Kenneth Arrow, “Economic Welfare and the Allocation of Resources for Invention” (1962)

#### 1 Introduction

This chapter describes two basic economic propositions regarding the relationship between competition and innovation. Section 2 describes a view attributed to Joseph Schumpeter that imperfectly competitive markets promote innovation by allowing firms to appropriate more value from their innovations.<sup>1</sup> Section 3 describes a theory, developed by Kenneth Arrow two decades later,<sup>2</sup> that implies that a firm with monopoly power that is protected from competition has less incentive to innovate than a firm in a competitive industry. The monopolist’s existing profits discourage research and development (R&D) if an innovation risks the loss of these profits. Firms in a competitive industry do not have a corresponding opportunity cost from innovation. Arrow’s theory supports a statement by Sir John Hicks that “the best of all monopoly profits is a quiet life.”<sup>3</sup> According to this theory, a firm that

is shielded from competition has neither the necessity nor the incentive to work hard to create new and improved products. The loss of existing profits from an innovation is often called the “Arrow replacement effect.” It is a fundamental force that appears repeatedly in this book.

Section 3 explores assumptions in the Arrow model that limit its generality. Arrow does not consider the implications of limited appropriability discussed in section 2. Furthermore, he does not consider incentives for the monopolist to innovate to protect its profits by excluding rivals. Moreover, he only examines cost-reducing innovations. Competition can have different implications for incentives to develop new products compared to incentives to lower the cost of producing existing products.

Neither Arrow nor Schumpeter addresses the dynamic interactions that exist between incentives to innovate, the production of innovations, and the state of competition in markets. Chapter 4 discusses these dynamic interactions, along with organizational theories that depart from simple profit maximization. I also note here that the effects of reduced competition on the incentive to innovate are not generally equivalent to the effects of a merger on innovation incentives. A merger places two formerly independent entities, along with their premerger R&D assets, under centralized control. Absent merger-specific economies or diseconomies of scale or scope in R&D, a merger does not change an industry’s capacity to invest in R&D. Instead, a merger allows the merged parties to coordinate economic decisions, such as setting prices and investing in R&D. Chapter 5 explores the effects of mergers on innovation incentives in more detail, and chapter 6 examines the empirical evidence relating competition and mergers to innovation.

## **2 Joseph Schumpeter and the Consequences of Limited Appropriation**

In the 1940s, Joseph Schumpeter challenged the prevailing view that competition is a superior form of market organization to create social value. In regard to dynamic efficiency and the creation of new products, Schumpeter wrote that, “Competition is not only impossible but inferior, and has no title to being set up as a model of ideal efficiency.”<sup>4</sup>

Schumpeter did not speak directly to the effects of market structure on the ability to appropriate the value of innovations. He was more concerned with the failings of models of perfect competition to account for innovation and entrepreneurship and emphasized the power of

“creative destruction” to invigorate economic progress, which can come from any source.<sup>5</sup>

Nonetheless, Schumpeter’s name has become shorthand for the proposition that scale and market power enable a more stable and productive platform for R&D. In *Capitalism, Socialism and Democracy*, he concludes that:<sup>6</sup>

There are superior methods available to the monopolist which either are not available at all to a crowd of competitors or are not available to them so readily: for there are advantages which, though not strictly unattainable on the competitive level of enterprise, are as a matter of fact secured only on the monopoly level, for instance because monopolization may increase the sphere of influence of the better, and decrease the sphere of influence of the inferior, brains, or because the monopoly enjoys a disproportionately higher financial standing.

Schumpeter provided no formal economic model to describe his vision of monopoly power and innovation incentives, and his emphasis on the ability of large firms to attract capital is outdated, given developments in the availability of venture capital. Nonetheless, his criticism of perfect competition as the ideal engine of innovation is valid. Perfect competition is not viable in industries such as semiconductor fabrication, for which new facilities incur multibillion-dollar sunk costs, or in industries such as computer software or genomics, for which the marginal cost of technology licensing and distribution is only a small fraction of the R&D costs required to create the licensed products. Pricing these products at or close to their marginal production costs would not generate sufficient profits to justify the R&D expenses that brought them to market.

According to this Schumpeterian perspective, a reduction in rivalry can enhance appropriation in several ways. For example, a reduction in rivalry can allow an innovator to profit from a higher profit-maximizing price for the innovation. In that case, antitrust enforcers would have to weigh the adverse effects on prices from a reduction in rivalry against possible benefits for innovation. In this section, I address two other ways in which a reduction in rivalry can enhance appropriation: (1) A reduction in rivalry can increase an innovator’s sales, which allows an innovator to appropriate more profit from the innovation; and (2) a reduction in rivalry can reduce technological spillovers, which allows competitors to imitate an innovation at the expense of the innovator.

To illustrate the effect of firm size on appropriation and innovation incentives, compare a highly stylized example of innovation by a firm

in a duopoly to innovation by a monopoly. Suppose that there is a market in which price is fixed at \$10 and total demand is fixed at 1 million units. There is an existing technology that enables production to take place at a constant marginal cost of \$8 per unit, but a new technology can lower that cost to \$6. Furthermore, suppose that the innovator cannot profitably license the new technology, perhaps because it would be difficult to monitor and prevent unauthorized copying.

Each firm has a profit margin of \$2 without the innovation and \$4 with the innovation. In the duopoly, each firm sells 500,000 units, and the innovation would add \$1 million to each firm's profit. A monopolist sells 1 million units, so innovation by the monopolist would add \$2 million to the firm's profits. The monopolist has a greater incentive to innovate because it can appropriate more of the innovation's value.

This simple example makes many assumptions. More generally, a successful innovator can profitably choose a lower price. A lower price would expand total sales and, in the duopoly case, allow a successful innovator to win sales from its rival. A monopolist also can benefit from greater total sales, but the monopolist has no rivals from which the firm can take sales. Furthermore, a new entrant or a small innovator might profit by licensing the innovation to other firms.

Partha Dasgupta and Joseph Stiglitz developed a formal model of cost-reducing innovations in an oligopoly,<sup>7</sup> and Xavier Vives developed the analysis further.<sup>8</sup> Both models show that there are circumstances in which firms in concentrated markets can have greater incentives to invest in cost-reducing innovations than do firms in less-concentrated markets. The benefit from a cost reduction is proportional to a firm's output, and the larger the firm's scale, the more it can benefit from cost-reducing innovation. Competition lowers prices and may increase total output, but it fragments output among firms that share the market with their rivals. By doing so, competition can reduce firm scale and lower the incentive for each firm to innovate.

This discussion of appropriation and R&D investment exposes another issue that is relevant to competition policy: the distinction between R&D investment and innovation. Greater R&D investment does not necessarily imply more innovation. Indeed, the correlation can be negative. For example, suppose that it costs \$1 million to reduce the marginal production cost from \$8 to \$6. A monopolist incurs an R&D cost of \$1 million for the cost reduction, while in this example, the industry with two firms incurs twice the R&D cost for the same improve-

ment in the total cost of production, assuming no difference in industry demand. There is greater R&D expenditure in the duopoly market compared to the monopoly, but no greater benefit for innovation.

The possibility that rivals can gain valuable information from another firm's innovations (i.e., technological spillovers) can reduce the incentives of firms in competitive markets to invest in R&D. Patents, trade secrets and copyrights provide only limited protection from imitation by rivals. Although the threat of imitation can reduce a firm's incentive to invest in R&D, it does not necessarily reduce innovation. Spillovers extend the benefit of innovation by allowing innovation by one to be enjoyed, at least partially, by others. With spillovers, a competitive industry may not have adequate incentives to invest in R&D, but the innovation that occurs yields high returns because it benefits many producers.<sup>9</sup> Spillovers are not always beneficial in this respect because they can encourage firms to play a waiting game, in which each firm postpones R&D in the expectation that it can learn from successful innovation by its rival. In extreme cases, the waiting game can result in a losing scenario, in which firms postpone innovation indefinitely.<sup>10</sup>

If an industry is characterized by high technological spillovers, an efficient policy is to subsidize R&D to increase the incentives for investment while encouraging competition to keep prices low. Without subsidies for R&D, an increase in market concentration can be a second-best solution, by reducing the number of rivals that can benefit from spillovers and thereby increasing incentives for innovation. Antitrust authorities, who have no control over R&D subsidies, then would have to balance the increased incentive for innovation from greater market concentration against the risk of higher prices.

I turn next to a model of the effects of competition on innovation incentives developed by Kenneth Arrow two decades after Joseph Schumpeter's writings on this issue.

### 3 Arrow's Model: The "Replacement Effect"

Arrow examines a firm's incentive to invest in a cost-reducing innovation in two polar market structures: (1) a monopolist that is protected from competition and (2) a perfectly competitive market. Because Arrow's theory is fundamental and influential, I review his model in detail in this section. Arrow makes the following assumptions:

- In both market structures, there is an existing technology that allows the production of a product with constant marginal cost.
- The innovation is a new technology that allows production of the same product at a lower constant marginal cost.
- The innovation is protected by a patent that prevents imitation.
- The product is sold at a uniform price and the profit from the innovation does not depend on the identity of the innovator.

Arrow shows that the incentive to invest in the new technology is greater for a firm in the competitive market than it is for the monopolist. The monopolist has an existing flow of profit from the old technology, which the invention would replace. A firm in a perfectly competitive market has no existing profit flow that is at risk from an innovation.

The fact that a firm in a competitive market has more to gain from the new technology than a monopolist is obvious if the new technology eliminates competition from the old technology. Arrow calls this a “drastic” innovation.<sup>11</sup> The monopolist and a firm in a competitive market earn the same profit with the innovation, but the firm in the competitive market has nothing to lose by innovating.

Incremental (nondrastic) innovations take sales from—but do not eliminate—competition from existing products or from the use of existing technologies. Arrow shows that a firm in a competitive market also has a greater incentive to invest in R&D for an innovation that reduces the marginal cost of production but is not drastic. His insight is that monopoly prices reduce sales compared to a firm in a competitive market for any level of the firm’s cost. Given reasonable assumptions about demand for the product, the lower sales by the monopolist reduce its incremental benefit from a cost reduction compared to the benefit for a firm in a competitive market.

Arrow concludes that the incentive to innovate is less than its social value in both the competitive and the monopoly regimes. This follows from his assumption that the innovator charges a single uniform price for the product, which implies that the monopoly profit from the innovation is less than its social value: Some consumers who would benefit by consuming the product are excluded because its price exceeds its marginal cost, while others purchase the product at a price that is less than its value. If the monopolist could capture all of the social benefit from an innovation, its incentive to innovate would equal the innovation’s social value.<sup>12</sup>

Arrow's model applies to any firm that has existing profits and is protected from competition. Its significance cannot be denied, but it is also important to understand its assumptions and limitations. In addition to the assumption that the product is sold at a uniform price, they include the following:

- Arrow's monopolist is protected from competition in both production and R&D. Consequently, the incumbent monopolist has no need to engage in conduct to prevent potential competitors from innovating, including by being the first to invent and patent the new technology.
- The innovation in Arrow's model is a reduction in the marginal cost of production. His model does not address the more typical case of product innovation. Consequently, his analysis does not consider possible interactions between an innovation and the profitability of a firm's existing product portfolio, including the incentives of a firm to increase sales by improving a durable good.
- The innovator in Arrow's model benefits from perfect patent protection. He does not consider the relationship between competition and innovation incentives when imperfect protection limits the ability of the innovator to profit from invention.
- Arrow does not consider cumulative innovation, in which firms make R&D investments that benefit from other firms' prior innovations, nor does he consider how market structures change over time to reflect the success of past innovations.

Imperfect patent protection invokes issues related to appropriation discussed in the preceding section, as does his assumption that the product is sold at a single uniform price. I discuss cumulative innovation and dynamic models of innovation incentives in the next chapter. In this section, I address how Arrow's conclusions change if a monopolist has incentives to innovate in order to exclude rivals, and if innovations are new products rather than new production technologies.

### **Arrow assumes a monopoly in both production and innovation**

The monopolist in Arrow's monopoly regime faces no competition in either production or innovation. If the monopolist chooses not to invest in R&D, it retains a monopoly with the old technology. Eliminating the assumption that a monopolist is protected from innovation competition can reverse Arrow's conclusion that firms in competitive industries have greater incentives to invest in R&D.



A firm with monopoly power has an incentive to *preempt* competition that would upset its monopoly.<sup>13</sup> Andy Grove, former chief executive officer (CEO) of Intel Corporation, expressed this incentive in his book *Only the Paranoid Survive*, as did former Apple CEO Steve Jobs, who told his biographer, "If you don't cannibalize yourself, someone else will."<sup>14</sup>

An incumbent monopolist's incentive to innovate to preempt competition is the difference between its monopoly profit with the innovation and the profit that the firm would earn with the old technology when it faces an innovating rival. If the innovation is not drastic, it is more profitable for the incumbent to keep its monopoly by patenting the new technology than it is for a rival to patent the new technology and compete with the incumbent. The incumbent risks losing its monopoly profit if it does not innovate, while a successful new competitor can only profit from competition with the incumbent. The former monopoly profit is greater than the latter duopoly profit. Hence the monopolist has a greater incentive to invest to win a patent that would preempt competition. This turns on its head Arrow's finding that monopoly profits lower the incentive to invent.

This preemption argument should be interpreted with caution because it fails in some practical circumstances. First, if the innovation is drastic, a rival innovator would change places with the monopolist and wipe out the former monopolist's profits. Consequently, a new competitor has as much to gain from a drastic innovation as the former monopolist has to lose if it does not innovate and another firm succeeds. In this situation, the monopolist has no edge to prevent competition. The monopoly preemption incentive holds only if the innovation is not drastic. This result has important implications for the organizational theories of disruptive innovation that will be discussed in the next chapter. Claims that dominant firms are organizationally inept at responding to disruptive innovation overlook the fact that incumbent firms have no greater economic incentives to invest in disruptive change (i.e., drastic innovation) than do new competitors.

A second criticism is that preemption incentives do not necessarily extend to the more common situation of markets that are oligopolies, but not monopolies. Suppose that the incumbent shares the market with one or more other firms. In that case, it does not necessarily follow that the incumbent's profit from preventing the entry of a rival is greater than the rival's profit with the new technology when the innovation is not drastic. The reason is that a newly innovating entrant

would take profit from all the incumbent firms, while an innovating incumbent shares the benefit from preempting new competition with other incumbents. These effects dilute the profit that any one incumbent can earn by preventing the entry of a new rival relative to the profit that an entrant would earn if it innovates. The incentive for preempting innovation by a new rival is strong only if the incumbent has a dominant position in the market that it can maintain by preventing entry.

Third, it does not necessarily follow that an incumbent would spend more to innovate than a new competitor if the incumbent cannot preempt rival innovation with certainty. Suppose there is a 50 percent probability that a rival will enter with a new technology and an equal probability that rival innovation will not occur. In the latter event, the incumbent's profit from its existing technology dulls its incentive to invest in R&D for an improved technology. This is the Arrow replacement effect. Although the replacement effect is operative only if rival innovation does not occur, the fact that there is a high probability that rival innovation will not occur reduces the incumbent's incentive to invest in the new technology. The reduction can be sufficient to make the monopolist's incentive to invest in the new technology less than a new competitor's incentive to invest.<sup>15</sup>

Fourth, preemption incentives do not necessarily foreclose a strategy in which rivals invest in R&D with the intention of selling or licensing discoveries to an established incumbent. An incumbent and a potential rival that owns a competing technology have incentives to avoid competition by negotiating an exclusive sale or licensing agreement.<sup>16</sup> If permitted by the antitrust laws, such *ex post* negotiation preserves the monopoly structure of production, with its adverse consequences for consumer prices. In that case, the incumbent monopolist would have no differential profit incentive to preempt rival innovation in order to preserve its monopoly. Many start-ups and research-focused organizations sell or license promising discoveries to established firms.

Fifth, and particularly important, a preemption strategy is unlikely to be profitable if it does not foreclose new competition. Spending R&D dollars to secure a patent does not foreclose competition if the incumbent's R&D efforts fail, or if potential rivals can invent around the patent and compete with a different technology. A preemption strategy can become an expensive game of Whack-a-Mole when potential rivals have multiple ways to enter and compete in an industry.<sup>17</sup> The constraint on the ability of a preemption strategy to foreclose competitors

is important because it is rarely the case that acquisition of a single asset, such as a patent, is sufficient to protect a firm from future competition. A patent gives its owner a narrow right to exclude others from using the technology covered by the patent. It does not necessarily grant its owner a monopoly over a substantial region of economic activity.<sup>18</sup>

Nonetheless, it would be unwise to dismiss preemption incentives as a significant force in markets with established incumbents. The new-economy titans have won hundreds of bidding contests to acquire young start-ups, some of which have the potential (if only remote) to disrupt their dominance. Incumbents may win bidding wars because the acquisitions provide complementary benefits. In other circumstances, the incumbent may prevail because it has more to lose if a start-up matures to become a viable competitor than the start-up can expect to gain on its own by competing head-to-head with a dominant firm.

### **Arrow does not consider interactions between a firm's product portfolio and the profitability of an innovation**

Most innovations are new products, not simply new methods to lower a firm's production costs. Arrow's claims about relative payoffs from cost-reducing innovations in the monopoly and competitive regimes extend to product innovations if they are drastic (and if his other assumptions also apply, such as the assumption that the profit from an innovation does not depend on the identity of the inventor). However, Arrow's conclusions about monopoly and competitive innovation incentives do not necessarily hold for nondrastic product innovations, even if the monopolist is insulated from competition in R&D as well as in the product market.

A new product allows an incumbent monopolist to coordinate prices for the new product and for other products in its existing portfolio. This can increase the monopolist's profit from innovating relative to a new rival that can profit only from the innovation. In some situations, higher prices from this coordination deny consumers the benefits of greater innovation incentives, while in other situations, price coordination by the incumbent can promote innovation and consumer welfare.

Price coordination by an incumbent monopolist can increase R&D incentives and result in lower prices compared to innovation by a competitor if the innovation is a complement for the incumbent's existing products. The lower prices result from the Cournot complements effect discussed in chapter 2. The Cournot complements effect also

implies that the incremental profit earned by a monopolist that makes a complementary innovation exceeds the profit that a new competitor can earn from the innovation. The monopolist also suffers a replacement effect that is absent for a competitor with no existing profits. If the replacement effect is not too large, consumers can benefit from greater innovation incentives and lower prices in the polar case of monopoly, compared to the polar case of innovation by a firm in a competitive market, when innovation involves complementary products.

It does not follow that monopoly is a superior organizational form for innovation when products are complements.<sup>19</sup> Competition in the supply of complementary products can create capabilities and incentives for innovation that are not available to a single firm. Consumers and firms that participate on the IBM-compatible PC platform benefit from competition that has generated thousands of complementary software and hardware innovations. Innovation in the field of plain-paper copiers flourished after a Federal Trade Commission (FTC) consent decree required the Xerox Corporation to license its patents, which opened the market to new competition for complementary innovations.

If the innovation is a substitute for the monopolist's existing products, a monopoly innovator can profit by coordinating higher prices for the new and existing products than would occur if a competitor innovates. Substitute products can be differentiated vertically or horizontally. Products with different qualities are vertically differentiated if, at equal prices, all consumers prefer a higher-quality product, such as a computer with a more powerful microprocessor. Products are horizontally differentiated if consumers prefer different products when they have the same price and quality. For example, some consumers have a brand preference for Ford trucks, while others prefer Chevy trucks.

Shane Greenstein and Garey Ramey analyze a model in which products are vertically differentiated.<sup>20</sup> In the simplest version of their model, a monopolist that is protected from competition earns the same profit from the new product as a firm in a perfectly competitive industry, provided that the new product is not a drastic innovation that eliminates demand for the old product. With minor changes in consumer preferences, the monopoly payoff from innovation can exceed the payoff to a firm in a competitive industry.

Yongmin Chen and Marius Schwartz examine product innovation incentives for a monopolist and competitive firms when products are horizontally differentiated.<sup>21</sup> In their model, a protected monopolist has

a greater incentive to introduce a new product than does a firm in a competitive industry, again under the assumption that the new product is not a drastic innovation that eliminates demand for the old product.

In these models, the monopolist charges high prices for its products, which lowers the consumer benefits from the innovation. Monopolists can have greater incentives to invent than do competitive firms, but the incentives do not necessarily improve consumer welfare, after accounting for higher post-innovation prices. Nonetheless, consumers may benefit from monopoly innovation incentives if the innovations have large spillover benefits in other markets. These spillover benefits might not occur but for the greater innovation incentives of monopolies, and in some situations, they can more than compensate for the harm that comes from higher prices in the market where the innovation occurs.

A firm's ability to coordinate prices for a portfolio of products has an important message for innovation policy: One should not assume that the results in Arrow's model of innovation incentives for cost-reducing technologies apply without qualification to the more common situation of product innovation. Portfolio effects for multiproduct firms with monopoly power can create positive incentives for innovation that offset—and in some cases more than offset—the negative incentive from the replacement effect.

Durable goods create additional incentives for innovation. A durable good supplies services for its useful life. A washing machine does not need to be replaced until it wears out. A PC provides services until the hardware fails or the software becomes irreparably corrupted. In contrast, consumption exhausts the benefit from a nondurable good, such as gasoline, printer ink, or laundry detergent. Durable goods account for a large share of the growth of economic output and include many products that embody large investments in R&D.<sup>22</sup>

When a firm sells (rather than rents) a durable good to a customer, the firm can obtain no future revenue from the customer unless the product wears out or the customer has a desire to upgrade to a new version. If the good does not wear out and no new customers enter the market, the firm can sell more only if it lowers prices to attract more price-sensitive customers, or if it can convince existing customers to upgrade to a new version of the product.<sup>23</sup> The replacement effect is less significant for the seller of a durable good because the firm has no revenues that the innovation would eliminate, other than the revenues it could earn by lowering prices for existing customers or by attracting new customers. Chapter 6 offers an empirical example that illustrates

the powerful effects of a durable good for innovation, even for a firm with monopoly power.<sup>24</sup>

Arrow's model ignores the dependence of appropriation on industry structure. He assumes that patent protection excludes imitation, and that an incumbent monopolist cannot obtain more value from an innovation than does a new competitor. An incumbent monopolist can have a greater incentive to innovate, even if it suffers the Arrow replacement effect, if the new competitor cannot match its ability to appropriate value from the innovation. The next chapter considers the interactions between limited appropriation and the Arrow replacement effect in a model of dynamic competition. The next chapter also explores the implications of managerial and organizational constraints for the relationship between competition and incentives to invest in R&D. Although innovation is not motivated purely by an economic comparison of expected costs and benefits, the power of economic incentives and disincentives for innovation, such as the Arrow replacement effect, should not be underestimated.



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