How Entrepreneurs Affect the Rate and Direction of Inventive Activity

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Abstract

Entrepreneurship in established industries poses a puzzle. Entrepreneurial entry increases competition, which suggests that innovators will earn greater returns simply by transferring their technology to incumbent firms. The paper provides a solution to the puzzle that does not rely on imperfections in the market for technology. Because product differentiation reduces the intensity of competition, it improves the returns to entrepreneurial entry. With product differentiation, therefore, industry profits can *exceed* monopoly profits. As a consequence, the innovator will prefer entrepreneurship to technology transfer. The paper obtains the following results. First, when consumers derive sufficient benefits from product variety, entrepreneurs will enter the market. Second, innovators with incremental innovations become entrepreneurs and innovators with major innovations transfer their technology. Third, an innovator who can choose between licensing the innovation and becoming an entrepreneur has a greater incentive to invent than an incumbent monopolist. Fourth, when innovations and entrepreneurs are independent, the market equilibrium always involves entrepreneurial entry. Fifth, an independent innovator has a greater incentive to invent than an incumbent monopolist.

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Introduction

Anyone who reads Kenneth J. Arrow's work is struck by his clear and careful reasoning and intuitive discussion of economic implications. In examining inventive activity, I have been guided not only by Arrow's important results but by his methodology. Arrow finds that the demand for invention is perhaps the most critical determinant of the rate and direction of inventive activity. Arrow's (1962) celebrated result shows that a competitive downstream product market generates greater economic rents for the inventor because it functions more efficiently than does a monopolistic downstream market. Greater returns to invention will increase incentives to supply inventions. By focusing on the demand for invention, Arrow's influential discussion highlights innovation, that is, the commercialization of invention. Arrow's classic analysis has important implications for innovation that have yet to be fully examined and understood. Arrow focused on the existing firms' demand for invention and examined the effects of downstream market structure. This paper considers the additional demand for invention by new firms and examines how changes in downstream market structure affect the rate and direction of inventive activity.

Entrepreneurs have been recognized as major contributors to innovation at least since Jean-Baptiste Say (1841, 1852) and Joseph Schumpeter (1934, 1942). Entrepreneurship is one of the main forms of commercialization of invention, see Baumol (1968, 1993, 2002, 2006), Audretsch (1995, 1995b), Audretsch et al (2006), Acs et al. (2004), Schramm (2006), and Baumol et al. (2007). However, entrepreneurship poses an interesting puzzle in established industries. Because entrepreneurship increases competition, why would innovators not prefer to sell their innovations to existing firms?

Technology transfer would commercialize inventions without increasing competition from new firms. For further discussion of this puzzle, see for example Gans, Hsu, and Stern (2000), Gans and Stern (2000, 2003), and Spulber (2010).

Product differentiation provides the key to resolving the puzzle of entrepreneurship. Guided by Arrow's analysis, the present discussion considers how the fundamental structure of market demand affects innovation. By establishing a new firm that embodies the invention, the entrepreneur increases product variety. Differentiated products mitigate the effects of creative destruction, allowing the new firm to operate beside the old firm. The incumbent firm can continue to operate after entrepreneurial entry. Product differentiation tempers the intensity of competition and gives the competing firms market power. This reduces the potential gains to the incumbent firm from receiving the new technology. When consumers derive benefits from product variety, the entrepreneur can compete profitably with the existing firm. The innovator will choose entrepreneurship when the returns to entry exceed the returns to the incumbent firm from technology transfer.

Inventions reach consumers through two major forms of innovation: technology transfer to existing firms and establishment of new firms. The demand side of the market for invention thus consists of existing firms and entrepreneurs who establish new firms. An innovator seeking to commercialize an invention, whether he is the original inventor or an intermediary, faces a crucial decision. The innovator can transfer the technology to an existing firm or become an entrepreneur and establish a new firm. Determining whether innovation takes the form of technology transfer or entrepreneurship affects the returns to invention. This paper examines the crucial economic factors that determine how to solve the innovator's decision problem. By offering an alternative to technology transfer to existing firms, entrepreneurs affect the rate and direction of inventive activity.

Product differentiation determines whether the innovator chooses to compete or to cooperate with the existing firm. When products are sufficiently differentiated, the returns to entrepreneurial entry exceed the net returns to technology adoption by the incumbent firm. Therefore, the innovator will choose entrepreneurship and embody the technology in a new firm. When products are not sufficiently differentiated, the innovator will transfer the technology to the incumbent firm. When the innovation is inferior to the existing technology, that is, when unit costs are greater than under the existing technology, sufficient product differentiation provides incentives for entry. When products are not sufficiently differentiated, and the innovation is inferior to the existing technology, there are incentives for the incumbent firm to buy out the innovator to prevent entry.

The extent of the innovation also affects the innovator's choice in a market with differentiated products. Arrow (1962) defines an innovation to be drastic or nondrastic depending upon whether the monopoly price with the new technology is less than or greater than the unit costs under the old technology. In our setting, incremental innovations lead to entrepreneurship. Major innovations generate returns to technology transfer that exceed the returns to entrepreneurship. A sufficiently inferior innovation also generates returns to technology transfer through a buy out to deter entry.

The analysis also considers whether an independent inventor would transfer the technology to both an existing firm and an entrepreneurial startup. The analysis shows that the incumbent firm's inertia, also noted by Arrow (1962), has an important implication in our setting. The royalty that induces adoption by the incumbent firm also will induce adoption by an entrepreneurial entrant. The independent innovator thus will sell either to the entrepreneur or to both the entrepreneur and the incumbent. This means that the independent innovator will always transfer the technology to an entrepreneur. Entrepreneurship always occurs with independent innovators.

Schumpeter emphasizes that entrepreneurs provide a large share of the technological innovations that stimulate the growth and development of capitalist economies. As Schumpeter (1934, p. 66) points out, entrepreneurship involves the carrying out of new combinations, which includes the introduction of a new good, the introduction of a new method of production, the opening of a new market, the conquest of a new source of supply of raw materials or half-manufactured goods, and the carrying out of a new organization of any industry. Schumpeter (1934, p. 66) observes that “new combinations are, as a rule, embodied, as it were, in new firms which generally do not arise out of the old ones but start producing beside them.” Entrepreneurs transform the economy through “gales of creative destruction,” creating new firms that displace existing firms through competition. Our analysis shows why new combinations are embodied in new firms.

The present analysis is carried out in a frictionless setting to highlight the effects of product differentiation. Certainly, path-breaking inventions that create new industries require entrepreneurs for commercialization. Even if the returns to technology transfer exceed returns to entrepreneurship, there are still circumstances that would lead to entry. For example, existing firms may face adjustment costs that are greater than the establishment costs of new firms, thus favoring entrepeneurship. A Coasian analysis suggests some further possibilities (Spulber, 2010). Legal property rights may not be clearly defined so that innovators prefer entrepreneurship to technology transfer as a means of protecting their intellectual property (IP). Transaction costs in the market for IP may exceed transaction costs of establishing firms, leading to entrepreneurship rather than technology transfer. Sources of these transaction costs include the possibility of imitation and expropriation when revealing technology to a potential buyer, as Arrow pointed out.

The analysis has public policy implications. Economic factors that influence entrepreneurship are likely to exercise a significant influence on the rate and direction of inventive activity. The greater are the opportunities for innovation, that is, commercialization of invention, the greater are the incentives to invent. Thus, greater opportunities for innovation increase the rate of inventive activity. In addition, various economic factors that determine how inventions are commercialized and differences in commercialization opportunities across economic sectors will affect inventive activity. By demonstrating how entrepreneurship contributes to innovation, the present analysis emphasizes the need for public policies that are consistent with entrepreneurship. Public policies such as business taxes and regulations that discourage entrepreneurship block a significant channel of innovation. This reduces incentives to invention. Public policy makers should not design incentives for innovation that rely exclusively on incumbent firms. Instead, public policies toward innovation should recognize the contribution of entrepreneurs to product variety, competition, and productive efficiency.

My analysis draws on the dynamic theory of the entrepreneur presented in Spulber (2009). The entrepreneur commercializes an invention by establishing a firm that embodies the innovation. The innovator's decision problem that is studied here is closely related to work on R&D and entrepreneurship. Spulber (2010) considers creative destruction when the entrepreneurial entrant displaces the incumbent through Bertrand competition. Spulber (2008) examines licensing and international technology transfer.

The standard analysis of innovation shows that due to the effects of competition, the monopolist has a greater incentive to invent than does an entrant, see Gilbert and Newbery (1982) and Gilbert (2006). Gans and Stern (2000), using a model with homogeneous products, suggest that entry by a startup is "something of an economic puzzle" in the absence of noncontractible information asymmetries. Gans and Stern (2000) look at an R&D race where the winner can license the technology and faces the possibility of imitation, see also Salant (1984), Katz and Shapiro (1987), and Reinganum (1981, 1982, 1989). Greenstein and Ramey (1998) consider vertical product differentiation and find that competition can yield greater returns than monopoly when the competitive entrant becomes the dominant firm, see also Chen and Schwartz (2009) in which the dominant firm produces multiple goods. This differs from my analysis in which the incumbent firm and the entrant compete on equal terms. Rasmusen (1988) considers an entrant that seeks a buyout after entry in a homogeneous products Cournot game with capacity constraints, although he does not consider technological change.

A number of studies consider alternative commercialization strategies for innovation. Teece (1986) examines the role of complementary assets and the strategic decisions of firms, see also Teece (2006) and the references therein. Arora et al (2001a) consider the incentives of startups to license their technology. Blonigen and Taylor (2000) consider acquisition of startups by established firms in the U.S. electronics industry. Management studies have examined competition between innovative startups and established firms, see Henderson and Clark (1990) and Christensen (1997). In the international context, Anand and Khanna (2000) find many licensing agreements in chemicals, electronics and computers. Tilton (1971) and Grindley and Teece (1997) examine licensing in the international diffusion of semiconductors and electronics. Arora et al. (2001a, b) consider the evidence for the existence of international markets for technology and provide extensive analysis of the chemical industry. Zucker, Darby, and Armstrong (1998) examine market-mediated transfers of biotechnology.

The paper is organized as follows. Section 2 presents the basic model. Section 3 considers the decision of an innovator who chooses between becoming an entrepreneur and transferring the technology to an incumbent firm. Section 4 considers an adoption-and-entry game with an independent innovator who chooses whether to transfer the technology to an incumbent firm, to an entrepreneur, or to both. Section 5 considers the adoption-and-entry game with an independent innovator when the entrepreneur has the option of using the initial technology. Section 6 examines various extensions to the basic model. Section 7 concludes the discussion.

2. The Basic Model

Consider an innovator who discovers a new production technology. The innovator chooses between licensing the production technology and becoming an entrepreneur by establishing a firm using the new technology. The market is served initially by a monopolist incumbent firm. The incumbent firm embodies the initial production technology, which is represented by the unit cost c_I. The innovator's new production technology, which is represented by the unit cost c_2, may be more or less efficient than the incumbent's initial technology. If the innovator's technology is superior to the initial technology, $c_2 < c_1$, the innovator can license the technology to the incumbent firm which produces its initial product more efficiently. If the innovator's technology is equivalent or inferior to the initial technology, $c_2 \geq c_1$, the incumbent firm can buy out the innovator without implementing the new technology in production. As in the case of Arrow's (1962) inventor, assume that the innovator has all of the bargaining power. This assumption is relaxed in a later section.

The innovator has the option of becoming an entrepreneur by establishing a new firm that embodies the new production technology. If the innovator becomes an entrepreneur, the new firm's product is differentiated from that of the incumbent. The incumbent firm's product and the entrant's product are substitutes. The new product can be differentiated by distinct features or by consumer perceptions of the brands of the incumbent firm and new entrant. The innovator can establish a firm whether the technology is superior, equivalent, or inferior to the incumbent firm's technology.

The incumbent firm and the entrant each produce only one product. If the innovator becomes an entrepreneur, the incumbent firm and the entrant engage in differentiated products competition. The assumption that the incumbent firm and the entrant each produce a differentiated product is important to the analysis. Entrepreneurial entry is profitable because the new firm provides consumers with the benefits of product variety and price competition. The assumption of single product firms rules out the possibility that the incumbent firm adopts the new technology and then produces two goods. This assumption can be relaxed by allowing both the incumbent and the entrant to diversify by producing two or more goods. This possibility is discussed in a later section.

The incumbent firm is designated as firm 1. If the innovator becomes an entrepreneur, designate the new firm as firm 2. Market demand is derived from the preferences of a representative consumer. The utility function is symmetric in its arguments, as is commonly assumed in differentiated products models. The consumer's utility is quadratic,

$$(1) \qquad U(q_1, q_2) = 2q_1 + 2q_2 - (1/2)(q_1)^2 - (1/2)(q_2)^2 - bq_1q_2.$$

Let the utility function be strictly concave, so that $b < 1$. Assume that the two products are substitutes, $b \geq 0$, so that producers will engage in duopoly competition. The analysis can be easily extended to other differentiated product settings such as Hotelling-type (1929) competition.

The representative consumer chooses consumption by maximizing consumer's surplus, $U(q_1, q_2) - p_1q_1 - p_2q_2$. The consumer's demand functions, $q_1 = D_1(p_1, p_2)$ *and* $q_2 = D_2(p_1, p_2)$, solve the first order conditions

$$U_1(q_1, q_2) = p_1,$$

$$U_2(q_1, q_2) = p_2.$$

Given the form of the utility function, demand for a good is decreasing in the good's own price and increasing in the price of the substitute good, $\partial q_i/\partial p_i < 0$ and $\partial q_i/\partial p_j > 0$, $i \neq j$, $i, j = 1, 2$.

The incumbent firm and the entrepreneurial entrant engage in Bertrand-Nash price competition with differentiated products. For differentiated duopoly with symmetric costs see Singh and Vives (1984) and for differentiated duopoly with asymmetric costs see

Zanchettin (2006). The results can be shown to hold if the two firms engage in Cournot quantity competition with differentiated products. The existing firm and the entrepreneurial firm choose prices p_1 and p_2 respectively to maximize profits, Π. The Bertrand-Nash equilibrium prices p_1* and p_2* solve

$$\max_{p_1} \quad (p_1 - c_1)D_1(p_1, p_2*),$$

$$\max_{p_2} \quad (p_2 - c_2)D_2(p_1*, p_2).$$

The Bertrand-Nash equilibrium prices depend on the costs of the two firms, $p_1*(c_1, c_2)$ and $p_2*(c_1, c_2)$.

Substituting for the Bertrand-Nash equilibrium prices, profits are functions of the underlying technologies,

(2) $\quad \Pi_i(c_i, c_j) = (p_i*(c_1, c_2) - c_i)D_i(p_1*(c_1, c_2), p_2*(c_1, c_2)), \qquad i \neq j, \quad i, j = 1, 2.$

By the quadratic utility assumption, each of the equilibrium price functions is increasing in both costs,

(3) $\quad p_i*(c_1, c_2) = [2c_i + bc_j + 2(2 + b)(1 - b)]/(4 - b^2), \qquad i \neq j, i, j = 1, 2.$

Output levels are positive for all values of costs in the unit interval and for all values of the substitution parameter,

(4) $$q_i*(c_1, c_2) = \frac{(2-b^2)(2-c_i) - b(2-c_j)}{(1-b^2)(4-b^2)}, \qquad i \neq j, i, j = 1, 2.$$

We restrict attention to cost values such that outputs and profits are nonnegative for both firms. The profits of the firms are

(5) $$\Pi_i(c_i, c_j) = \frac{[(2-b^2)(2-c_i) - b(2-c_j)]^2}{(1-b^2)(4-b^2)^2}, \qquad i \neq j, i, j = 1, 2.$$

This implies, by the envelope theorem and $\partial D_i/\partial p_j > 0$ for $i \neq j$, that profits are increasing in the competitor's cost,

$$\frac{\partial \Pi_i(c_i, c_j)}{\partial c_j} = (p_i * - c_i)\frac{\partial D^i}{\partial p_j}\frac{\partial p_j *}{\partial c_j} > 0, \quad i \neq j, \quad i, j = 1,2.$$

Also, it follows from the quadratic utility assumption that profit is decreasing and convex in the firm's own cost, $\partial \Pi_i(c_i, c_j)/\partial c_i < 0$ and $\partial^2 \Pi_i(c_i, c_j)/\partial c_i^2 > 0,\ i \neq j,\ i = 1,2$. The firms' marginal profits are decreasing in the competitor's cost,

$$\partial^2 \Pi_i(c_i, c_j)/\partial c_i \partial c_j < 0, \qquad i \neq j,\ i = 1,2.$$

In addition, outputs are decreasing in the own cost, increasing in the competitor's costs and have zero cross-effects, $\partial q_i*(c_i, c_j)/\partial c_i < 0,\ \partial q_i*(c_i, c_j)/\partial c_j > 0,\ \partial^2 q_i*(c_i, c_j)/\partial c_i \partial c_j = 0,$ $i \neq j,\ i, j = 1, 2$. These results hold more generally. For additional discussion of the class of utility functions that yield similar properties for comparative statics analysis of a duopoly equilibrium, see Milgrom and Roberts (1990).

If entry does not occur, the incumbent firm is a monopolist. Letting $q_2 = 0$, the representative consumer's utility function implies that $U(q_1, 0) = 2q_1 - (1/2)(q_1)^2$. The consumer's demand for the incumbent's product is $D_1(p_1) = 2 - p_1$. The monopolist's profit with costs c_i equals

$$\text{(6)} \qquad \Pi^m(c_i) = (p_i^m(c_i) - c_i)D_i(p_i^m(c_i)) = (2 - c_i)^2/4, \qquad i = 1, 2.$$

The incumbent monopolist is assumed to be viable either with the initial technology or with the new technology, $c_1 < 2$ and $c_2 < 2$. Suppose that the innovator transfers the new technology to the incumbent firm. Then, if the innovator's technology is superior to the initial technology, $c_2 < c_1$, the incumbent firm will earn profits of $\Pi^m(c_2)$. If the innovator's technology is equivalent or inferior to the initial technology, $c_2 \geq c_1$, the incumbent firm will earn profits of $\Pi^m(c_1)$.

3. The Innovator's Choice between Entrepreneurship and Technology Transfer

Consider the incentive of the innovator to transfer the technology to the incumbent firm when the technology is superior to that of the incumbent, $c_2 < c_1$. The benefit to the incumbent firm is the monopoly profit after adopting the new technology, $\Pi^m(c_2)$. If the incumbent firm does not adopt the new technology and the innovator establishes a competing firm, the incumbent firm would earn the duopoly profit, $\Pi_1(c_1, c_2)$. The incumbent firm's net benefit from adopting the new technology offered by the innovator equals the difference between monopoly profits at the new technology and duopoly profits when the incumbent has the old technology and the entrant has the new technology. Therefore, the incumbent firm's net benefit from adopting the new technology equals the incremental returns from remaining a monopolist, $\Pi^m(c_2) - \Pi_1(c_1, c_2)$. This is the maximum amount that the innovator can obtain from transferring the technology to the incumbent firm.

The returns to establishing a new firm equal $\Pi_2(c_1, c_2)$. If the new technology is superior to the existing technology, the innovator prefers entrepreneurship to technology transfer when the incremental returns to the incumbent firm are less than or equal to the returns to entry,

$$\Pi^m(c_2) - \Pi_1(c_1, c_2) \leq \Pi_2(c_1, c_2).$$

This is equivalent to the condition that monopoly profit at the new technology is less than or equal to total industry profit when the incumbent firm has the old technology and the entrepreneurial firm has the new technology,

$$\Pi^m(c_2) \leq \Pi_1(c_1, c_2) + \Pi_2(c_1, c_2).$$

If this condition holds, the innovator with a superior technology will become an entrepreneur and enter the market. If this condition does not hold, full information bargaining will result in the innovator transferring his technology to the incumbent who then will use it in production of a new good.

We can also consider the possibility that the innovator's technology is equivalent or inferior to that of the incumbent, $c_2 \geq c_1$. The incumbent would not wish to employ the innovator's technology. However, the incumbent might wish to buy the innovator's technology to prevent entry and maintain the incumbent's monopoly. The incumbent firm's net benefit from buying out the innovator equals the difference between monopoly profits at the initial technology and duopoly profits when the incumbent has the initial technology and the entrant has the new technology. Therefore, the incumbent firm's net benefit from buying out the innovator equals the incremental returns from remaining a monopolist, $\Pi^m(c_1) - \Pi_1(c_1, c_2)$. This is the maximum amount that the innovator can obtain from being bought out by the incumbent firm.

The innovator that chooses entrepreneurship must compete with the incumbent firm, so that the returns to establishing a new firm equal $\Pi_2(c_1, c_2)$. When the innovator's technology is equivalent or inferior to the existing technology, the innovator prefers entrepreneurship to technology transfer when the incremental returns to the incumbent firm are less than or equal to the returns to entry,

$$\Pi^m(c_1) - \Pi_1(c_1, c_2) \leq \Pi_2(c_1, c_2).$$

Otherwise, the innovator will transfer the technology to the incumbent firm. The inequality condition is equivalent to the condition that monopoly profits at the initial technology are less than or equal to total industry profits when the incumbent has the initial technology and the entrant has the new technology,

$$\Pi^m(c_1) \leq \Pi_1(c_1, c_2) + \Pi_2(c_1, c_2).$$

If this condition holds, the innovator will become an entrepreneur and enter the market with an equivalent or inferior technology. If this condition does not hold, full information bargaining will result in the innovator transferring his technology to the incumbent, even thought the technology is not employed in production.

For the innovator to choose entrepreneurial entry, the monopolist must earn lower profits than the competitive industry whether or not the invention improves on the existing technology. The possibility of entrepreneurial entry may seem counterintuitive because it may appear that the monopolist will always earn greater profits than the competitive industry. Product differentiation makes entrepreneurial entry possible even when the innovator has the option of technology transfer.

Product differentiation has greater effects on the market outcome for lower values of the substitution parameter *b*. This reduces the extent of competition in the product market and makes competing firms more profitable. As a result, lower values of the substitution parameter increase the expected returns to innovation. It can be shown that when the substitution parameter equals zero, entrepreneurial entry will take place whether or not the new technology improves on the existing technology. Therefore, entrepreneurial entry always occurs when the substitution parameter is not too large.

When there is sufficient product differentiation, entrepreneurial entry causes industry profits to be greater than what would be obtained by technology transfer to the incumbent monopoly. Products are sufficiently differentiated when there is a critical value of the substitution parameter b^* such that for all b satisfying $0 \leq b \leq b^*$, monopoly profits are less than or equal to industry profits. When products are differentiated sufficiently, the innovator prefers entrepreneurial entry to technology transfer.

Proposition 1. Entrepreneurial entry will take place when products are differentiated sufficiently whether the new technology is superior, equivalent, or inferior to the existing technology.

Proof. The result is established by showing that for any value of the new technology c_2, there exists a positive value of the substitution parameter b^* such that for all b in $[0, b^*]$, monopoly profits are less than or equal to industry profits. Consider the limiting case where the substitution parameter equals zero. The effects of competition are eliminated so that each firm's profits equal monopoly profits,

$$\Pi_i(c_1, c_2; b = 0) = \Pi^m(c_i) = (2 - c_i)^2/4, \qquad i = 1, 2.$$

Then, the condition for entrepreneurial entry holds,

$$\max \{\Pi^m(c_1), \Pi^m(c_2)\} < \Pi_1(c_1, c_2; b = 0) + \Pi_2(c_1, c_2; b = 0).$$

Total industry profits, $\Pi_1(c_1, c_2) + \Pi_2(c_1, c_2)$, are decreasing in the substitution parameter, b. Given $c_1 < 2$ and $c_2 < 2$, it follows that for small b, $c_1 < 2 - b(2 - c_2)/(2 - b^2)$ and $c_2 < 2 - b(2 - c_1)/(2 - b^2)$ so that profits are positive for both the new firm and the entrant. Given that total industry profits exceed monopoly profits for one firm evaluated at the new or existing technology when b equals zero, industry profits are greater than one firm's monopoly profits for all positive $b \leq b^*$ where b^* is positive. Q.E.D.

This result confirms Schumpeter's assertion that the entrepreneur will enter beside the existing firm. Even if the innovator has the option of transferring the technology to the incumbent, the innovator will choose entrepreneurship when product differentiation attenuates competition in the product market. When product differentiation limits product market competition, entrepreneurship takes place whether or not the new technology improves on the incumbent's technology.

The critical value of the substitution parameter depends on the values of the initial and new technologies. Depending on the range of cost parameter values, for sufficiently high values of the substitution parameter there is a basis for bargaining between the incumbent and innovator. High values of the substitution parameter indicate vigorous competition with entrepreneurial entry. This provides incentives for the incumbent to buy out an equivalent or inferior technology or to adopt a superior technology.

The quality of the new technology also affects the market outcome. Suppose that the new technology is an improvement over the existing technology, $c_2 < c_1$. The quality of the innovation can be indicated by the difference between the unit costs. The smaller is the value of the new unit costs c_2 relative to unit costs under the initial technology c_1, the higher is the quality of the innovation. It is useful to think about this as a higher value of the initial technology c_1 relative to the new technology. c_2. Because profits are increasing in the competitor's costs, a higher value of c_1 relative to c_2 will increase the entrant's profit. Because profits are decreasing in the firm's own costs, a higher value of c_1 will reduce the incumbent's costs.

Therefore, a higher value of the initial technology c_1 for a given value of the new technology c_2 will have opposite effects on the profits of the two firms. It can be shown that total industry profits are convex in c_1 and cross the monopoly profits line once at a critical value greater than the new technology c_2. This is represented in Figure 1. Let c_1* be the critical value of the initial technology such that total industry profits with competition equals monopoly profits at the new technology.

$$\Pi^m(c_2) = \Pi_1(c_1^*, c_2) + \Pi_2(c_1^*, c_2).$$

The critical value c_1* depends on the value of the innovation c_2 and the substitution parameter. Because total industry profits is decreasing in the substitution parameter, it follows that the critical value of costs c_1* is decreasing in b. For b equal to zero, total industry profits are everywhere decreasing and are above monopoly profits except at the endpoint so that $c_1^* = 2$ for $b = 0$. For positive values of b, the critical value c_1* is less than the value of initial costs at which total industry profits are minimized,

$$c_1^{Min} = 2 - \frac{2b(2-b^2)(2-c_2)}{(2-b^2)^2 + b^2}$$

Figure 1 shows that for incremental innovations, total industry profits with differentiated products competition exceed monopoly profits at the new technology. The industry returns to product differentiation and efficient entry exceed the benefits of cost reduction for a monopoly producer. For major innovations, total industry profits are less than monopoly profits at the new technology. Then, the returns to cost reduction by the incumbent exceed the returns to product differentiation and entry. This implies that in equilibrium entrepreneurship occurs with small improvements in the technology and technology transfer occurs with large improvements in technology.

Figure 2 illustrates the effects of the size of the innovation relative to the initial technology. When the innovation is incremental, monopoly profits are less than or equal to industry profits. Then, the innovator prefers entrepreneurial entry to technology transfer. This implies the following result.

Proposition 2. For incremental innovations, $c_2^*(c_1) \leq c_2 \leq c_1$, entrepreneurship occurs in equilibrium. For major innovations, $c_2 < c_2^*(c_1)$, technology transfer occurs in equilibrium.

This result further explains Schumpeter's assertion that the entrepreneur establishes a firm beside the existing firm. With incremental improvements in technology, creative destruction occurs at the margin. The innovator uses incremental technological change to offer a new product that competes with the incumbent firm. With significant improvements in technology, cost savings and monopoly profits outweigh the returns to product differentiation and entry. The innovator with a significant technological improvement chooses to transfer the technology to the existing firm.

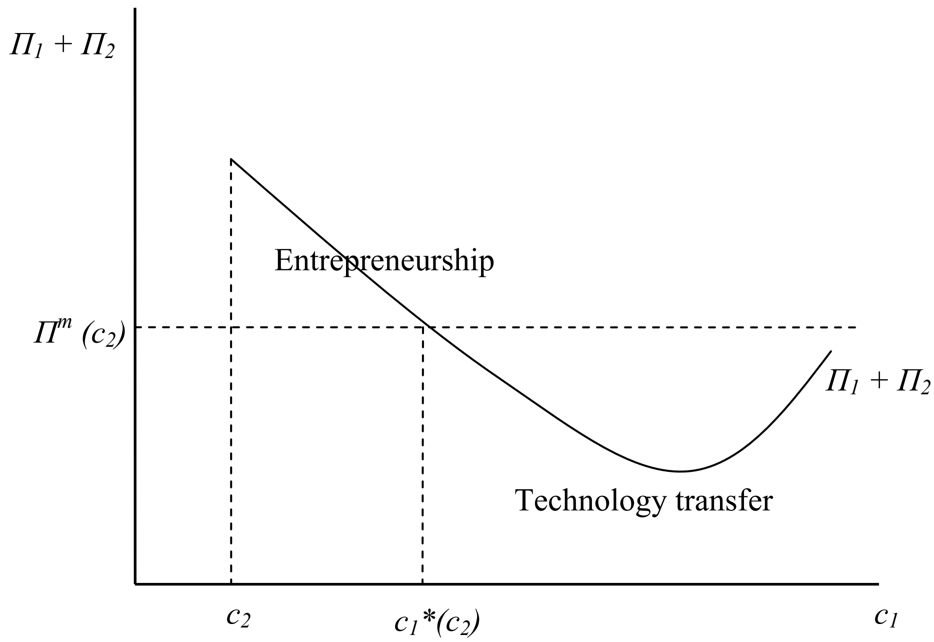

Figure 1 The critical value of the initial technology in comparison to the value of the innovation.

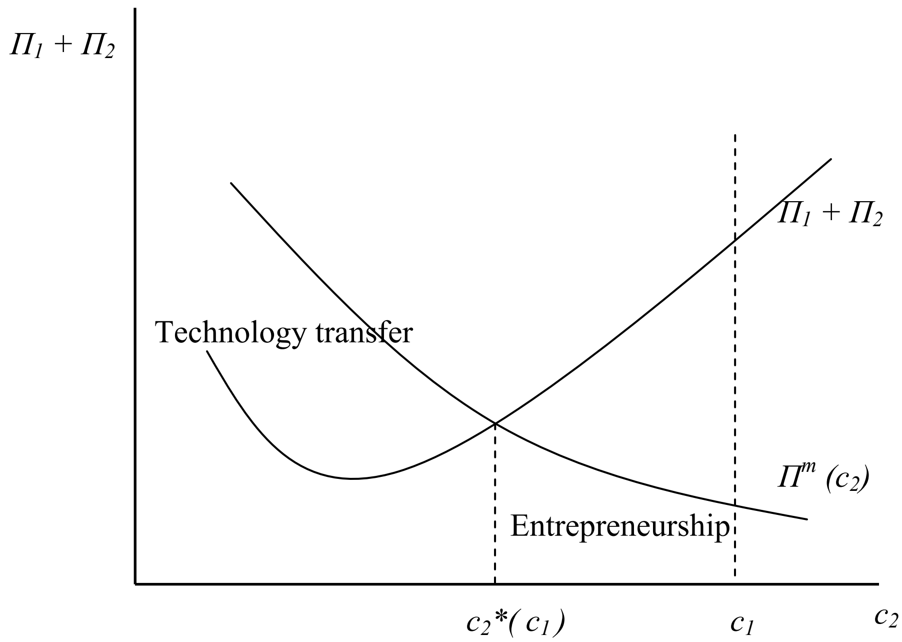

Figure 2 The critical value of the new technology in comparison to the value of the initial technology.

An increase in the substitution parameter *b* increases the intensity of competition in the product market. This has the effect of reducing total industry profits. Shifting down the total industry profits curve in Figure 2 increases the critical value of the new technology in comparison to the value of the initial technology, $c_2^*(c_1)$. This has the effect of narrowing the range of costs in which entrepreneurship occurs.

Proposition 3. An increase in the substitution parameter *b* reduces the range of innovations for which entrepreneurship occurs, $c_2^*(c_1) \leq c_2 \leq c_1$, and increases the range of innovations for which technology transfer occurs, $c_2 < c_2^*(c_1)$.

More intense competition in the product market reduces entrepreneurship. In the limit, Bertrand price competition with homogeneous products eliminates the returns to entrepreneurship. This explains the standard view that innovators always prefer technology transfer.

Entrepreneurial entry with process innovations is closely tied to differentiated products. When consumers benefit from product variety, innovators with new production processes become entrepreneurs and provide new products to the market. Innovators with incremental technologies will embody their innovations in new firms. Transaction costs in the market for technology transfer enhance these effects. When the innovator and the incumbent firm would encounter transaction costs, innovators are more likely to become entrepreneurs. When there is intense competition in the product market or when innovators have major innovations, it follows that entrepreneurship requires some form of transaction costs in the technology transfer market.

The analysis yields insights into Arrow's original investigation of the incentive to invent. Consider the innovator's incentive to invent when the new technology is superior to that of the incumbent firm, $c_2 < c_1$. The innovator's incentive to invent reflects the returns from commercializing the invention through either licensing or entrepreneurship. The innovator's incentive to invent therefore equals

$$V^I = \max \{\Pi^m(c_2) - \Pi_1(c_1, c_2), \Pi_2(c_1, c_2)\}.$$

In contrast, the incumbent monopolist's incentive to invent equals

$$V^m = \Pi^m(c_2) - \Pi^m(c_1).$$

The innovator's incentive to invent when the new technology is equivalent or inferior to that of the incumbent firm, $c_2 \geq c_1$, equals

$$V^I = \max \{\Pi^m(c_1) - \Pi_1(c_1, c_2), \Pi_2(c_1, c_2)\}.$$

The incumbent monopolist would have an incentive to invent equal to zero if the new technology were equivalent or inferior to the existing technology, $V^m = 0$.

Proposition 4. The innovator's incentive to invent, V^I, is greater than that of an incumbent monopolist, V^m, whether or not the new technology improves on the existing technology.

Proof. Suppose that the new technology is superior to that of the incumbent firm, $c_2 < c_1$. Notice that the incumbent firm using its initial technology earns more as a monopolist than with competitive entry, $\Pi^m(c_1) < \Pi_1(c_1, c_2)$. This implies that the monopolist's incentive to invent is less than the benefit of adopting the new technology,

$$\Pi^m(c_2) - \Pi_1(c_1, c_2) < \Pi^m(c_2) - \Pi_1(c_1, c_2).$$

Therefore, $V^m < \max \{\Pi^m(c_2) - \Pi_1(c_1, c_2), \Pi_2(c_1, c_2)\} = V^I$. Now suppose that the new technology is equivalent or inferior to that of the incumbent firm, $c_2 \geq c_1$. The, $V^I > 0 = V^m$. Therefore, $V^I > V^m$ whether or not the new technology improves on the existing technology. Q.E.D.

The innovator's incentive to invent is greater than that of the incumbent monopolist for all realizations of the new technology. This allows the result to be generalized to address uncertainty in the invention process. With uncertain invention, the innovator's expected incentive to invent is greater than that of the incumbent monopolist.

The result in Proposition 4 is related to Arrow's (1962) original insight that competition improves the incentive to invent. The innovator's incentive to invent is derives from transferring the technology or from competing with the incumbent firm. If the innovator licenses the technology to the incumbent monopolist, the incumbent monopolist's willingness to pay is the difference between the incumbent's monopoly profit and the incumbent's profit after competitive entry. The incumbent monopoly's inertia from initial technology is eliminated because the incumbent compares monopoly profits with profit after entry of the entrepreneur. If the innovator becomes an entrepreneur, the return from entry must be greater than what could be obtained from transferring the technology to the incumbent. The innovator's return from being an entrepreneur is obtained by competing with the incumbent firm. Therefore, the innovator's total rents derive from the returns to differentiated products competition.

4. The Technology Transfer Decision of an Independent Innovator

The discussion has so far assumed that the innovator must choose between technology transfer and entrepreneurship. Suppose instead that the innovator and the prospective entrepreneur are independent actors. The innovator can offer to license the technology both to the existing firm and to an entrepreneur. The innovator chooses the royalty for the technology license but cannot otherwise choose which firm purchases the technology. There is no need to consider the choice of licensee because if the innovator could make such a choice, the outcome would be the same as the situation in which the innovator can become an entrepreneur, which was already considered in the previous section. In this section, we restrict attention to the situation in which the new technology is superior to that of the incumbent firm, $c_2 < c_1$.

By selecting the amount of royalty to charge for the license, the innovator can affect the outcome of the adoption and entry game between the incumbent firm and the entrepreneur. The existing firm chooses whether or not to adopt the new technology. Suppose first that the entrepreneur can only enter the market by adopting the new technology so that the entrepreneur chooses between entry with adoption and not entering. This assumption will be relaxed later in the section by allowing the entrepreneur access to the initial technology.

The adoption and entry game has four possible outcomes. The existing firm chooses between continuing with the initial technology and adopting the new technology. The potential entrepreneur chooses whether or not to enter the market. Let R be the lump-sum royalty offered by the innovator. If both the incumbent and the entrepreneur adopt the new technology the payoffs are symmetric, $\Pi_1(c_2, c_2) - R$ and $\Pi_2(c_2, c_2) - R$. If only the entrepreneur adopts the new technology, the payoffs are asymmetric, with the incumbent firm earning profits $\Pi_1(c_1, c_2)$ and the entrepreneur earning net returns $\Pi_2(c_1, c_2) - R$. If only the incumbent firm adopts the new technology, the incumbent earns $\Pi^m(c_2) - R$ and the entrepreneur's payoff is zero. If neither firm adopts the new technology, the incumbent firm earns $\Pi^m(c_1) - R$ and the entrepreneur's payoff again is zero. The adoption-and-entry game is represented in Table 1.

Suppose that the innovator chooses royalties that are less than or equal to the incumbent's incremental returns from adoption when there is entrepreneurial entry,

$$R \leq \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2).$$

Then, the outcome (Adopt, Enter) is the unique dominant-strategy equilibrium. To see why, first consider the incumbent firm's decisions. When $R \leq \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2)$, it follows that the incumbent firm will prefer to adopt the new technology as a best response to entry by the entrepreneur because

$$\Pi_1(c_2, c_2) - R \geq \Pi_1(c_1, c_2).$$

Since $c_2 < c_1$ and $\partial \Pi_1(c_1, c_2)/\partial c_1 < 0$, it follows that $\Pi_1(c_2, c_2) > \Pi_1(c_1, c_2)$ and $\Pi^m(c_2) > \Pi^m(c_1)$. Also, because $\partial^2 \Pi_1(c_1, c_2)/\partial c_1 \partial c_2 < 0$, for $c_2 < c_1$,

$$\Pi_1(c_2, c_2) - \Pi_1(c_1, c_2) \leq \Pi^m(c_2) - \Pi^m(c_1).$$

This implies $R \leq \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2) \leq \Pi^m(c_2) - \Pi^m(c_1)$, so that the incumbent firm will prefer to adopt the technology even if there is no entrepreneurial entry,

$$\Pi^m(c_2) - R \geq \Pi^m(c_2).$$

So, adoption is a dominant strategy for the incumbent firm.

Next, consider the decisions of the entrepreneur. If the incumbent firm adopts the technology and $R \leq \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2)$, it follows that $R \leq \Pi_1(c_2, c_2) = \Pi_2(c_2, c_2)$. The entrepreneur will adopt the technology and enter the market when the incumbent also adopts the technology. Because the entrepreneur earns greater profits when the incumbent does not adopt the technology, it follows that $R \leq \Pi_2(c_2, c_2) \leq \Pi_2(c_1, c_2)$. This implies that the entrepreneur also will choose to enter the market when the incumbent does not adopt the new technology. So, entry is a dominant strategy for the entrepreneur. Therefore, if $R \leq \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2)$, (Adopt, Enter) will be the unique dominant strategy equilibrium.

Now, we examine a monopoly innovator with market power who maximizes the returns from royalties. The adoption-entry game shows that if royalties induce adoption by the incumbent, they also induce entry by the entrepreneur. This is because $R \leq \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2)$ implies that $R \leq \Pi_1(c_2, c_2) = \Pi_2(c_2, c_2)$. The innovator earns royalties from both the incumbent and entrant by setting

$$R^* = \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2).$$

Alternatively, the innovator can raise the royalties to induce entry by the entrepreneur without adoption by the incumbent firm,

$$R^{**} = \Pi_2(c_1, c_2).$$

To see why the royalty that only induces adoption by the entrepreneur is greater, notice that $\partial^2\Pi_1(c_1, c_2)/\partial c_1\partial c_2 < 0$ and $c_2 < c_1$ imply

$$\begin{aligned} R^* &= \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2) \\ &< \Pi_1(c_2, c_1) - \Pi_1(c_1, c_1) \\ &< \Pi_1(c_2, c_1) = \Pi_2(c_1, c_2) = R^{**}. \end{aligned}$$

The incumbent firm's profit when both adopt firms adopt the technology is less than industry profits when only the entrant adopts the technology, $\Pi_1(c_2, c_2) < \Pi_1(c_1, c_2) + \Pi_2(c_1, c_2)$.

The incumbent firm has less incentive to adopt the new technology because of the inertia generated by the initial technology, as Arrow (1962) observed. The innovator chooses the lower royalty when he earns more from both firms adopting the innovation, $2R^*$, than from adoption by the entrepreneur, R^{**}. When $2R^* \geq R^{**}$, the independent innovator induces adoption by both firms, which differs from the possible outcomes when the innovator and the potential entrepreneur are not independent. The innovator chooses to transfer the technology to both the incumbent and the entrepreneur if and only if

$$\Pi_1(c_2, c_2) \geq \Pi_1(c_1, c_2) + \Pi_2(c_1, c_2)/2.$$

When $2R^* < R^{**}$, the independent innovator induces adoption by only the entrepreneur, which corresponds to the equilibrium with entry when the innovator and the potential entrepreneur are not independent.

The technology transfer decision of an independent innovator has the following important implication.

Proposition 5. When the innovator is independent and the entrepreneur must adopt the new technology to enter the market, entrepreneurship always takes place.

When the innovator is independent from the entrepreneur, royalties that allow technology transfer to the incumbent firm always involves also selling to the entrepreneur. The entrepreneur values the innovation more than the incumbent because of the inertia from the initial technology. Choosing greater royalties excludes the incumbent firm so that the innovator then sells only to the entrepreneur. This result provides an additional explanation for entrepreneurship as the mechanism for innovation. It further emphasizes Schumpeter's observation that entrepreneurs operate beside the incumbent firm.

The independent innovator's incentive to invent equals

$$V^* = \max \{2R^*, R^{**}\}.$$

Given the definition of R^*, the independent innovator's incentive to invent is greater than that of the non-independent innovator if $2\Pi_1(c_2, c_2) - 2\Pi_1(c_1, c_2) > \Pi^m(c_2) - \Pi_1(c_1, c_2)$. This is equivalent to the condition that the invention's effects on a duopolist's profit are greater than the effects of market power on profits,

$$\Pi_1(c_2, c_2) - \Pi_1(c_1, c_2) > \Pi^m(c_2) - \Pi_1(c_2, c_2)$$

This holds only for a sufficiently major invention.

Proposition 6. For a sufficiently major invention, the independent innovator's incentive to invent, V^*, is greater that that of the non-independent innovator, V^I, and greater than that of the monopolist, V^m.

The second part of the statement follows from Proposition 4. For small inventions, the independent inventor can only extract rents from the entrepreneur, so that the independent innovator's incentive to invent is equivalent to that of the entrepreneur. This implies that for small inventions, the independent innovator's incentive to invent is greater than that of the monopolist.

5. The Technology Transfer Decision of an Independent Innovator When the Entrepreneur Can Use the Initial Technology

Entrepreneurship with independent innovators does not require the entrepreneur's outside option to be zero. Suppose that both the incumbent and the entrant have access to the initial technology. The entrepreneur can enter with the initial technology which is available without cost or the entrepreneur can obtain the new technology from the innovator. Then, both the incumbent and the entrant are subject to the same inertia. The payoffs of the adoption and entry game are symmetric, see Table 2.

By symmetry, the innovator then sells to both the incumbent and the entrant and cannot exclude the incumbent. The innovator with market power will choose the lower royalty,

$$R^* = \Pi_1(c_2, c_2) - \Pi_1(c_1, c_2) = \Pi_2(c_2, c_2) - \Pi_2(c_1, c_2).$$

This implies that the technology adoption game has an unique dominant-strategy equilibrium. The equilibrium of the technology adoption game is for both the incumbent firm and the entrepreneur to adopt the new technology.

Proposition 7. When the innovator is independent and the initial technology is available to both the incumbent firm and the entrepreneur, the innovator transfers the technology to both the incumbent and the entrepreneur.

As before, only when the invention is sufficiently major, the independent innovator has a greater incentive to invent than the non-independent innovator and the monopolist.

Entrepreneurial firm 2 **Existing firm 1**	**Enter**	**Do not enter**
Adopt	$\Pi_1(c_2, c_2) - R, \Pi_2(c_2, c_2) - R$	$\Pi^m(c_2) - R, \quad 0$
Do not adopt	$\Pi_1(c_1, c_2), \Pi_2(c_1, c_2) - R$	$\Pi^m(c_1), \quad 0$

Table 1 The technology adoption and entrepreneurship game with payoffs (Existing firm 1, Entrepreneurial firm 2).

Entrepreneurial firm 2 Existing firm 1	Adopt	Do not adopt
Adopt	$\Pi_1(c_2, c_2) - R$, $\Pi_2(c_2, c_2) - R$	$\Pi_1(c_2, c_1) - R$, $\Pi_2(c_2, c_1)$
Do not adopt	$\Pi_1(c_1, c_2)$, $\Pi_2(c_1, c_2) - R$	$\Pi_1(c_1, c_1)$, $\Pi_2(c_1, c_1)$

Table 2 The technology adoption game with payoffs (Existing firm 1, Entrepreneurial firm 2) when the initial technology is available to both the incumbent firm and the entrepreneurial firm.

6. Extensions

The section examines possible extensions of the analysis. The main results appear to hold under more general conditions. This section considers the effects of imperfect legal protections for IP, asymmetric information, diversification by incumbents, increased competition in the product market, and bargaining power.

6.1 Legal Protections for IP

Innovators seeking to sell technology licenses face the problem of imperfect legal protections of their IP. This affects the market for technology transfer because the innovator must show the technology to the prospective buyer. The buyer may then copy the technology or simply attempt to expropriate it, see Arrow (1962) and Anton and Yao (1994, 1995, 2002, 2003, 2004).

In the present framework, the risk of imitation or expropriation reduces the expected returns that the innovator can obtain by transferring the technology to the existing firm. This has the effect of making entrepreneurship more likely. The results obtained here continue to apply. A lower value of the substitution parameter, which makes the product market less competitive, still increases entrepreneurship. A greater risk of expropriation means that entrepreneurship occurs with relatively more post entry competition. As before, the entrepreneur will prefer to start a new firm with incremental innovations rather than with major innovations. A greater risk of expropriation associated with technology transfer means that entrepreneurs start firms with larger innovations.

Improvements in legal protections for IP in the market for technology transfer can reduce entrepreneurship that occurs as a means of realizing the value of IP. In addition, better IP protections reduce the magnitude of innovations for startups. This suggests that multiple entrepreneurs may enter an industry in clusters as a means of commercializing a series of incremental innovations.

6.2 Asymmetric Information

Asymmetric information about the new technology complicates the transaction between the innovator and the existing firm. This raises transaction cost problems that extend beyond IP protections. The innovator may not be able to convey accurately the nature of the discovery. The technology may not be fully observable leading to problems of adverse selection in the technology market.

Asymmetric information in the technology market would make entrepreneurship more likely than under full information. The entrepreneur would establish a firm as a means of realizing the value of the innovation. A lower value of the substitution parameter, which makes the product market less competitive, would still increases entrepreneurship.

Adverse selection would affect the types of innovations that lead to entrepreneurship. This might counteract the effects of product differentiation on the types of innovations that are commercialized through licensing. Under asymmetric information, incumbent firms are willing to pay for innovations based on their average quality. This would attract innovators with incremental innovations rather than those with major innovations. With full information, innovators with incremental innovations prefer entrepreneurship and innovators with major innovations prefer technology transfer. Asymmetric information is likely to change the types of innovations that technologies that commercialized through entrepreneurship.

6.3 Diversification by Incumbent Firms

A natural question to ask is why the incumbent firm does not diversify. When the incumbent firm diversifies, the innovator could simply sell the new technology to the incumbent and the incumbent then would produce two goods. In this setting, the innovator will always prefer transferring the new technology to the incumbent to establishing a new firm. This is because the incumbent firm is a monopolist in the two goods and rents are not dissipated by competition. This approach returns the analysis to the equivalent of a single product setting. In some industries, such diversification is feasible and incumbents tend to absorb multiple innovations by adding new products. In other industries, incumbent firms face limits on their ability to diversify. For example, their brand images and distribution channels may be associated with particular types of products. Incumbent firms may face limitations on managerial attention that constrain the number of products they produce.

More fundamentally, diversification by incumbents and entrants can be treated symmetrically. Entrepreneurs also have the option of offering multiple products. Suppose for example that firms choose the range of products that they offer. Then, an innovator must choose between transferring technology to a multiproduct incumbent and establishing a multiproduct firm. Similar tradeoffs between technology transfer and entrepreneurship examined here in with single product firms should arise in the multiproduct environment.

Innovations can take the form of new product development with through improvements in quality. Innovators that develop new products face the choice between entrepreneurship transferring the technology to existing firms. Klete and Kortum (2004) consider diversification in a model with exogenous entry of single product firms. After entry, existing firms invest in innovation that leads to product diversification. Their discussion focuses on incumbent firm innovation without a market for technology transfer. Our analysis suggests that introducing innovators who choose between entrepreneurship and technology transfer should affect the incentives of incumbent firms to develop new products.

6.4 Competition among Incumbent Firms

The present analysis assumed that there was only one incumbent firm. More generally, there may be multiple incumbents. How competition among multiple incumbents affects innovation depends on the type of technological change. Suppose that the technology is sufficiently generic that it can be transferred to many firms. Then, competition among multiple incumbent firms should increase the returns to transferring the technology to all of the industry, as Arrow's analysis suggests. At the same time, competition from multiple incumbent firms should reduce the returns to entrepreneurial entry. This implies that an innovator will be more likely to transfer the technology the greater is the intensity of competition in the existing industry.

In contrast, if the technology is very specific to a particular product and can only be transferred to one incumbent, greater competition among incumbent firms will reduce the benefits of the transfer to an existing firm. As was shown in the previous discussion, the existing firm is willing to pay for the incremental benefits of the new technology in comparison to what it would earn if the innovator entered the industry. Because the entrepreneur obtains the full benefits of entry with the new technology, a more competitive industry before entry will favor entrepreneurship.

6.5 Bargaining power

The discussion thus far assumed that the innovator has all of the bargaining power in the market for technology licenses. Consider the innovator's incentive to invent when the innovator chooses between technology transfer and entrepreneurship. Let α represent the innovator's bargaining power, where $0 \leq \alpha \leq 1$. When the new technology is superior to that of the incumbent firm, $c_2 < c_1$, the innovator's incentive to invent therefore equals

$$V^I = \max \{\alpha(\Pi^m(c_2) - \Pi_1(c_1, c_2)) + (1 - \alpha)\Pi_2(c_1, c_2), \Pi_2(c_1, c_2)\}.$$

Recall that the incumbent monopolist's incentive to invent equals

$$V^m = \Pi^m(c_2) - \Pi^m(c_1).$$

When technology transfer is the equilibrium outcome, the innovator's incentive to invent may be lower that that of the monopolist when bargaining power is low. However, when entrepreneurship is the equilibrium outcome, the innovator's incentive to invent must be greater than the monopolist's increased profits from adoption, $\Pi^m(c_2) - \Pi_1(c_1, c_2))$, regardless of the value of the bargaining power parameter.

Notice that Propositions 1 and 2 apply for all values of the bargaining power parameter. These results provide sufficient conditions for entrepreneurship to occur in equilibrium regardless of the value of the bargaining power parameter. Either of these conditions is sufficient for the innovator's incentive to invent to be greater than that of the incumbent monopolist.

Proposition 4a. For all b such that $0 \leq b \leq b^*$, entrepreneurship occurs in equilibrium so that the innovator's incentive to invent is greater than that of the incumbent monopolist regardless of the value of the bargaining power parameter. For incremental innovations, $c_2^*(c_1) \leq c_2 \leq c_1$, entrepreneurship occurs in equilibrium so that the innovator's incentive to invent is greater than that of the incumbent monopolist regardless of the value of the bargaining power parameter.

The innovator's incentive to invent when the new technology is equivalent or inferior to that of the incumbent firm, $c_2 \geq c_1$, equals

$$V^I = \max \{\alpha(\Pi^m(c_1) - \Pi_1(c_1, c_2)) + (1 - \alpha)\Pi_2(c_1, c_2), \Pi_2(c_1, c_2)\}.$$

The incumbent monopolist would have an incentive to invent equal to zero if the new technology were equivalent or inferior to the existing technology, $V^m = 0$. Here, the innovator's incentive to invent is always greater than that of the incumbent monopolist, regardless of the value of the bargaining power parameter.

6.6 Technological Change versus Intrapreneurship by Incumbent Firms

The analysis has focused on innovation by inventors who are not affiliated with the incumbent firm. Suppose instead that the existing firm engages in invention. Again, the existing firm cannot apply the new technology without changing its product. Maintaining the restriction on diversification, the incumbent firm then faces a similar commercialization decision to that of the innovator considered previously. The incumbent firm can innovate by replacing its existing technology with the new technology. Alternatively, the incumbent firm can innovate by intrapreneurship, that is, by creating a spinoff that commercializes the invention and competes with the incumbent firm. The incumbent firm thus chooses between technology replacement and intrapreneurship.

The incumbent firm's decision turns out to be the same as that of the innovator. To see why this is so, suppose that new the technology is superior to that of the incumbent, $c_2 < c_1$. Then, the incumbent chooses technology replacement if and only if monopoly profit at the new technology exceeds total industry profit when the incumbent firm has the old technology and the entrepreneurial firm has the new technology, $\Pi^m(c_2) > \Pi_1(c_1, c_2) + \Pi_2(c_1, c_2)$. Suppose that new the technology is not superior to that of the incumbent, $c_2 \geq c_1$. Then, the incumbent firm chooses intrapreneurship if and only if monopoly profits at the initial technology exceeds total industry profits when the incumbent has the initial technology and the entrant has the new technology, $\Pi^m(c_1) > \Pi_1(c_1, c_2) + \Pi_2(c_1, c_2)$. Therefore, the analysis applies to the innovating incumbent firm. This helps to explain why an incumbent firm would establish a technology incubator or "skunk works." The technology incubator provides the incumbent with an option to replace its technology or spin off the technology depending on the realization of R&D.

7. Conclusion

Product differentiation fundamentally affects the choice between technology transfer and entrepreneurship. By mitigating competition, product differentiation creates opportunities for entrepreneurs to operate beside existing firms. With product differentiation, industry profits with entrepreneurial entry can be greater than monopoly profits for an incumbent firm. An innovator then will choose entrepreneurship rather than technology transfer. The analysis shows that when the products are not close substitutes, the innovator will choose entrepreneurship. Incremental innovations will lead the innovator to choose entrepreneurship and major innovations will lead the innovator to transfer the technology to the incumbent firm. In addition, if the innovator is independent from the entrepreneur, the innovator always will transfer technology to the entrepreneur.

The analysis shows that consumer benefits from product variety lead to more entrepreneurship. When innovators develop new production processes, entrepreneurs enter the market by providing new products that use the new production processes. The interaction between product differentiation and adoption of process technology plays a crucial role. This helps explain Schumpeter's assertion that entrepreneurship involves "new combinations." Product differentiation generates rents for entrepreneurs by mitigating the intensity of product market competition. When products are differentiated sufficiently, entrepreneurial entry causes industry profits to be greater than what would be obtained by technology transfer to the incumbent monopoly.

Entrepreneurship opens new avenues for innovation beyond technology transfer. This is consistent with the many empirical observations of the close association between innovation and entrepreneurship. Together, technology transfer to incumbents and the establishment of new firms increase the returns to inventive activity. The innovator who chooses between technology transfer and entrepreneurship has a greater incentive to invent than the incumbent monopolist. By embodying innovations in new firms, entrepreneurs profoundly influence the rate and direction of inventive activity.

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