Market Power and the Incentive to Innovate: A Return to Schumpeter and Arrow

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Using a simple linear demand and marginal cost function, we demonstrate that both competition and monopoly have incentives to innovate since this increases their profit levels. However, our results show that perfect competition is more motivated to innovate since the increase in the profit is greater with the same cost reduction and the same innovation. We also conclude that a more drastic innovation brings greater rent to the monopolist and reduces the advantages of perfect competition over monopoly. It could be presumed that monopoly firms would be attracted to more substantive innovations rather than non-drastic ones.

Keywords: competition, monopoly, innovation, profit

JEL classification: D23, D24, D41, D42, L12, O31, O32

1. Introduction

Industrial organization has long studied how research and development act as the engine of technological change, and how this change has shaped industry and the distribution of power in it. Many new industries have emerged out of new technologies or have prospered significantly with the advancement of technologies. Such industries include airspace and aircraft, computers and electronic communications, audio and video production, etc. Technological growth shifts the firm’s production function outwards and directly increases output. This way knowledge accumulation and knowledge diffusion give a strong impetus to the individual firm increasing its competitiveness. Technological growth is directly related to competition, since the production function of the firm is restricted by the level of technology or the technological set within which it operates.

The debate between which types of firms have stronger incentives to innovate is eternal. In "Capitalism, Socialism and Democracy" Joseph Schumpeter (1942) studied the managerial function, innovation, and the capitalist system. He saw capitalism as "creative destruction" where periods of quiet and stability are interrupted by the springing of new products and processes which create new markets, replacing the old ones. To Schumpeter market disequilibria is more common and typical than market equilibria, the state of flux more prevalent than the state of calmness and stability. Schumpeter (1942) believed that competition is not so much over prices and quantities but over new products and processes. He defined innovation as the knowledge that has been applied for the first time, in the form of a production process or product. Innovation is creative destruction and serves to improve the managerial function. Schumpeter viewed entrepreneurs as innovators and the progress of capitalism as one prompted by technological change which was quickly diffused and imitated. In his view perfect competition, although ideal from the welfare perspective, is not an efficient market structure for creating incentives for innovation. Rather, it is the monopoly position that creates the strongest incentives to innovate. It is the large scale of operations that creates advantages for innovation.

This view was later shared by John Galbraith in "American Capitalism: The Concept of Countervailing Power" (Galbraith, 1956) and "The New Industrial State" (Galbraith, 1967). Galbraith (1956, p. 86) stated that "a benign providence … has made the modern industry of a few large firms an almost perfect instrument for inducing technical change. It is admirably equipped for financing technical development." Galbraith (1956, p. 91) argues that the competitive model almost precludes technological advance and continues:

> "The showpieces are, with rare exceptions, the industries which are dominated by a handful of large firms. The foreign visitor, brought to the United States to study American production methods and associated marvels, visits the same firms as do attorneys of the Department of Justice in their search for monopoly."

While research is the discovery of new knowledge, development represents the translation of this new knowledge into productive processes and products. Both Schumpeter and Galbraith were convinced that large firms can transform existing knowledge into finished products or services and are the most efficient generators and transmitters of technological change since research and development require substantive resources, favor economies of scale and carry risks of failure which can be borne by only few firms. Only big firms can run multiple research projects at a time so that few of them are successful. Only large firms have the resources to bring innovative ideas to production and exploit the advantages of new research.

At the other extremum is Arrow (1962) who maintains that market structure dramatically affects the incentives of different firms to innovate and that large “sleepy” firms could be outstripped by more dynamic, innovative firms. The so called “sleepy monopolist” hypothesis assumes that the large monopoly firm has significant market power but no stimulus to innovate. Arrow (1962) hypothesizes that the competitive firm has greater incentives to introduce an innovation because this would allow it to undercut the price of every competitor in the industry, take the entire market demand and, eventually, turn into a pure monopoly from a pure competitor. In support of this Jewkes, Sawers and Stillerman (1969) argue that some major discoveries are being made by ordinary people with limited finances who work in “their backyard garage.” In their book “The Sources of Invention” they found that 33 of 61 most significant inventions of the 20^{th} century were the result of individual inventive activity and only 12 inventions emanated from large corporate research laboratories. Product ideas such as cellophane, the jet engine and air conditioning were invented by private individuals. Scherer (1980), who contrasts examples in favor of Galbraith and Schumpeter with those against them, argues that smallness is not necessarily an obstacle to the creation of patentable inventions but can, in fact, be an advantage.

Transaction cost theory, as advanced by Coase (1937), demonstrates that technology has a dual effect on the firm and the market. Coase (1937) stresses that technological improvements such as the telephone and the telegraph contribute to the larger size of the firm since they facilitate the role of the managerial function. In this sense, the relationship is opposite – it is not market structure that determines technology but the other way round, technology shapes market structure with larger firms being operational due to the use of sophisticated technologies in substituting the market mechanism and overcoming the significant costs of market transacting. On the one hand, technological improvements reduce the costs of bureaucracy within hierarchical organizations, but, on the other hand, they help bring the factors of production in proximity on the very markets. Whether firms will grow or shrink depends on the relative effect of technological improvement on the firm and the market. If an innovation reduces market transaction costs more significantly than the costs of administrative organization within the firm, then the market is an efficient resource allocation mechanism and the size of the firm is limited. But if the innovation affects the firm much more seriously, as in the case of multinational corporations which grow immensely and allocate global factors of production, then the effect of innovation was stronger on the particular firm than on the market. Growing firms supersede the market and the administrative mode has a stronger role in the economy.

Global corporations are the most vivid illustration of how technological growth and innovation can increase firm size. In his survey of 500 large companies in the USA in 1971 Vernon (1971) finds that 187 of them have a strong participation in foreign markets. It is just those 187 corporations which invest considerably in research and development while the others do not. Thus Vernon (1971) concludes that multinationals are more frequent innovators and technological generators when it comes to their initial investment abroad. Williamson (1985) also reports that a high concentration of FDI in production is reported in industries where the transfer of technological knowledge is of special importance. But there is one more reason for the concentration of advanced technologies in large corporations. The need to protect their industrial and technological knowhow forces large companies to integrate vertically or horizontally, thus expanding in size. The "knowledge paradox" as introduced by Arrow (1962) demonstrates that a piece of knowledge is only valuable to someone once this knowledge is revealed to him. But once the knowledge is revealed and the buyer of the information finds how potentially important it is to him, he has no incentive to pay for it. This is how corporations have difficulty protecting their knowhow through the market mechanism and prefer to safeguard it by organizational means and firm growth. Buckley and Casson (1976), Hennart (1980), Kang (1990), etc. support the view that multinationals are key generators of innovations and try to protect them through firm expansion, i.e., through forward, backward, or horizontal integration. This technological determinism perhaps results from the fact that multinationals are quite receptive when it comes to innovation. Their technological intensiveness determines their growth, success, and domination in the global economy. The technological factor seems to have a stronger impact on the global corporation, rather than on the market, which determined the rise of the multinational firm in the world today.

The essential question remains – does market structure influence technological change and how? Would a monopolist or a competitive firm be more likely to introduce an invention? The fierce competition among firms in competitive sectors can speed innovation but only the budgets of large firms allow them to finance major research initiatives and to stimulate technological change. Others join the Schumpeter-Arrow discussion in later years. Tirole (1997), Sutton (1998, 2007), Gilbert (2006), Shapiro (2012) and many others discuss the role of competition and innovation. Gilbert (2006) and Shapiro (2012) define some principles by which competition and innovation are interrelated. Holmes, Levine and Schmitz (2012) maintain that monopolies may be less inventive due to switchover disruptions. These are interruptions of the production process when upon adoption of the new technology the firm must temporarily reduce its output of the pre-adoption level.

Our paper is a modest contribution to the Schumpeter-Arrow debate. We no way aim to thoroughly review the extensive literature on the matter but propose a simple framework for analysing the incentives of the two firms to innovate.[1] Using a simple linear demand function and linear (constant and rising) marginal cost, we demonstrate that both types of market structure have incentives to innovate since innovation inevitably increases their profits levels. Furthermore, we find that the incentives for perfect competition to innovate are stronger since the increase in the profit at the same level of cost reduction, i.e., innovation, are greater for the competitive firm. The more drastic the innovation, the greater the rents which accrue to the monopolist which implies that monopoly firms would be lured to more substantive inventions rather than minor ones. Ours is a static model which bases the incentive for innovation on profit levels. Being simple, the model does not consider other aspects of industrial organizations such as product differentiation, elasticities or speed of research and development. The section that follows is a discussion of this simple setting comparing competition and monopoly. The paper ends with conclusions.

2. Competition versus monopoly

With a linear demand function $p = a - bq$, where a and b are positive parameters, the marginal revenue function is twice as steep, that is, $MR(q) = a - 2bq$. With constant marginal cost $MC_i = c_i$, ($i = 1,2$), where the slope of the marginal cost function is assumed to be zero, the graph follows Figure 1. In the case of the competitive outcome, we assume that the firm charges the lowest possible price equal to marginal cost. Since firms in competitive industries use standardized equipment and there is free entry, it is difficult for them to lower the price further. Innovation improves the process of production by reducing marginal cost. It is rather sudden, unexpected for

[1] For a more detailed review of the literature on competition and innovation see Shapiro (2012) and Holmes, Levine, and Schmitz (2012).

the perfect competitor. If the industry were served by a single firm, the market demand curve would be relatively steep and extended from the origin of the coordinate system.

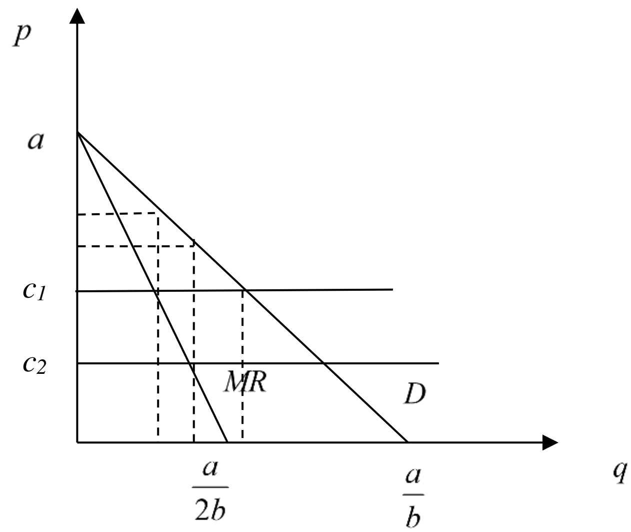

Figure 1. Profit maximization under constant MC

Before the innovation, the competitive firm sells at $p_c' = MC_1 = c_1$, that is, at the competitive outcome. Thus, for the output we have

$MC_1(q) = c_1 = a - bq$ which gives

$$q_c' = \frac{a - c_1}{b} \quad \text{at} \quad p_c' = c_1 \tag{1}$$

Theoretically after the introduction of the innovation the competitive firm could produce greater output and charge a price equal to the new marginal cost $MC_2 = c_2$, such that

$$q_c'' = \frac{a - c_2}{b} \quad \text{and} \quad p_c'' = c_2 , \tag{2}$$

but the competitive firm would like to benefit from the innovation and would keep on producing at the initial point realizing an economic rent. The rent which accrues to the innovating competitor is

$$\pi_c = \left[p_c' - MC_2(q_c')\right]q_c' = (c_1 - c_2)\frac{(a - c_1)}{b} = \Delta c \frac{(a - c_1)}{b} = \Delta c q_c' > 0 , \tag{3}$$

where Δc is the result of innovation representing the reduction in production costs. Since previously the firm did not achieve any economic profit, this result is also the increase in profit from an initial level of zero, that is, $\Delta\pi_c = \pi_c$. In the case of monopoly constant marginal costs produce the following results:

$$q'_m = \frac{a - c_1}{2b} \qquad p'_m = \frac{a+c_1}{2} \tag{4}$$

The monopoly output is half of the competitive output $q'_c = \frac{a - c_1}{b}$. After the innovation, the optimal monopoly quantity and price are

$$q''_m = \frac{a - c_2}{2b} \qquad p''_m = \frac{a+c_2}{2} \tag{5}$$

The increase in monopoly output depends on the magnitude of the innovation and is found to be

$$q''_m = q'_m + \frac{\Delta c}{2b} \tag{6}$$

According to Church and Ware (2000) a drastic innovation is one where the monopoly price after the innovation falls below the level of the original marginal cost, that is, the *ex-post* price is lower than the *ex-ante* marginal cost. A non-drastic innovation is one which does not reduce the price so substantially, and the *ex-post* price remains higher than the *ex-ante* marginal cost. Due to the reduction in the costs the optimal monopoly output increases, while the optimal monopoly price falls. The monopolist benefits from the innovation if his profit of launching it increases, that is, $\Delta\pi_m > 0$. To find this out, we need to express the monopoly profit before and after the innovation. The profit before the innovation is

$$\pi'_m = [p'_m - MC_1(q'_m)]q'_m = \left(\frac{a + c_1}{2} - c_1\right)\frac{(a - c_1)}{2b} = \frac{(a - c_1)^2}{4b} > 0 \tag{7}$$

With the innovation the monopoly achieves profit to the amount

$$\pi''_m = [p''_m - MC_2(q''_m)]q''_m = \left(\frac{a + c_2}{2} - c_2\right)\frac{(a - c_2)}{2b} = \frac{(a - c_2)^2}{4b} > 0 \tag{8}$$

This profit is clearly bigger since the costs of production decline substantially while the other parameters are the same. The increase in profit for the monopolist, therefore, is

$$\Delta\pi_m = \pi''_m - \pi'_m = \frac{(a - c_2)^2 - (a - c_1)^2}{4b} = \frac{(2a - c_2 - c_1)(c_1 - c_2)}{4b} =$$

$$= \Delta c \frac{(2a - c_1 - c_2)}{4b} = \frac{\Delta c}{2}(q'_m + q''_m) > 0 \tag{9}$$

Comparing $\Delta\pi_c$ and $\Delta\pi_m$, we can check that $2q_c' > q_m' + q_m''$ where q_m'' is lower that q_c', as can be seen from the graph, and q_m' is half of q_c', as found previously.[2] Hence,

$$\Delta\pi_c > \Delta\pi_m \quad (10)$$

Therefore, the competitive firm clearly has greater incentives to innovate than the monopoly firm, *ceteris paribus*. Substituting for q_m'' in monopoly profit,

$$\Delta\pi_m = \frac{\Delta c}{2}(2q_m' + \frac{\Delta c}{2b}) \quad (11)$$

We can apply an identical analysis to the case of linear and rising marginal cost MC. This case produces two essential subcases. In one subcase the post-innovation output of the monopolist q_m'' is lower than the competitive output q_c'. Figure 2 illustrates this case. Figure 3 illustrates the case when q_m'' exceeds q_c'. We explore both cases further.

Subcase 1. $q_c' > q_m''$

In this case the post-innovation price of the monopolist p_m'' is above the competitive price p_c'. In the competitive market prior to the innovation everybody sells at the competitive price. Once the competitive firm experiences a sudden innovation, it sells at a price slightly lower than it but close to it. Thus, the competitive firm undercuts the price for everybody in the market. It would ideally produce at $MR = MC$ but is unable to push the price above p_c'.

[2] Note that with a drastic innovation when there is a sharp decline in the marginal cost, such that c_2 is much lower, it is possible for q_m'' to exceed q_c', which we explore further. With a drastic innovation the incentives for both the competitive and monopolistic firm converge, as the profit level achievable by the monopoly approaches that of the perfect competitor.

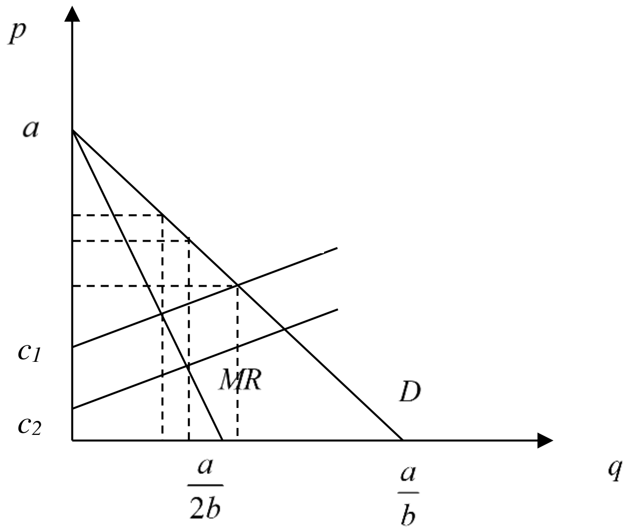

Figure 2. Effect of innovation with nonconstant *MC*

With rising *MC* as in Figure 2, we have

$MC_1(q) = c_1 + dq$,

where $d > 0$ is the slope of the marginal cost function. At the competitive outcome, the firm would sell at $MC = p$, that is,

$MC_1(q) = c_1 + dq = a - bq$ which gives

$$q_c' = \frac{a - c_1}{b + d} \tag{12}$$

as the total output of the firm if it behaves competitively. The competitive price is, respectively,

$$p_c' = \frac{ad + bc_1}{b + d} > 0 \tag{13}$$

Similarly, after the introduction of the innovation the firm could potentially produce a greater output at a lower price as follows:

$$q_c'' = \frac{a - c_2}{b + d} \quad \text{and} \quad p_c'' = \frac{ad + bc_2}{b + d} > 0 \tag{14}$$

Since $c_1 > c_2$, for symmetrical expressions of output and price, we see that competitive output increases with the innovation, that is, $q_c'' > q_c'$. Along the market demand curve, this leads to a reduction in the price such that $p_c'' < p_c'$. But the competitive firm would have no reason to give up on its profit and would, therefore, keep on charging the original price p_c' or a price close to it while producing the old level of output $q_c^{'}$ at reduced costs. The rent which the competitive firm achieves is

$$\pi_c = [p_c^{'} - MC_2(q_c^{'})]q_c^{'} = \left[\frac{ad + bc_1}{b+d} - c_2 - \frac{d(a-c_1)}{b+d}\right]\frac{(a-c_1)}{(b+d)} = \frac{(c_1-c_2)(a-c_1)}{(b+d)} =$$

$$= \Delta c\frac{(a-c_1)}{(b+d)} = \Delta c q_c^{'} > 0 \qquad (15)$$

This rent could be attained if the innovating competitive firm sells at a price slightly lower than the equilibrium industry price p_c' while incurring lower marginal costs MC_2. The result is identical to the one under constant marginal cost and the increase in the profit is exactly the amount π_c since prior to the innovation the competitor earned zero economic profit. Hence,

$\Delta\pi_c = \pi_c > 0$

In the case of monopoly, prior to the innovation we have $MR(q) = a - 2bq$ and

$MC_1 = c_1 + dq = a - 2bq$

This gives optimal monopoly quantity and price

$$q_m' = \frac{a-c_1}{2b+d} \qquad p_m' = \frac{ab+ad+bc_1}{2b+d} > 0 \qquad (16)$$

As can be expected, this output is lower than the optimal competitive output $q_c' = \frac{a-c_1}{b+d}$. The results are identical to those under zero slope d of the marginal cost function derived previously. Furthermore, the optimal monopoly quantity and price after the innovation are

$$q_m'' = \frac{a-c_2}{2b+d} \qquad p_m'' = \frac{ab+ad+bc_2}{2b+d} > 0 \qquad (17)$$

Optimal output again increases with the innovation, while optimal monopoly price falls. Innovation is, therefore, preferable for society and an innovating monopoly is more justifiable than a non-innovating one. Consequently, how sizable the innovation is, determines the increase in cumulative monopoly output and profit.

$$q_m^{''} = q_m^{'} + \frac{\Delta c}{2b+d} \qquad (18)$$

Prior to the innovation,

$$\pi_m' = [p_m' - MC_1(q_m')]q_m' = \left(\frac{ab+ad+bc_1}{2b+d} - c_1 - \frac{d(a-c_1)}{2b+d}\right)\frac{(a-c_1)}{(2b+d)} = \frac{b(a-c_1)^2}{(2b+d)^2} > 0 \qquad (19)$$

With the innovation the monopoly achieves profit to the amount

$$\pi''_m = [p''_m - MC_2(q''_m)]q''_m = \left(\frac{ab + ad + bc_2}{2b + d} - c_2 - \frac{d(a - c_2)}{2b + d}\right)\frac{(a - c_2)}{(2b + d)} = \frac{b(a - c_2)^2}{(2b + d)^2} > 0 \quad (20)$$

The increase in profit for the monopolist, therefore, is

$$\Delta\pi_m = \pi''_m - \pi'_m = \frac{b(a - c_2)^2 - b(a - c_1)^2}{(2b + d)^2} = \frac{b(2a - c_2 - c_1)(c_1 - c_2)}{(2b + d)^2} =$$

$$= \Delta c \frac{b(2a - c_1 - c_2)}{(2b + d)^2} > 0 \quad (21)$$

The innovation brings further profit to the monopolist and the result could be expressed as

$$\Delta\pi_m = \pi''_m - \pi'_m = \Delta c \frac{b}{(2b + d)}(q'_m + q''_m) > 0, \quad (22)$$

which resembles the results previously obtained. We compare $\Delta\pi_c$ and $\Delta\pi_m$ again where we know that $2q'_c > q'_m + q''_m$. This can be seen in Figure 2 where the terms q'_m and q''_m are each smaller than q'_c.

$$\Delta\pi_c = \Delta c \frac{(a - c_1)}{(b + d)} = \Delta c q'_c > 0 \quad (23)$$

It follows, therefore, that

$$2q'_c > (q'_m + q''_m) > \frac{2b}{(2b + d)}(q'_m + q''_m), \quad (24)$$

where $\frac{2b}{(2b+d)}(q'_m + q''_m)$ is a fraction of $(q'_m + q''_m)$ and, therefore,

$$q'_c > \frac{b}{(2b + d)}(q'_m + q''_m) \quad (25)$$

This implies that

$\Delta\pi_c > \Delta\pi_m$,

or again the competitive firm has an advantage in its decision to innovate over the monopoly firm. This difference in profits and incentives is bigger the less drastic the innovation. The more drastic the innovation and the greater the reduction in marginal cost, the lower the advantage of perfect competition over monopoly. The less drastic the innovation, the greater the advantage of the competitive firm over monopoly and the higher its profits of innovating. This is because with a non-drastic innovation the monopoly produces close to its original level of output and price and no substantial gains accrue to it. With a drastic innovation however, the monopoly output increases substantively, reducing thus the advantages of the competitive firm and increasing the profit of the monopolist.

$$\Delta\pi_m = \Delta c \frac{b}{(2b + d)}\left(2q'_m + \frac{\Delta c}{2b + d}\right) \quad (26)$$

From this last result we deduce that the increase in monopoly profit is bigger, the lower the slope of the demand curve b and that of the marginal cost curve d. The less elastic the market demand curve, the more slowly the output of the monopolist grows.

Subcase 2. $q_m^{''} > q_c^{'}$

In this case the post-innovation price of the monopolist $p_m^{''}$ is lower than the competitive price $p_c^{'}$. This would be the result of a substantive drop in marginal cost as well as steeper marginal cost MC. In this case the innovating competitive firm does not sell close to the competitive price but at $MR = MC$ which is the monopoly outcome after the innovation. From a perfect competitor the firm turns into a pure monopoly, thus maximizing its profit (Figure 3).

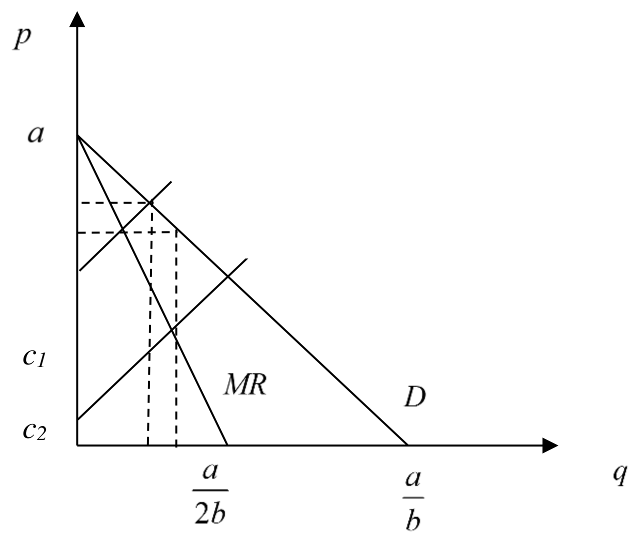

Figure 3. Effect of innovation with steep MC

After the innovation, the perfect competitor achieves the post-innovation monopoly profit $\pi_m^{''}$, where his profit increases from zero. Thus,

$$\Delta\pi_c = \pi_m^{''} \tag{27}$$

At the same time, because of the innovation the increase of profit for the monopolist is $\Delta\pi_m = \pi_m^{''} - \pi_m^{'}$, which again implies that $\Delta\pi_c > \Delta\pi_m$. In all cases discussed the perfectly competitive firm gains more from the innovation than a pure monopolist.

3. Conclusions

Our analysis indicates that both the monopoly and the competitive firm have incentives to innovate because both see profits rise after the innovation. Even a minor technological advancement increases their profit and improves society's welfare. The competitive firm has greater incentives to innovate since the increase in profits it achieves is greater. An innovative technology will give a clear marketing advantage to the competitor over the rest of the firms in the industry. Even a minor innovation would help the competitive firm attract all market demand. However, the competitor is constrained by the lack of funding due to modest profits and lack of capital. Therefore, the competitive firm is less likely to generate a major innovation than the monopoly.

From the viewpoint of profit, motivation, and competition, the competitive firm is more likely to adopt new technologies. From the viewpoint of funding, budgeting, and stay-out pricing as a form of preventing competition, monopoly and oligopoly are more likely to invest in new technologies. The more drastic the innovation, the greater the increase in profits for the monopoly and the greater its motivation to innovate. This implies that monopolies would likely pursue deeper, drastic innovations, rather than minor improvements in production which achieve insignificant cost economies. The monopoly is better off with the innovation since the reduction in the price serves as an entry-limit pricing device and keeps competitors out of the industry. The presumably "sleepy" monopolist, relying on firm, guaranteed profits, is not so "sleepy" and would strive to innovate. An innovating monopoly is advantageous both for the firm and society. Although a single firm offering in an industry, the monopoly is encouraged to innovate by higher profits.

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