CREATIVE DESTRUCTION AND UNDERINVESTMENT IN R&D: DID ARROW POINT THE WRONG WAY?

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Abstract: This paper revisits Arrow's (1962) classic work on incentives to invention in the light of current discussions re creative destruction. Creative destruction and market contestability are viewed as very closely linked. It is argued that although the case for IPR is as strong as ever, previous findings re the relative payoffs to invention under competition and monopoly need modification if there is contestability in the market. It is concluded that policy intervention via institutions such as a patent system are necessary, however under such regimes policy should target contestability rather than realised market structures. Whether further incentives are still then required depends upon the nature of competition in the production of inventions.

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1. Introduction

In 1986, in conjunction with Partha Dasgupta, I arranged a conference on *Economics and Technology Policy* under the auspices of the Centre for Economic Policy Research[1]. An important contribution to that conference was provided by John Barber with his colleague Geoff White on *Current Policy Practice and Problems from a UK Perspective*. In his contribution to the book of the Conference Partha Dasgupta makes the observation that from a normative perspective each inventor or innovator "wants to be the winner whereas society does not care who wins". Recently (in the last ten to fifteen years) the traditional literature on the Economics of Innovation has been supplemented by a new stream of work with its foundations in the macroeconomics of new growth theory. Although it is disappointing that the literatures rarely cross and, as a result, the new literature often reinvents the wheel and the traditional literature does not seem to have the high profile it should, that new literature has been emphasising of late a very traditional Schumpeterian concept – creative destruction.

Building upon the work of Aghion and Howitt (1992) and Grossman and Helpman (1991), it is argued in the new literature (Jones and Williams, 2000) that, through creative destruction, innovation may lead to a redistribution of rents from past innovators to current. Redistribution per se yields no social gain and as such the private payoff to innovation may exceed the social payoff. It is this statement that reminded me of Dasgupta and Stoneman (1987) and that 1986 conference when we argued that society does not care *who* innovates. The prime purpose of this paper is to consider whether creative destruction does imply that the private payoff to innovation may exceed the social payoff and if so what are the implications.

In my mind this raises an issue of considerable interest in its own right but also of particular interest to John Barber. First his concern has been policy and that is to the forefront. Secondly, I believe that at heart he believes in evolutionary theory, and although I am not willing to go that far, to centre upon a Schumpeterian concept will

[1] The conference proceedings can be found in Dasgupta and Stoneman (1987).

meet the prejudices of us both. Finally the echoes of our respective pasts make the paper particularly relevant to this event.

In the sections that follow we will first return to the classic Arrow (1962) model and the standard results relating to the gross private and social payoffs to R&D based on that model. In the following section we then ask what difference the creative destruction argument makes to these results. Next we address implications, although policy implications are reserved to the following section. The conclusions are summarised in the final section.

2. The status quo

All sides involved with discussions of technology policy are aware that there is a standard argument that R&D markets generally fail to provide sufficient private incentive to invest in R&D given the social benefit of such R&D. Over the years however this issue has been discussed at some length such that the original simplicity of the statement has been refined to become more complex.

Not to be too complex we consider the simple model proposed by Arrow in 1962 and represented in Figure 1. The main purpose is to consider the incentives to innovation under monopoly and competition. There is a linear demand curve, AU and associated marginal revenue curve AV. Output is Q and price P. Producers costs per unit produced are such that marginal cost (MC) equals average costs (AC). Pre innovation, such costs are c_0. Use of the innovation of interest allows production costs of c_1. Prior to innovation the monopoly price would be P_m^0 and the competitive price $P_c^0 = c_0$. Post innovation monopoly price would be P_m^1 and the competitive price $P_c^1 = c_1$. For simplicity and ease of exposition we assume that the innovation is drastic i.e $Pm^1 \leq c_0$.

As I see it, the current standard state of play is represented by the following arguments:

1. In the absence of property rights in the innovation (such as patents or some other equivalent appropriability mechanism) the private payoff to the inventor of new technologies may tend towards zero due to copying or free riding. If there are no profits to earned there will be no incentive to innovate.

2. The social benefit from an innovation will be maximised when the goods it produces are sold at marginal cost. In such circumstances pre-innovation consumer and producer surplus would be the area ABH, after the innovation is introduced the surplus would be ACJ, and thus the potential gain in surplus will be ACJ - ABH = HBCJ.[2]

3. Although many of the "externalities" arising from R&D may be market intermediated through the introduction of appropriability instruments such as patents or copyrights, even then not all social benefit payoffs can be appropriated by the owner of the technology and as such the private benefit will be less than the social benefit. This may result for example because

(i) policies that provide property rights in knowledge to the inventor enabling that inventor to receive a return on investment via mark ups of price over cost distort sales downward from the optimum level that would occur if the good were sold at marginal cost.[3]

(ii) there may be a standing on shoulders effect whereby present knowledge provides a base for further advances the benefits of which cannot be appropriated by the original inventor.

[2] Clearly the gain could be greater if in introducing the new technology there would be eradication of an existing monopoly but that is not the standard argument.

[3] Although under certain restricted circumstance if the seller can perfectly price discriminate that seller can appropriate the whole (maximal) social surplus.

4. In the presence of property rights the private payoff to introducing new technology in a competitive industry is greater than in a monopoly industry. If the technology is being sold into a competitive market the industry will initially operate with price equal to c_0 and excess profits of zero. If the inventor has property rights he/she can charge a royalty for use of the technology that enables a gross payoff to be earned equal to monopoly profits with costs c_1. The payoff to the inventor is thus LKDJ. If the inventor is selling to a monopoly industry, the monopolist is initially making profits of EFGH. With use of the new technology that monopolist could make profits LKDJ. Arrow then argues that the maximum that the inventor can appropriate from the monopolist is LKDJ – EFGH.

5. The private return under competition is less than the **potential** social return even though the private return is partly made up of the acquisition of monopoly rents. This is easily shown as LKDJ $\leq$ ACJ – ABH = HBCJ. As the private payoff to selling to a monopoly industry is less than the potential payoff from selling into a competitive industry the monopoly also provides less private incentive to innovate than is socially desirable.

6. Under competition the **realised** social return, HBKDJ, will always either equal or exceed the competitive incentive to invent, LKDJ and thus also the monopolists incentive to invent which is less than LKDJ.

To take two specific quotes from Arrow

> "the inventor's incentive under competition……..will….always exceed the monopolist's incentive"

and

> "the realised social incentive always equals or exceeds the competitive incentive to invent and a fortiori the monopolist's incentive"

Later work, especially that of Dasgupta and Stiglitz (1980), has argued that in the presence of intellectual property rights the complete R&D incentive story requires detailed consideration of the nature of competition in the invention discovery process. Competition to be first (e.g. via patent races) may lead to over investment in R&D because for example of common pool issues or through duplication and repetition (stepping on toes) as well as many other game theoretic possibilities that I do not want to go into here. These effects may counteract the previous forces implying under investment, although balancing patent life with common pool issues may redress this (see Dixit, 1988). These are issue that we do need to consider in depth in this paper.

3. Creative destruction.

The creative destruction argument is that when a **new** firm introduces a new technology in the face of a previously profit making incumbent, some of the new firm's profits arise from reductions in the profits of the incumbents, i.e. there is a redistribution of rents. In terms of the Figure, a new monopoly user of the new technology will make profits of LKDJ but the incumbent has suffered a reduction in profits from HEFG to zero. The gross payoff and incentive to innovate is thus LKDJ and not, as argued by Arrow, LKDJ – HEFG.

Why is the Arrow result at such odds to this creative destruction result? The standard Arrovian argument re the payoff under monopoly rests upon the basic argument or proposition that the market position of the monopoly firm or user does not rely upon the technology in use. The monopoly firm could for example have monopoly power through the ownership of particular brands or an exclusive supply of inputs. It is however being implicitly assumed that the inventor has only one firm to which he is able to sell his technology. This means that in determining the return to the inventor there is a bilateral monopoly.

Of course there is the possibility that the monopoly position results from the exclusive right to the technology that underlies costs c_0. Should this be so, and should there be

potential entrants to the industry who could also establish a monopoly position given access to a new low cost technology, then the inventor may establish quite a different stance and quite a different payoff. If the monopoly comes with the technology then the inventor can offer the new technology to the existing incumbent, using the argument that if the inventor's price is not paid then the technology will be sold to a new entrant and the profits of the incumbent would be reduced to zero instead of LKDJ. The inventor would thus charge and get a payoff of LKDJ. Alternatively the inventor may offer the technology to a new entrant, stressing that a monopoly position comes with the technology and the payoff to the incumbent will be LKDJ if purchased and zero otherwise. Again the payoff to the inventor is LKDJ. This is equivalent to saying that the payoff to the inventor when the market is initially monopolised is determined by the counter factual that faces that monopolist if it does not acquire the new technology.

Thus, if the market is monopolised but contestable, under monopoly the payoff is LKDJ which is in fact exactly the same return as under competition. The private incentives to innovate are exactly the same under the two market structures. We may thus argue that the difference between the Arrow result and the creative destruction result comes down to whether the market is "contestable" i.e. whether there is competition amongst potential users to adopt the new technology.

Can creative destruction or contestability create a payoff that is socially excessive? One of the problems here is what do we mean by the social gain. Clearly it cannot if we talk in terms of the pre and post social optima i.e. LKDJ < HBCJ. We might however think in a more limited sense of pre and post sums of consumer and producer surplus.

If the market is initially competitive, social welfare being generated (the sum of consumer and producer surplus) will be the area ABH. Given that the new technology allows monopolisation the post innovation welfare will be the area AKDJ and thus the social gain will be the area HBKDJ. This social gain arising from an initial competitive state equals the sum of the areas HENL and EBKN + LKDJ. The gross private gain is the increase in producer surplus LKDJ, which is clearly less than the social gain.

If the initial state is monopolised then in that state realised welfare will be the area AFEH. If there is contestability, the private gain will be LKDJ just as when the initial state is competitive. The social gain on the other hand with contestability will be the area AKDJ – AFEH which equals HENL + EBKN + FEB + LKDJ. Thus with contestability the social welfare gain is greater (by the monopoly welfare loss in the initial state, FEB) when the market starts in a monopoly rather than competitive state.

Is the private gain under contestability greater than the social gain i.e. is there any way that creative destruction can create a gross private payoff greater than the social gain generated by the technology, or in the terms of Jones and Williams (2000), can creative destruction lead to a redistribution of rents from past innovators to current such that the private payoff to innovation may exceed the social payoff? This means comparing LKDJ to HENL + EBKN + FEB + LKDJ from which it is obvious that the social gain is always greater than the private gain.

If there is not contestability but monopoly in the initial state then the social gain will again be HENL + EBKN + FEB + LKDJ, but the private gain will be only LKDJ – EFGH. Thus contestability and/or creative destruction bring the private gain closer to the social gain but they do not allow the private gain to exceed the social gain.

4. Measurement and Implications

The stylised model above does not immediately fit the real world. The competition/monopoly comparison is more a useful device than a description of the world. Most markets are oligopolistic and most firms rely on several technologies. Creative destruction would this only have a limited effect on a firm's profits rather than the drastic effect we have modelled.

Jones and Williams (2000) have attempted to estimate the impact of the creative destruction and other effects on R&D. They consider that if the appropriability problem

were eliminated then R&D would increase by 140%. Compared to this the creative destruction effect stimulates R&D by only 25%. Thus, relatively, the creative destruction effect is not large.

Surprisingly there are very few estimates in the literature of the creative destruction effect. This could be because the effects do not tend to appear until the technologies are used and the study of R&D does not tend to go into the study of use. However Stoneman and Kwon (1996) estimate, for some UK data, the impact of technology adoption on firm profits where the profits are modelled as profits without the new technology plus the profit gain from the new technology. It is shown there that the profits of the non-user do decline as usage of new technology by others extends.[4] Creative destruction may well therefore have a significant role to play in stimulating the generation and use of new technology.

There is a long-lived and extensive literature that tries to measure the return to R&D and in particular whether market structure impacts upon that return. A typical approach is reflected in the recent and sophisticated work of Blundell et al (1999) looking at the market value of innovations, who argue that "innovations of high market share firms receive a greater value on the stock exchange". Whether this is empirically sound is another matter (see for example Toivanen et. al., 2002), but the approach above suggests that what one should be exploring is not the impact of existing market shares but rather the extent to which those market shares are based upon firm and market characteristics other than then technologies in use i.e. the extent to which the market is contestable.

Much of the work looking at the impact of innovations on firm performance tends to be unclear as to the counter factual being employed. If creative destruction is operating then clearly the counter factual return when not innovating when others are so doing will be profits somewhat below those currently being earned. The generally measured private returns to innovation may thus be underestimates. Much of the literature also tends to view the return to innovation as an add-on to returns derived from other sources whereas

[4] Also that although new technology yields a profit gain, that gain declines as usage extends

the creative destruction or contestability argument would suggest that innovation is a sine qua non of a positive return.

There is also considerable empirical work on whether concentrated market structures encourage or discourage R&D. Much of this work has foundations in the Arrow proposition that competition stimulates innovation. The results above suggest however that competition and monopoly markets with contestability generate the same incentives to innovate. The question may thus be badly framed. We see now that it would be more useful to consider in oligopoly or competitive markets whether contestability stimulates R&D.

5. Policy Implications

For many years John Barber has been involved with technology policy. It is thus appropriate that I close this short paper with a brief discussion of the policy implications of our analysis. I am sure that over the years in talking to economists more than one has advised him that competition stimulates innovation whereas monopoly power stifles innovation. The government should thus, it is argued, direct anti trust policy towards stimulating competition and eradicating monopolies. This argument very quickly comes up against the problem of those firms that have monopoly power built upon success in innovation. Can it really be a good policy for stimulating innovation if procedure is to constrain a monopolist from exploiting its market power when the prospect of that market power was the initial stimulus to innovation?

With the creative destruction approach we can now see the error of our ways and the way out of the policy conundrum. The error of our ways is that there is no difference in the private returns to innovation under competition and monopoly as long as the market is contestable. It is contestability or the possibilities of creative destruction that are of crucial importance. Policy should thus concentrate upon creating contestability. The creative destruction approach also encompasses the apparent problem of a monopoly built upon successful innovation. As monopoly per se does not deter further innovation,

only a lack of contestability does so, for purposes of innovation policy governments do not need to control monopolies. As long as the market is contestable the economy will generate its own incentives to further innovation and the eradication of the incumbent's monopoly. Anti-trust policy the main thrust of which is to prevent abuses of dominant positions that eradicate contestability (e.g. entry barriers) would seem to be the appropriate policy stance.

Even with contestability will the private incentives be large enough. We have shown that, even with IPR, in competitive markets or in contestable markets, the private stimulus is still less than the potential social gain from innovation. There may thus still be a need for some taxes and subsidies. However we must return to consider the supply side where there may be common pool problems or duplication for example. It has been shown in the literature that in "winner takes all" types of competition (as exists with patents for example) there will over investment in R&D (again society does not care who wins but the players do). The necessary relationship between the private and social gains from innovation to generate optimal R&D may thus be quite finely balanced and not simply predicted. The work of Dixit (1988) suggests how variations in the length of patent life might be one useful instrument.

6. Conclusions

In 1962 Arrow presented the case for a patent system. He then argued that (i) although such a system will yield a reward to the inventor that reward would still be less than the actual (and potential) social payoff to innovation and (ii) the payoff to the inventor would be less when selling to a monopolised industry than to a competitive industry. The issue of creative destruction, which has been more extensively pursued in the new growth theory field, argues that, when a new technology is introduced, part of the return to the innovator comes from a reduced return to the incumbent. We have argued that if markets are contestable creative destruction will remove the difference between the payoffs to the inventor in a monopolised industry and a competitive industry, essentially increasing the

private payoff in the former. This approach removes natural concerns as to whether, from a social point of view, market power built upon technological superiority is desirable. From this perspective it is that power which yields the return that induced the innovation and it is desirable. What is not desirable is that current market power should be used to prevent further innovation by limiting market contestability. Policy should worry less about current market positions and concentrate instead on ensuring contestability. However, although contestability yields a greater incentive to innovate whether it will generate the social optimum will depend upon the nature of competition in the invention producing industry as well as, inter alia, the particular characteristics of the IPR schema in place.

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Figure 1.