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The Skew Nature of Innovation Returns

Introduction

"BlackBerry maker Research in Motion said Friday it agreed to pay USD 612.5 million to patent holding company NTP to settle a long-running dispute that had threatened to shut down the popular wireless e-mail service for its 3 million users" was the opening sentence of a news message on cnnmoney.com on 3 March 2006. USD 612 million for a single invention, the wireless transmission of email, is a tremendous amount, representing, for example, about 5% of the GDP of a developing country like Kenya at the time. The example shows that the commercial gains from innovation are potentially huge, although the Blackberry is, of course, an extreme example.

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This paper is about extreme rewards for innovation. It will sketch the available economic evidence for the nature of innovation reward distribution, briefly present the methods that can be used to obtain estimates of this distribution, and discuss the implications, for business and policy, of the remarkable nature of innovation.

Observing the distribution of innovation rewards

Economists have very little data that directly address the nature of the distribution of innovation rewards. Corporate accounting systems are not oriented towards estimating these rewards at the individual innovation level. Moreover, information on the monetary value of innovations is sensitive so firms tend to be secretive about it. Therefore, economists have had to resort to indirect methods for estimating innovation rewards.

One method that has been popular (e.g. Schankerman and Pakes, 1986) is the use of data on patent renewal. Where patents are used to protect inventions, they must be kept in force by the payment of administrative fees to the patent office, i.e. so-called patent renewal fees. These fees differ from one patent office (country) to the next, and may also depend on the time period and type of invention. For legal purposes, information on which patents are still in force (i.e. for which the renewal fees have been paid) must be made public. Economists use these data to estimate the distribution of patent values. Although the models that have been proposed to do this are complex and far beyond the scope of a short text like this, the underlying idea is quite simple. It relies on the notion that patent renewal decisions are based on cost-benefit analyses. If the cost of keeping a patent alive one more year exceeds the (commercial) rewards, the patent holder will make a rational decision not to renew the patent (or vice versa). Hence, the information on how many of a cohort of patents are still alive *n* years after the patent reward, for varying *n*, provides information on the distribution of commercial value within that cohort. Note that the decision to not renew a patent is final, i.e. if the fees have not been paid for even a single year, the patent will lapse and can never be re-activated. This implies that the value of renewing a patent for one year includes the value of the option to renew it again. If a future patent value is highly uncertain, this may be an important factor in the decision about whether or not to renew.

The renewal-based measures indicate that patent value distribution is indeed very skew: The modal and median parts of the distribution are found on the left, i.e. at relatively low patent values. In non-formal terms, the large majority of patents has a low value (is not renewed for very long), while a small number of patents has a very high value (is renewed to the maximum). A small number of patents represents a large fraction of the total value. A similar result is found using more indirect indicators of economic value, such as patent citations (Silverberg and Verspagen, 2007). The skew nature of patent value distribution is confirmed by recent studies on the statistical relationship between stock market values of enterprises and their patent portfolios (e.g., Hall, Jaffe and Trajtenberg, 2005). This implies that stock markets take account of important information on patent value.

Recent evidence based on a more direct measure of patent value obtained from a large-scale survey of inventors in Europe, indicates that patent-renewal estimates may underestimate total patent value (Gambardella and others, 2008). There is also theoretical corroboration for this. For example, the patent renewal decision does not give any indication of the potential value of the invention without patent protection. This has been pointed out by Arora and others (2008), who introduced the term *patent premium* to describe the part of the total value of a patent/invention that is related to patent protection. For example, when the initial years of patent protection have established a dominant market position that cannot easily be assailed by competitors, an additional year of patent protection does not represent great commercial value, even if the invention itself is still very valuable. In other words, renewal-based methods measure the patent premium rather than the total patent value.

Gambardella and others (2008) concluded that the average value of the patents in their sample was in the range of EUR 5 – 10 million, and the median value was around EUR 650 000. They quote previous estimates based on patent renewal data, arriving at estimates of average value in the range of USD 5 – 20 thousand. Figure 1 illustrates the distribution obtained by Gambardella and others (2008). It clearly shows the skew nature of patent value distribution. Note that the indicated returns are gross of lower R&D costs, i.e. they do not represent pure profits.

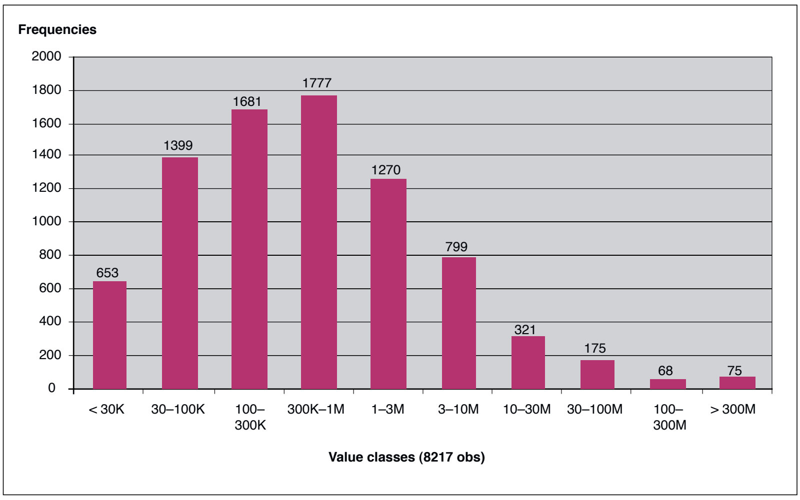

Figure 1. Distribution of patent value in the PatValEU survey
Values on the horizontal axis in EUR (K indicates EUR 1000; M indicates EUR 1 000 000).

Implications for business and policy

Firms invest in R&D and other innovation-related expenditures with the aim of generating a profit. R&D costs need to be paid upfront, while, as discussed above, the returns on R&D are very skew. The combination of these two phenomena makes innovation a very uncertain process. A firm that wants to 'hit the jackpot' and is faced with taking the *a priori* odds of drawing from the right tail of the distribution, will have to implement a large number of projects (i.e. draw a large number of times) in order to have a reasonable probability of success. Our ongoing research shows that spending resources on a single project increases the probability of a high-value invention, but significant uncertainty still remains (i.e. very expensive projects can also yield mediocre-value inventions). Judging by the skew distributions of innovation returns, mediocre returns, or even failure, are the norm, rather than the huge innovation returns that make headlines in the business press. In the aggregate, these many failures are offset by the few innovation projects with very high returns.

However, firms do not operate in terms of averages. On their own, they cannot realize the many innovation projects required to hedge against the risk that the distribution of skew innovation returns represents. This implies that failure is a realistic part of the innovation process, and it also underlines that entrepreneurship and innovation are indeed two very clearly related phenomena. Entrepreneurship is closely related to the capabilities that are needed to beat the odds, i.e. we can expect that some firms have the right capabilities and skills needed to more successfully generate high-value innovation projects than the average, or better, the median, of the distribution would predict.

Policy makers, on the other hand, have different options for influencing the aggregate distribution of innovation returns (Scherer and Harhoff, 2000). On the one hand, they have the means to influence the institutions that facilitate entrepreneurship, for example, by ensuring an efficient credit system, in particular a venture capital system, or institutions (education) that generate the human capital necessary to implement efficient

R&D projects. In implementing these institutions, policy makers need to be aware of the long-term and uncertain nature of the innovation processes they are trying to influence.

Where R&D and technology policy take a more direct form, for example, in the form of funding of R&D projects or stimulating cooperation between universities and firms, the skew nature of innovation returns implies a clear warning against overly high expectations. The majority of R&D projects generates mediocre returns, and there is no reason to expect that this should not be true for government-funded projects (in fact, firms may select the high-value projects for their own funding and leave the ones with expectations of lower value for government subsidy). Even though it is clearly beneficial to invest in the ability to select the 'right' projects for funding, government R&D policy in particular should be aimed at taking risks, and hence policy makers should be willing to accept failures.

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