Entrepreneurship and Uncertainty: Innovation and Competition among the Many

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ABSTRACT. Schumpeter stressed innovation and Knight uncertainty as preconditions for entrepreneurship and productivity growth. Schumpeter emphasized entry in his early work but came to consider incumbent innovation the dominant mode in his later work. Modern growth theory emphasizes dissemination of knowledge to explain progress in the steady state. The paper analyzes the effects of entry, market structures and uncertainty on the incidence and diffusion of innovation. The insertion of Knightian uncertainty in Schumpeter's model can explain why innovators are numerous and arrive unexpectedly. Uncertainty spurs diffusion and improves the utilization of human capital. Combining the ideas of Schumpeter and Knight also elucidates several stylized facts of entrepreneurship, such as small entry size; low chances of survival and high growth rates.

1. Introduction

Innovation and technological progress are considered vital to understanding productivity increases and economic growth. Schumpeter was one of the first economists who stressed innovation as the engine of economic growth. He spelled out under what social conditions entrepreneurship could take off. Innovative capacity only got unleashed after capitalism had supplanted feudalism and absolutist monarchy. Innovation and growth could thrive from that time onwards, because capitalism rewarded commercial success instead of military prowess or courtly behaviour (Brouwer, 1996). Schumpeter stood in a long tradition of writers on entrepreneurship. He was preceded by Cantillon, Say, Sombart and Weber and succeeded by F. H. Knight (Hébert and Link, 1982). However, the entrepreneur has taken back stage in theories on economic development since World War II. Modern endogenous growth theorists have trod partly in Schumpeter's footsteps as they consider technological progress the sole determinant of productivity increase in the steady state (Grossman and Helpman, 1993, p. 2). However, entrepreneurs do not feature largely in endogenous growth theory.

Schumpeter's work is often partitioned in two parts; entrants or entrepreneurs are the main carriers of innovation in his model of competitive capitalism [*Theory of Economic Development* (ED), 1978 and *Business Cycles* (BC), 1982], whereas large firms possessing market power stood out as the vehicle for economic progress in his model of trustified capitalism (*Capitalism, Socialism & Democracy* (CSD), 1974). Entry was central to competitive capitalism and prevented it from becoming stationary. New firms were supposed to appear at regularly spaced time-intervals of 9 or 45 years; the pace of progress being regulated by (fixed) lengths of life of capital goods. So, innovative entrepreneurs needed to wait until the former group of entrepreneurs had repaid its debts. Entry thus distinguishes competitive from trustified capitalism. A related difference between the two models lies in the way innovations are selected; by bankers in competitive and by incumbent firms in trust capitalism. Another difference involves the number and size of firms. Firms are supposed to be more numerous and of smaller size in competitive than in trustified capitalism, although Schumpeter never explicitly addressed the issue of market structures.

Schumpeter saw innovation as an inexhaustible

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source of growth. He did not share the gloomy outlook of the stagnationists of his days, who thought that all important inventions had already been made (CSD, p. 112). The innovative impetus remained intact, because able individuals from all social classes were continuously drawn towards entrepreneurship in competitive capitalism. Innovation could also flourish in trustified capitalism (and in socialism) as long as commercial interests prevailed which would force large firms to hire the most talented innovators and reward them appropriately (CSD, p. 208).

Post World War II growth theory has focused on investment in structures and knowledge as the engine of growth. Technical progress was put forward to explain the large residual found by Solow (1956) in his neo-classical growth model wherein investments in plant and equipment stood central. Neo-classical growth theories predicted great possibilities for catch-up. Knowledge was considered a public good in those theories from which lagging nations and firms could benefit. New endogenous growth models, however, stress private appropriation as a prerequisite for keeping the incentive to innovate intact.[1] But, growth rates can only be kept from falling, if there are no diminishing returns to the accumulation of human capital (Lucas, 1988, p. 18). Private appropriation makes diminishing returns to investment in human capital a distinct possibility. It is argued that growth can only be sustained if returns to innovation cannot be fully privately appropriated (Grossman and Helpman, 1991, pp. 56–58). The insertion of imperfect competition into economic growth theory imposes, therefore, rather strict conditions on appropriability and quality of R&D for perpetual growth to occur. Some innovation rents need to spill-over to consumers. A conflict between static and dynamic efficiency has been observed. "*Static efficiency demands marginal cost pricing, but firms need to sell their products above marginal costs, if they are to recover their up-front investment outlays*" (Grossman and Helpman, 1993, p. 20). The requirements for static and dynamic efficiency are diametrically opposed and cannot be met simultaneously. Moreover, knowledge also needs to spill over into a common stock of knowledge capital; the intertemporal spill-over effect. *Growth can only be sustained, if each new project is a function of the previous stock of knowledge and if present contributions are not less significant than earlier ones* (Grossman and Helpman, 1991, pp. 56–58). A third (negative) spill-over effect is also distinguished, which involves the negative effect of innovation on profits of laggard firms (Grossman and Helpman, 1991, p. 105).

Endogenous growth theories thus seem to conclude that markets will always fail on at least one aspect of innovation. Complete appropriability yields the right incentives but hinders economic growth, whereas non-appropriability spurs diffusion but destroys incentives. We could conclude that too little will be invested in innovation if appropriability is imperfect. But this conclusion needs modification, since the profit destruction effect of innovative rivalry can increase R&D investment above the amount of its contribution to total profits (Grossman and Helpman, 1993, p. 21). Consequently, R&D expenditures will be either too large or too small, which in both cases calls for government interference (Grossman and Helpman, 1991, p. 106). Cross-country regression studies of economic growth have shown a rather strong relationship between growth and physical investment, but the interpretation of the data is beset with simultaneity and multi-collinearity problems (Mankiw, 1995). The impact of investments in human capital on growth still remains unclear (Fagerberg, 1994).

Schumpeter also held the view that prompt diffusion would rob entrepreneurs of their incentive to invest. Innovation needed to be spaced in time in order to maintain the investment impetus. Schumpeter and endogenous growth theorists also agree on the negative impact of uncertainty on innovation. Knight's theory of entrepreneurship, however, revolves around the positive effects of uncertainty on investment. Knight's entrepreneur differs from Schumpeter's, because Knight cast the investor in the role of entrepreneur and not the innovator, who in Knight's view is only an employee and therefore not entitled to the residual.

This paper seeks to investigate whether and how innovation and diffusion is affected by the number of incumbent competitors and by entry. Another question involves, how the introduction of Knightian uncertainty can abate diminishing returns to innovative investment.

II. Schumpeter and Knight on selection

Schumpeter stressed the importance of entry for innovation in his early work. His insight that entry is crucial for innovation has been confirmed by many later studies, which have pointed out that new and small firms boost innovation due to their superior innovative performance (Jewkes et al., 1958; Acs and Audretsch, 1987). Moreover, the process in which old firms are replaced by new firms constitutes a major dynamic force of capitalist economies (Baldwin, 1995). Hence, entry (and exit) are relevant features of modern economic dynamics.

But, entry is less crucial in Schumpeter's later work. Innovation seems to change character, if large R&D investments are required to produce an innovation. Not newcomers, but incumbent firms are now best equipped for innovation. His alleged ideas on the innovative advantages of large firms have led to a large body of literature in the field of industrial organization on the validity of the so-called Schumpeterian hypotheses, but with inconclusive results (Scherer, 1990).

We can wonder what differences will occur, if innovations are introduced by incumbents instead of entrants. An issue that will be taken up in the next section. Another issue involves the effects of uncertainty on innovation. Schumpeter assumed that the quality of innovation would not be affected by selection modes, because innovative quality is easily discernible. Both bankers and incumbent firms will select the "best" entrepreneurs.[2] Schumpeterian investors are supposed to select only "good" investment projects and commit no errors. However, they do not select all good projects, because innovations are only launched at certain points in time, in which they cluster. It can be argued that uncertainty is introduced in Schumpeter's second approximation, in which credits are granted to projects which later turn out to be unsuccessful. Schumpeter, however, emphasized the negative effects of such selection errors; i.c. excessive inflation, deflation and even depression (BC, pp. 145–157). It looks like Schumpeter's bankers needed to be gifted with perfect foresight to prevent economic harm. Schumpeter's harsh vision on the consequences of business failures springs from his assumption that innovative investments are financed by bank credits. His view on the sources of entrepreneurial profit differs diametrically from that of Frank H. Knight, who in contrast to Schumpeter, put uncertainty central in his explanation of profits. In Knight's view, uncertainty needs to be sharply distinguished from risk. Risk can be calculated beforehand and turned into costs. Insurance premiums are a case in point. "It is true '*uncertainty' and not risk which forms the basis of a valid theory of profits and accounts for the divergence between actual and theoretical competition*' (Knight, 1921, p. 21). *If profits could be calculated before the act, or even if there is a mathematical or a-priori type of probability of success, these risks can be insured and will be changed into costs*, according to Knight. In his view the investor/selector is the entrepreneur and not the person, who starts a new business. The (successful) entrepreneur is gifted with above average perceptive talents "*The typical uninsurable (because unmeasurable and this because unclassifiable) business risk relates to the exercise of judgment in the making of decisions by men: although these estimates tend to fall into groups within which fluctuations cancel out and hence approach constancy and measurability, this happens only after the fact*" (Knight, 1921, p. 251). He also stressed that capital markets are forward looking and that uncertainty involves *prospective* outcomes, so that (changes of) expected revenues are translated into present effects on asset values (Knight, 1935, pp. 79–80 fn.). True uncertainty is the only source of profits in Knight's view, since profits would disappear as soon as change would become predictable. "*If any of these changes take place regularly, whether progressively or periodically or according to whatever known law, their consequences in the price system and the economic organization can be briefly disposed off*" (Knight, 1921, pp. 147–148). Knightian uncertainty refers to uncertainty about the economy at large and uncertainty about outcomes of individual ventures. All efforts to depict regular business cycles and to predict the outcomes of individual ventures are in vain according to Knight. Uncertainty does not need to raise average ex post rates of return, in Knight's view. Excess profits represent a margin of error in calculation on the part of the non-entrepreneurs, in his view (Knight, 1921, p. 284). Consequently, Knight saw rates of return on entrepreneurial investment vary around an average which does not need to exceed the riskless rate of return in competitive capital markets. Hence, it is only relative entrepreneurial quality that is rewarded. But, uncertainty can still prompt investment even if excess profits are absent due to the differences in profitability expectations of entrepreneurial ventures. Knight's analysis seems more realistic, since business cycles follow an unpredictable pattern and many entrepreneurial ventures fail. The successful, surviving companies, however, make huge gains (Scherer, 1999). This paper combines elements of both Schumpeter's and Knight's work to explain the pace of innovation and diffusion. A related issue involves the question, how capital markets can best cope with uncertainty.

III. Simultaneous innovation and creative destruction

Schumpeter held the view that innovations needed to be spaced in time to ward off the negative effects of creative destruction. A new cohort of innovators could only appear on the scene at regular intervals that were determined by the length of life of capital goods. The efficiency advantage of innovation could thus only be transferred to consumers after innovators had been given the time to recoup their investments. We will investigate the effects of the number of competitors and of entry on innovation and diffusion. Diffusion is complete if the whole efficiency advantage is transferred to consumers and firms are unable to appropriate any of these advances. We shall investigate the effects of the number of firms on diffusion by a Nash-Cournot quantity setting model with linear price and cost functions. We start out by modelling bundled/simultaneous innovation. It is assumed that a cost-reducing innovation is introduced simultaneously by all incumbents. It is thus assumed that knowledge spills over completely within a certain group of firms. The industry will then count an identical number of equal-sized firms before and after innovation. The efficiency increase due to innovation is expressed as a decline of marginal cost (-Δc). A new Cournot-Nash equilibrium is established after a cost reducing innovation has been introduced. Each firm will supply a larger quantity of output:

$$\begin{aligned} P &= a - bQ \\ C(q_i) &= F + c_i q_i \\ c_2 &= c_1 + \Delta c \\ q_2 &= \frac{a - c_2}{b(n+1)} \rightarrow \\ q_2 &= \frac{a - c_2}{b(n+1)} + \frac{-\Delta c}{b(n+1)} \rightarrow q_2 \\ &= q_i + \frac{-\Delta c}{b(n+1)} \end{aligned} \tag{1}$$

Price will decline by:

$$\begin{aligned} \Delta Q &= \frac{-n\Delta c}{b(n+1)} \\ \Delta P &= -b\Delta Q \rightarrow \Delta P = \frac{n\Delta c}{(n+1)} \end{aligned} \tag{2}$$

We can conclude that the cost reduction is only fully transferred to consumers, if the number of firms approaches infinity. In monopoly – in contrast – only half the cost decrease is transferred to consumers. Market structures thus have a role to play in this model. Diffusion is more complete, if firms are more numerous. Creative destruction is absent, if firms only introduce another innovation after they have fully recouped investments of the former. The absence of creative destruction thus comes at the price of sporadic innovation. But, business cycles of fixed periodicity cannot occur as Knight has spelled out. His theory took the heart out of all business cycle theories of his days, including Schumpeter's. Knight's analysis implies that the length of busts and booms cannot be predicted accurately. Incumbent losses will emerge, if innovations are introduced prematurely, whereas (excess) profits can be incurred, if firms can extend their stay beyond the expected economic life-time of capital goods.

The introduction of innovations will be less predictable, if it is carried out by entrants. Market structure is less relevant if each new cohort consists of entrants that need to oust incumbents if they want to grasp the whole market. Entrants will set price at or below incumbent marginal cost c1, if they want to replace incumbents. The new price-cost margin will equal the cost decrease ($c_1 - c_2$) irrespective of the number of innovative firms, if price is set at c_1. Price is no longer determined by the number of firms, since an entering monopolist will also set price equal to c_1. Monopoly even emerges as the most plausible market structure, if innovative talent is easily discernible. Schumpeterian bankers will just select the best entrepreneur available in each industry and get him started. We can also conclude that the three evolutionary stages distinguished by Schumpeter do not need to differ with respect to market structures. Competitive capitalism, trustified capitalism and socialism can all be monopolistic, if uncertainty is restricted to the arrival time of entrants. Schumpeter's emphasis on entry in competitive capitalism can explain his lack of interest in market structures. The competition that counts is the competition from the new, innovative firms, which – in his words – is much more effective than ordinary price competition. This competition will in the long run enforce behaviour very similar to the perfectly competitive pattern (CSD, pp. 84–85). Our conclusion, that prices are set equal to the former marginal cost level, substantiates this view to some extent. But, price does not equal actual but former marginal costs! Hence, the economy is in the perfectly competitive equilibrium of the former round of innovations. We can also conclude that entrepreneurial profits are entirely determined by efficiency gains and by the size of the market under these conditions:

Entrepreneurial Profits:

$$\begin{aligned} &\Pi_e = -\Delta c Q_2 \\ &\Delta\Pi = -\Delta c Q_2 - (-\Delta c_f)Q_1 \\ \rightarrow\ &\Delta\Pi = (-\Delta c + \Delta c_f)Q_1 - \Delta c \Delta Q \end{aligned} \tag{3}$$

Profits increase by $-\Delta c\Delta Q$ each time an innovation is introduced, if each round of innovations increases efficiency by an equal amount. The two – alleged irreconcilable – goals can be obtained simultaneously, if incumbents are replaced. Entrants can appropriate the full efficiency gain and consumers can benefit from complete diffusion. Consumers are the main beneficiaries of innovation under these conditions, since consumer surplus grows by a greater amount than profits.

$$\begin{aligned} &P_2 = c_1;\ \ \Delta c = \Delta P;\ \ Q_2 = \frac{a - c_1}{b} \\ &\Delta CS = \frac{1}{2}(a - c_1)\ (Q_1 + \Delta Q) - \frac{1}{2}(a - c_0)Q_1 \\ &\Delta CS = \frac{1}{2}\left[-\Delta c Q_1 - \Delta P \frac{a - c_1}{b}\right] \\ &\Delta CS = -\frac{1}{2}\Delta c[Q_1 + Q_2] > -\Delta c \Delta Q \end{aligned} \tag{4}$$

The exit of incumbents implies that nobody is lagging behind and no difference between best and average practice exists. Employment (L) can remain constant, if price-elasticity of demand equals unity in the new equilibrium[3].

Assumptions:

$$\begin{aligned} &\textit{Wages Costs}: wL = cQ \\ &w_1 = w_2 \\ &L_2 = L_1,\ \text{ if }\ c_1Q_1 = c_2Q_2 \\ &\Delta P = \Delta c = -b\Delta Q \\ &\quad \rightarrow P_2 = c_1 \end{aligned} \tag{5}$$

Analysis:

$$\begin{aligned} &c_1Q_1 = c_2Q_2 \\ &\Delta c Q_2 = -c_1\Delta Q \\ &\Delta c Q_2 = -c_1\frac{\Delta c}{b} \\ &Q_2 = -\frac{P_2}{b} \rightarrow e = -1 \end{aligned} \tag{6}$$

It was argued above that uncertainty about the time of entry arrival and incumbents' retreat prompts entrants to set price equal to incumbents' marginal cost. Uncertainty thus needs to be inserted in a Schumpeterian model in order to achieve the results obtained above. Endogenous growth theory often assumes that the technological leader practices limit pricing and so drives the technological follower from the market (Grossman and Helpman, 1991, p. 91). "*The innovation process has a distinct Schumpeterian flavour, in as much as successful innovators displace previous industry leaders and snatch from them a share (or 100%) of industry profits*" (Grossman and Helpman, 1993, p. 16). However, such competitive pricing will only emerge under conditions of uncertainty about the date of incumbent departure.

Another advantage of entry innovation under uncertainty is that entrants are more motivated to innovate than incumbents in the case of simultaneous innovation. This issue was first raised by Arrow in 1962. Entry profits exceed the addition to incumbent profits caused by innovation, since entrants have zero profits before entering. The difference between the innovation incentives accruing to entrants and incumbents widens, if the number of firms increases as is demonstrated below.

$\Delta\Pi$ in the case of incumbent innovation:

$$\begin{aligned}\Delta\Pi &= (P_2 - c_2)Q_2 - (P_1 - c_1)Q_1\\ &= (P_2 - c_2)\ (Q_1 - \Delta Q) - (P_1 - c_1)Q_1\\ &\quad P_2Q_1 - c_2Q_1 + P_2\Delta Q - (P_1 - c_1)Q_1\\ &\quad (P_2 - P_1 - c_2 + c_1)Q_1 + (P_2 - c_2)\Delta Q\end{aligned}$$

$$\Delta\Pi = (\Delta P - \Delta c)Q_1 + (P_1 - c_1)\Delta Q + (\Delta P - \Delta c)\Delta Q$$

$$\rightarrow \Delta\Pi = -\frac{\Delta c}{n+1}Q_1 + (P_1 - c_1)\Delta Q - \frac{\Delta c}{n+1}\Delta Q$$

$$(P_1 - c_1)\Delta Q = -\frac{bQ_1}{n}\,\frac{n}{n+1}\,\frac{\Delta c}{b} = -\frac{\Delta c}{n+1}Q_1$$

$$\rightarrow \Delta\Pi = -\frac{\Delta c}{n+1}(2Q_1 + \Delta Q)$$

$$\Delta\Pi = \frac{-\Delta c}{n+1}(Q_1 + Q_2) < \Pi_e = -\Delta c Q_2 \qquad (7)$$

Entry thus stimulates innovation through a double positive effect. Firstly, entry promotes the transfer to consumers because prices drop to former cost levels. Secondly, entrants are more motivated to innovate due to larger additional profits in the case of entrant than incumbent innovation.

IV. Sequential innovation

We will now relax the assumption that innovation is introduced collectively and assume that innovation is introduced by one firm at a time in a Cournot-Nash quantity setting model. It is demonstrated below that individual incumbent innovation impedes diffusion by a factor n (number of firms) compared to collective innovation (Equations 1 + 2). Our approach is based on Bergstrom and Varian's model for a Cournot market structure with linear marginal costs. The aggregate production level can then be obtained by summing up all individual revenues functions (Shy, 1995, pp. 126–127). The additional output due to innovation is obtained by subtraction.

Individual innovation:

$$Q^c = \frac{na}{(n+1)b} + \frac{\sum_{i=1}^{n} c_i}{(n+1)b}\ \text{(Shy)}$$

$$\rightarrow \Delta Q = \frac{-\Delta c}{b(n+1)} \qquad (8)$$

$$\Delta P = \frac{\Delta c}{n+1}$$

Hence, price will only decline by $1/n$th of the cost decrease, when the first firm adopts the innovation. That is because, the innovative firm expands his output, whereas his non-innovative counterparts contract theirs.

$$q_{\text{inn}} = \frac{a - c_i}{b} - Q_2$$

$$q_{\text{inn}} = \frac{a - c_1}{b} - \frac{\Delta c}{b} - Q_1 + \frac{\Delta c}{(n+1)b}$$

$$q_{inn} = q_1 - \frac{n}{(n+1)b}\Delta c$$

$$\rightarrow \Delta q_{\text{inn}} = -\frac{n}{(n+1)b}\Delta c$$

$$\Delta Q_{\text{noninn}} = -\frac{\Delta c}{b(n+1)} + \frac{n\Delta c}{b(n+1)} = \frac{n-1}{b(n+1)}\Delta c$$

$$\rightarrow \Delta q_{\text{noninn}} = \frac{\Delta c}{b(n+1)} \qquad (9)$$

We can conclude that a single innovative firm can now appropriate innovative rents of n times the size of what he would have obtained in the simultaneous model.

$$\Delta\Pi_{\text{inn}} = -(\Delta P - \Delta c)q_2 + (P_1 - c_1)\Delta q{:}$$

$$-\Delta\Pi_{\text{inn}} = \frac{-n\Delta c}{n+1}q_2 + bq_1 \cdot \frac{-n\Delta c}{b(n+1)} \qquad (10)$$

$$\Delta\Pi_{\text{inn}} = \frac{-n\Delta c}{n+1}(q_2 + q_1)$$

Hence, individual innovation is n times as profitable as collective innovation! Non-innovative firms, however, will see their profits shrink:

$$\begin{aligned}\Delta\Pi_{\text{noninn}} &= \frac{\Delta c}{n+1}(q_2 + q_1)\\ (n-1)\Delta\Pi_{\text{noninn}} &= \frac{n-1}{n+1}\Delta c(q_2 + q_1)\end{aligned} \qquad (11)$$

We can conclude that innovative profits exceed losses in a one-period Cournot equilibrium. Creative destruction does occur at the level of the individual firm, but total industry profits increase. Diffusion will occur gradually each time capital goods are replaced. Each incumbent firm will invest in the new technology, if imitation is easy, or if capital goods are produced outside the industry of use. Price will have declined by $n/(n+1)$th of the efficiency gain after all n firms have renewed their equipment. The price decline thus equals that of simultaneous incumbent innovation, but price will now decline gradually instead of jump-wise. All firms except the adopter will contract output each time a firm adopts the innovation in this scenario. Hence, early adopters will lose market share later on and all firms will again be of equal size after diffusion has been completed.

We will now look at a situation of innovation by an entrant that behaves as a quantity follower. It is demonstrated below that diffusion is much furthered by such entry. An innovative entrant will supply as much as an incumbent, if the cost decrease equals the former price-cost margin in a Stackelberg model.

$$MR_e = Mc_e$$
$$2bq_e = a - c_2 - bQ_1$$
$$\rightarrow q_e = \frac{a-c_1}{2b} - \frac{(n-1)\,(a-c_1)}{2b} + \frac{-\Delta c}{2b}$$
$$q_e = \frac{1}{2}q_i + \frac{-\Delta c}{2b} \tag{12}$$

We can conclude that one entrant suffices to completely diffuse an innovation, if the cost decrease equals the former price-cost margin. Entrant output will then equal incumbent output and price will equal c_1.

$$P_2 = c_1, \text{ if } q_e = q_i$$
$$\rightarrow \text{if } -\Delta c = bq_i = P_1 - c_1 \tag{13}$$

Hence, one entrant can do the diffusion job of $n+1$ incumbent innovators! Consumers benefit from innovative entry, but all incumbents will lose their profits, if price equals c_1. The entrant firm will incur profits equal to the profits of an incumbent firm before the innovation was introduced and industry profits will now be reduced to $1/n$th of former profits:

$$\Pi_e = q_e \cdot -\Delta_c = \Pi_i = \frac{1}{n}\Pi_1 \tag{14}$$

Hence, losses would outstrip profits by far in this scenario and creative destruction is rampant. The entrant's incentive to innovate is less than in the case of incumbent individual innovation, but exceeds that of collective incumbent innovation for all $n > 1$:

$$\Pi_e = -\Delta c q_1$$

Incumbent Individual Innovation

$$\Delta\Pi_i = -\frac{n\Delta c}{n+1}(q_2 + q_1) \tag{15}$$

Incumbent Collective Innovation

$$\Delta\Pi_i = -\frac{\Delta c}{n+1}(q_1 + q_2)$$

The incentive to fight innovative entry, however, is n times as large as the incentive to innovation. That is because each incumbent is induced to spend all its profits on fighting entry. Incumbents can curb creative destruction by contracting output in order to accommodate innovative entry. They can also acquire innovative entrants. Both policies are less likely if entrepreneurs are in ample supply. Porter has pointed out that acquisition of entrants encourages others to start up new firms and hence cannot achieve the desired goal (Porter, 1980). The same applies to an accommodating strategy.

A more likely reaction to innovative entry, therefore, consists of acquisition of an incumbent. Such acquisition can annihilate the price reducing effect of innovative entry, if both the entrant and incumbent firms maintain their pre-innovation output. Incumbent profits will amount to $(n-1)n$th of pre-entry profits, if one firms is removed from the scene. We can, therefore, conclude that incumbents would ultimately be prepared to pay $(n-1)$ times annual profits to acquire a rival.

Aquisition Strategy:

$$\Pi_{\text{noninn}} = \frac{(n-1)\,(a-c)^2}{b(n+1)^2} \tag{16}$$

Acquisition becomes cheaper if the number of firms increases. However, an increase in numbers will make the implementation of an acquisition policy more cumbersome. Incumbents need to reach an agreement to share the acquisition costs in oligopoly. Some cooperative mode should, therefore, be found to make such a policy viable. An acquisition policy also becomes more attractive, if life-expectancies of incumbents vary, so that less can be paid for a firm with only a short life-time left.

The acquired firm escapes creative destruction if it is acquired at book value. A market, in which assets can be resold at book values can be called contestable. But, exit cannot be totally painless in the case of innovative entry as was shown above. Either acquiring incumbents or acquired incumbents need to pay a price to stop the profit dissipating effects of entry. Genuine contestability would – in contrast – imply that entry and exit are totally painless. Contestability requires that assets are not industry specific and that all assets can be resold at book values. It looks like entrepreneurs can enter incessantly in contestable markets, since they do not need to wait till the former round of entrepreneurs has recouped its investment. But, contestable markets also need to be sustainable, which is attained if price equals average costs of the most efficient firm. Hence, all innovation is futile in contestable markets, since diffusion is immediate and leaves no time to collect innovative rents. A contestable market is like a car without brakes, about which Schumpeter remarked that you can actually drive faster in a car provided with brakes (CSD, p. 88). Contestability implies the absence of creative destruction and of uncertainty, since firms can always recoup their investments and hence cannot fail. An innovative industry can, therefore, never be contestable. Contestable markets resemble markets with perfect knowledge spill-overs. The efficiency gain can be completely transferred to consumers in a market with complete knowledge spill-overs. Such a market, however, leaves little incentive to innovate either. It was demonstrated above that a multitude of firms only assists diffusion if they act collectively. A large number of firms will actually impede diffusion if knowledge can be privately appropriated. It was also demonstrated above that adaptive innovative entry would stimulate diffusion but reduce industry profitability by a factor n. Such a situation could not be sustained for long. In fact, investment would come to a halt, if entry can be expected to occur any minute and rob all incumbent firms of their profit. Investment can only be sustained, if profits and losses strike a positive balance in the long term.

Uncertainty about both the arrival time and the identity of successful innovative entry will cause entry to take incumbents by surprise, which makes it more difficult for them to respond adequately. But uncertainty will also reduce entrant size and therewith the creative destruction effect of entry on incumbents. Entrants will be small and numerous if entry success is uncertain, because uncertainty will induce investors to spread their capital thinly over many ventures. With time, more information will become available about a venture's prospects and capital will be re-allocated, as investors revise their opinions. This picture fits the stylized facts about (innovative) entry. Entrants are of relatively small size and have relatively low survival rates while survivors show rapid growth (Audretsch, 1995; Baldwin, 1995). The low survival rate of entrants indicates that creative destruction affects entrants severely. This applies with the greatest force in R&D intensive industries (Audretsch, 1995). Exit is easy in "high tech" industries, because R&D investment does not constitute a barrier to exit as sunk investments in plant and equipment do. Hence, the winner of an R&D game can occupy the whole market and incur huge profits.

The pace of innovation is slowed down – in contrast – by longevity of physical capital goods. Economic growth can accelerate, if capital goods are replaced after an abbreviated period of time. Price declines may spur replacement and therewith innovation as has been the case in computers. It was demonstrated above that the average length of life of capital goods can also decrease if the oldest firms in the industry are acquired and shut down.

We can thus conclude that there is an important difference between tangible and intangible sunk investment. Innovation is arrested in the case of sunk tangible investment, because non-innovative firms are inclined to remain in the industry and depress innovative profits. However, unsuccessful intangible investment does not impede innovation, because exit is swift and complete. R&D intensive firms can best be financed by equity capital as will be demonstrated below.

V. Uncertainty and finance

Schumpeter stressed the importance of finance for economic development. Bankers have the task to select entrepreneurs in competitive capitalism. The importance of finance in economic growth is supported by recent research (Levine, 1997). Schumpeter foresaw an evolution from competitive to trustified capitalism and to socialism. But, innovation could proceed unhampered – in his view – because innovative quality can be assessed objectively by expert opinion. Complete certainty about entrepreneurial quality implies that bankers are unanimous in their ranking of (potential) entrepreneurs. It seems completely reasonable to assume that only one entrepreneur is needed, if all investors are gifted with perfect foresight. All investors would then rank entrepreneurs identically. Uncertainty, however, changes this picture. Knight sketched a picture of an economy, in which some investors/entrepreneurs lost and others gained. The average rate of profit, however, could equal the market rate of return.

We will assume that all investments are completely sunk, so that no failing firm will receive any reimbursement. Each venture has an equal ex ante chance of success β and the chance of failure can then be written as (1– β). However, only one firm can actually win; the others will disappear and lose their whole investment. The success rate of each individual venture is narrowed down, if more ventures are funded. The annual amount of innovative investment will depend on several variables, such as the length of life of capital goods and expected profits. We can conjecture that more will be invested in innovative entrants, if their expected relative innovative quality exceeds that of incumbents. The amount of external entry investment will also depend on the organization of capital markets, as will be demonstrated below. Sunk investment requires (expected) market rates of return to exceed the average or riskless rate of return r^* by a large margin, if the chances of success are small.

Markets with sunk costs:

Failing firms: $(1 - \beta)P^kK = 0$

$$\beta(1 + r)P^kK + (1 - \beta)P^kK = (1 + r^*)P^kK$$

$$1 + r = \frac{1 + r^*}{\beta} \rightarrow r = \frac{1 + r^*}{\beta} - 1 \qquad (17)$$

Uncertainty would not affect the total amount invested if the average rate of return on investment equals r^*.

$$(1 + r)\beta\, P^kK = (1 + r^*)P^{k*}K^*$$

$$1 + r = \frac{1 + r^*}{\beta} \qquad (18)$$

$$\rightarrow P^kK = P^{k*}K^*$$

Innovative investment thus does not need to be curtailed by uncertainty. The winner-takes-all scheme described above enhances losses, but also ensures that the prizes will be large. The organization of capital markets is of crucial importance, since bankers need to absorb uncertainty in a way that does not affect total investment.

Entrants can be funded by either equity or debt capital. We will first analyze the effects of uncertainty in the case of complete equity finance. Aggregate entry investment (K_e) consists of investment in human and physical capital. Knight assumed that all uncertainty was borne by investors and not by starters.[4] We will, however, assume that starters and financiers share the ex ante risk. People who start their own business lose income, if their wages in the entrepreneurial firm (W_e) fall short of their earnings as an employee (W_{em}). Entrepreneurship is only worthwhile, if salary sacrifices are compensated by a portion of stock equivalent to their wage sacrifices. The number of entrepreneurs is indicated by H. Shares issued to entrepreneurs do not need to dilute equity capital, if entrepreneurs' share of stock equals the present discounted value of their wage sacrifices. Investors then save on the one hand what they give with the other. Financiers pay entrepreneurial wages and fixed capital. The respective shares of equity capital can be expressed in the following manner:

Starters' Investment = $(W_{em} - W_e)H$
Financiers' Investment = $(W_e)H + F$
Total equity Investment $K_e = (W_{em})H + F$
Starters' Share of equity capital:

$$s_e = \frac{(W_{em} - W_e)H}{K_e} \qquad (19)$$

Financiers' share of equity:

$$(1 - s_e) = \frac{(W_e)H + F}{K_e}$$

The amount of (human) capital invested per entrepreneur will increase, if highly paid employees turn entrepreneur. Fewer ventures and/or fewer entrepreneurs per venture can get started, if employees with high salaries become entrepreneurs. Successful ventures need to earn many times their initial investment, if investment is sunk and the number of contestants is large. Successful entrepreneurs need to earn almost 13 times their initial investment after five years to attain a rate of return of five percent for all investment, if β = 0, 1. Such returns can be achieved by IPO's.

$$\overline{P}_2\overline{K}_2 = (1 + r^*)^t P_1 K_1$$
$$(P_2K_2)_{\text{winner}} = \frac{(1 + r^*)^t P_1 K_1}{\beta} \tag{20}$$

Rates of returns on entrepreneurial investment can only exceed r^* if less is invested than the competitive amount. This can occur if capital markets are not well developed, and/or if the ex post success ratio exceeds the expected or ex ante success rate: $\beta_{\text{post}} > \beta_{\text{ante}}$. The reverse applies, when investors have underestimated uncertainty and invested too much. But investors cannot afford to be too prudent, because competition among investors counteracts the inclination to underinvestment. We can say that entry investment equals the optimal amount K_e^* if competition among investors is perfect. Periods of overshooting and underinvestment can still occur, but K_e will equal K_e^* in the long run. Capital markets approach perfection more closely if problems of opportunism and liquidity can be solved. Institutions, such as venture capital companies and stock markets assist in solving these problems. Both entrepreneurs and venture capital managers share the rewards of success if their income is (stock) performance related. Initial Public Offerings (IPOs) enhance liquidity. The idea that capital markets can work close to perfection can, therefore, not be immediately discarded. Only those individuals, who think their chances of success are high will start as entrepreneurs. Potential entrepreneurs can sketch a too optimistic picture of their capacities. But insufficient average returns can only occur if too much is invested in entrepreneurship at large, as was mentioned above.

Uncertainty about investment outcomes raises the ex ante rate of return above the risk free rate. Investors will only finance ventures that are expected to meet this elevated rate of return. However, uncertainty implies that investors will not all bet on the same entrepreneur. In contrast, investors and employers will only agree on an individual's worth if uncertainty is absent. They will then all chase the same high paid individuals. Consequently, investors either need to hand out a larger share of equity stock to entrepreneurs, or need to pay higher wages than in the case of more poorly remunerated workers. More will be invested per venture and as a consequence fewer ventures will be launched for a given amount of capital under these conditions. All uncertainty will be banned, if only one venture is launched (in each industry). We are back in Schumpeter's world of complete certainty! It is demonstrated below that entrepreneurship does not pay if uncertainty is absent. The one selected entrepreneur has already won before entering the race! The present discounted value of an entrepreneur's income exactly equals his discounted income as an employee, if he is the only one chosen.

$$K = K^*; \quad \beta = 1$$
$$\text{PDV} = \frac{W_{em} - W_e}{1 + r^t} + \frac{F}{1 + r^t}$$
$$\text{PDV}_{\text{ent}} = \frac{W_{em} - W_e}{(1 + r)^{*t}} + \frac{W_e}{(1 + r^{t*})}$$
$$\rightarrow \text{PDV}_{\text{ent}} = \frac{W_{em}}{(1 + r)^{*t}} \tag{21}$$

Incentives to entrepreneurship only exist if human capital cannot be ranked unambiguously with respect to quality. Individuals whose economic value did not materialize in the labour market can prove themselves as entrepreneurs. Uncertainty implies that investors' opinions about a person's prospective worth differ not only from those of employers but also among their own group. Consequently, starters will wind up with the investor who values them most and receive only one investment offer if investors' valuations do not overlap. Investors as a group can only gain, if the average rate of return exceeds the risk free rate of return. But, individual investors and entrepreneurs can incur profits, if their ventures become successful. We can also conclude that uncertainty improves innovative quality, since a large number of start-ups enables manifold experimentation and opens up hitherto hidden potentials of human capital. Social and economic mobility are enhanced by entrepreneurship, since unexpected successes become possible. In contrast, a social ranking of individuals which is cast in stone and never challenged stifles effort and initiative.

Uncertainty only arises, if financiers compete for deals, since a monopolist-banker can never be proved wrong. Less equity will be issued by a monopolistic than by a competitive banking system, which will ensue sub-standard economic performance. We also inferred that more ventures will be launched, if starters could earn only modest salaries as employees. This inference is corroborated by empirical research by Evans and Leighton, who found that entrepreneurs earned somewhat lower wages than their equally well-educated colleagues.

It was demonstrated above that equity finance can absorb uncertainty without affecting total investment. Debt financed new ventures cannot defer capital and labour expenditures. Uncertainty will lead to high interest rates, which increases expenses and reduces the chance of success. Starters' incomes consist of entrepreneurial wages and the residual left after all expenses have been paid.

Entrepreneurs' income (Inc_e) in the case of debt finance:

$$\mathrm{Inc}_e = W_e H + [(P - c)Q - rK - W_e H]$$
$$\rightarrow \mathrm{Inc}_e = (P - c)Q - rK$$
$$\mathrm{Inc}_e > W_{em}H, \text{ if } (P - c)Q > rK + W_{em}H \qquad (22)$$

Entrepreneurs are only stimulated to make salary sacrifices, if the profits after interest payments are expected to exceed the salaries they would have earned as employees. Such cases will be more rare than with equity finance because interest payments cannot be postponed and contribute to current costs. Entrepreneurs are, therefore, less induced to make wage sacrifices. As a consequence less entrepreneurial investment will be funded by debt capital if uncertainty prevails. Debt capital seems, therefore, unsuited to finance uncertain ventures in contrast to equity capital (Myers, 1977).

VI. Conclusions

Combining the ideas of Schumpeter and Knight on entrepreneurial investment can shed some light on several stylized facts, such as relatively small de novo entry size; low chances of survival and high growth of survivors. It can also explain the rise of venture capital and equity finance.

Modern endogenous growth theory stresses that sustainable growth requires the absence of diminishing returns to scale. Otherwise, ever increasing research monies need to be spent in order to let knowledge grow at a constant rate. R&D cooperation is one way to prevent diminishing returns from occurring. Cooperation in R&D can also spur diffusion, but diminishes incentives to innovation. The paper demonstrates that entry can enhance diffusion and improve the quality of innovation without affecting incentives. Tapping from an enlarged pool of human capital can sustain the innovative impetus. This was Schumpeter's idea, when he stressed that entrepreneurship boosts innovation. The insertion of Knightian uncertainty makes perpetual innovation more likely. It is also concluded that capital markets and particularly equity finance have an even more prominent role to play than Schumpeter assumed.

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Notes

[1] These models were developed by Romer (1990), Grossman and Helpman (1991) and Aghion and Howitt (1992). (Fagerberg, 1995).

[2] Socialism was not supposed to affect progress either, since the same people would be selected as innovators. Socialism can even be seen as capitalism put to perfection. Comparing blue-prints, Schumpeter noticed; *it is undeniable that the socialist blue-print is drawn at a higher level of rationality, which partly results from the fact that in the capitalist order improvements occur as a rule in individual concerns and take time and meet resistance in spreading. In the socialist order every improvement could theoretically be spread by decree and sub-standard practice could be promptly eliminated (CSD, p. 196).*

[3] Distributive shares, however, will not remain constant, if wage payments are constant and profits increase.

[4] To prevent confusion, we will stick to the Schumpeterian vocabulary and call starters and not financiers entrepreneurs.

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