Intertemporal Blockaded Entry:
The Incumbent-Entrant Balance under Conditions of Extremely Rapid Technological Innovation

ABSTRACT:

This paper develops a model of intertemporal blockaded entry, in which an incumbent faces a series of potential entrants under conditions of exogenous underlying technological progress. I examine the effects of varying the speed of technological progress on the profitability of the incumbent, the credibility of the entrants' threats to come into the market, and the consequent speed with which the incumbent adopts these new technologies.

Our intuition (and the case literature on technology adoption) suggests that rapid technological change would favor new entrants over incumbents, particularly those incumbents who delay in adopting new technologies when they become available. Many industry stories suggest that incumbents who persist in employing outdated technologies are quickly eclipsed.

The model's counterintuitive conclusion, however, is that sufficiently fast underlying technological change can serve as an intertemporal barrier to entry, even when the incumbent does not adopt technologies as soon as they are available. Thus, extremely rapid technological progress can lead to the same sorts of extraordinary incumbent profitability, and the consequent continued use of obsolescent technologies, as would extremely slow technological progress. Although it is essential for the incumbent to improve its technology once entry actually occurs, under certain conditions it need not even invest in technology as an entry-deterring mechanism.

MODEL SUMMARY:

My paper has a simple point: that faster speeds of underlying innovation cease to benefit the entrant--and that, after a certain well-defined point, faster underlying innovation actually *harms* the entrant.

Assume an incumbent using a given technology is making a profit of $\mathbf{\Pi_m}$ per period. A stream of entrants lines up to consider entering the market, with one entrant considering joining the market at the beginning of every period. A new technology comes along after **N** periods, which costs the entrant of the day K>0 to implement, which will enable the entrant to come into the market and profitably compete against the incumbent. The entrant consider the investment of **K** to enter the market, with the idea that it will then receive some profit $\mathbf{\Pi_e}$ per period for **N** periods. (Of course, this is a simple case: the argument goes through as long as the entrant receives some total expected profit, which can be calculated as the integral of per-period profit over time; the entrant can even weather short period of negative marginal profitability and still stay in the market, as long as she can exit if the NPV of future profits becomes negative.) The parameter **N**, the useful life of the innovation, is exogenous in this model, but not primitive--it depends on the speed of underlying innovation, the primary focus of the model.

The speed of underlying innovation **r** is exogenous and feeds into **N** in an intuitive way: the faster the underlying innovation, the shorter the **N**. A simple relationship might be that **N** is roughly inversely proportional to **r**. (Of course, a formal model would have **N** be the length of time -- similar to a half-life -- over which the "depreciation" at a rate of r per year reduces the original asset to something that no longer deters further entry. The relationship **N=1/r** represents "straight-line" depreciation, in that an investment which depreciates at r=5% per year is good for 20 years; more complex schemes are certainly imaginable. Of course, what we are interested in is the depreciation in *competitive effectiveness* of the technology, not any accounting-based measure of historical cost.)

Note that the exogeneity of underlying innovation is a key assumption; I don't pretend to address all the complexities of endogenous innovation, standard-setting, and so on.

When the incumbent is alone in the market, a low **r** seems to be a good thing. A low r means that it will be a long time before the technology develops enough to let an entrant come in at a profit. Certainly industries where technological progress is slow give incumbents plenty of time to build up and enjoy the traditionally

cited economic advantages of incumbency (brand awareness, known quality, economies of scale, experience, etc.) Indeed, a traditional industry analysis would suggest that when capital must be committed to at the time of entry, low rates of technological improvement offer better chances of eventual profitability. One can easily imagine the incumbent updating technology only grudgingly, and just before the entrant is ready to come in -- a sort of "limit investment" strategy, similar to a "limit pricing" strategy, to deter entry. In this case, the incumbent need not adopt the very latest technology; he should, indeed, adopt technology at a rate (and frequency) to minimize investment cost, subject to keeping the entrant out (assuming, as we do, that deterring entry is more profitable than accommodation.) Thus, an outside observer would see that obsolete (non-state-of-the-art) technology would always be in place by the incumbent, who was never challenged by an entrant actually coming in. I submit that we see precisely this behavior in certain telecom markets, stock exchanges, and other markets dominated by a long-lived incumbent.

The entrant who comes in clearly needs to expect N to be at least as large as a particular $\underline{N}$, representing the "break-even useful life" of the investment K. If **N**< $\underline{N}$**,** investing **K** simply isn't worth it--the expected present value of the stream of future profits doesn't pay enough to match the present cost of K.

Let's now perform some comparative statics on **r**, the rate of technological innovation. As **r** gets larger and larger, the incumbent's cost of limit-investing goes up (keeping K constant, of course)--technology needs to be replaced more and more often to keep those pesky entrants out. After **r** gets to a certain medium level, it becomes worthwhile for the incumbent to accommodate entry rather than pouring money into the bottomless pit of limit-investment. If **r** gets too high, however, **N** will fall below $\underline{N}$, and the entrant, knowing this, will decide that investing **K** is not worthwhile--and therefore not enter the market. The next entrant will make exactly the same calculation, and the next, and the next… The incumbent will thus be protected by the very ease of entry exhibited in the market. even though the incumbent doesn't adopt better technology itself. The incumbent's profitability will snap back to the pleasantly high level characterized by a very low r. It's the speed of innovation and the threat of the next entrant which deters entry, and not the investment by the incumbent. Paradoxically, entry is *too easy*, and happens *too often*, to be profitable to do at all!

A medium level of speed of technological progress is therefore worst for the incumbent (and, consequently, best for the entrant.) At a medium level of progress, the incumbent is faced with the unattractive choice of (a) constantly making costly limit-investments in technology, which depreciate relatively rapidly and must be freqently replaced to maintain its monopoly position, or (b) accommodating entry to an entrant with superior technology, who will eventually be replaced with an entrant with even *more* superior technology. The incumbent can thus make large amounts of profit over time when r is "too large" as well as when r is "too small."

No particularly complicated analytical technique is required to demonstrate that incumbent profits are not monotonic in innovation speed (although I invoke the properties of Nash equilibrium to demonstrate that "No Entry" is indeed Nash.) Indeed, the beauty of this model is the ability to explain it in graphical form using intuitive notions of present value.

Errors in Entrants' Perceptions of Technological Progress, and Resulting Major Expensive Mistakes

Of particular interest are markets where the actual rate of underlying innovation is different from the apparent rate of innovation (that is, the rate at which the potential entrants *think* innovation is occurring.) If entrants believe that innovation happens more slowly than it actually does when r is high, there will be continuing entry into the market despite the fact that previous entrants incurred losses. But if entrants believe that innovation happens more slowly than it actually does when r is medium, they will wait too long to enter the market and allow the incumbent to protect itself cheaply by limit-investing.

If entrants believe that innovation happens more quickly than it does when r is low, they will enter the market prematurely and be dashed against the rocks by the traditional advantages of incumbency. If

entrants believe that innovation happens more quickly than it actually does when r is medium or high, however, they will stay out of the market even though profitable entry opportunities exist.

It may thus be strategically useful for incumbents (who are frequently modelled as sources of information about the industry) to over- or understate the speed of technological innovation--a "signal jamming" explanation of why obsolete technologies might persist in industries where laboratory innovations are developed at very rapid paces.

Wireless telecommunications, semiconductor manufacturing, and electronic commerce, strange competitive dynamics pertain. In semiconductor manufacturing. incumbents are periodically replaced by entrants only to "leapfrog" these entrants in the next round innovation, with two firms thus splitting a dominant position in the market intertemporally. This model explains why such behavior maximizes long-term profitability when underlying technological progress is extremely fast.

Finally, an observation. Pages written in HTML or applets written in Java can be developed and altered at very rapid rates. It would seem that such rapid development must mean that "there are no barriers to entry in electronic commerce"--and yet we see extraordinarily high expected profits (as reflected in equity values) for businesses such as Yahoo!, amazon.com, and AmeriTrade where technological progress and ease of entry is "extremely fast" and relatively low expected profits (by the same measure) for firms such as Seagate, Western Digital, Gateway, and SyQuest where underlying innovation is only "fairly fast." Could it be that the threat of future entry will keep well-funded, rational entrants out of these industries characterized by extremely rapid technological progress, and allow the incumbents to earn extraordinary profits over long periods of time while adopting technologies which are constantly a few months or years behind state-of-the-art?