# Too Big to Succeed or to Big to Fail?

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**Abstract**

It is often argued that large incumbent firms are less adept at innovation than smaller and younger firms because the former are less flexible and adaptable, encumbered with bureaucracy and so on. In this paper we argue that if larger firms, because of their size advantage, are better able to survive adverse shocks than smaller ones, then smaller firms may appear to be better at innovation even if size and the ability to innovate are unrelated.

**JEL Classification Numbers**:

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## 1. Introduction

Who is more likely to innovate, established incumbent firms or more recent entrants? Schumpeter argued that monopolies are more likely to innovate than more competitive firms. In the formal economic The question as to whether incumbents or new entrants have a greater *incentive* to innovate has been debated in the literature. According to one view (Gilbert and Newberry (1982), Schmalensee (1983), because innovation destroys some of the rents to older processes, incumbents have less of an incentive to invest than new entrants. A contrary view (Reinganum (1983)) is that incumbents' potential losses from entrants' innovation creates a motive for preemptive innovation[1]

A different approached argued by organizational theorists (e.g., Hannan and Freeman (1984), Tushman and Anderson (1986)) is that younger firms are more likely to be technologicaly innovative than incumbents because the latter are encumbered with more bureacracy, are less flexible and adaptable and so on. In an empirical industry study, Henderson (1993) finds evidence that established firms invest more than entrants in incremental innovation but their investment in radical innovation is less productive than that of entrants.

In many contexts, incumbency gives a competitive advantage over new entrants. Incumbents may have a technological advantage because of learning by doing, or have greater access to consumers by dint of a more established reputation, or becasue of consumer switching or search costs. In such cases, incumbents, becuase of their competitive advantage, may be able to better survive adversity than newer entrants. Thus, an incumbent which fails to adopt a new technology may have a better chance at surviving in the market than a new entrant that so fails. In that case, the data may *appear* to show that older/larger firms innovate less than younger/smaller firms even if the ability to innovate is actually unrelated

[1] See also Gilbert and Newberry (1984), Reinganum (1984), Salant (1984), Breshnahan (1985).

to age or size *per se*.

More specifically, suppose that due to their first mover advantage, incumbents have a larger customer base than new entrants and that initially all firms employ the same technology. Then a new technology becomes available, which reduces the production costs of those firms which are able to adopt it. Suppose further that the probability of successful adoption is unrealted to size or age, so that an equal proportion of larger incumbents and smaller entrants successfully innovate. Nevertheless, incumbent non adopters, because of their size advantage, are better able to survive such adversity than smaller entrants. Consequently, a greater proportion of *surviving* incumbents continue to employ the outdated, high cost technology while a greater proportion of small survivors adopt the more advanced technology. Thus, the data may seem to suggest that smaller/newer firms are more successful at innovation, when it may really be that small firms which failed to innovate simply exit and disappear from the data.

## 2. Model

Consider a market for a homogenous product which lasts for three periods. The product is launched at period 1 and at that period $W$ identical consumers (early adopters) enters the market. Each of these consumers demands at most one unit per period, for which she is willing to pay up to $\overline{p}$, which is thus the monopoly price. At period 2, $V$ new customers (late adopters) who are otherwise identical to period 1 customers, enter the market.

There is a continuum of identical potential firms (the measure of firms which actually enter the market is derived endogenously below). At any period, a firm must pay a fixed cost $F > 0$ to be operative. It can save the fixed cost by exiting. After paying the fixed cost, it can produce any number of units at a constant cost per unit at that period, where, as described below, the unit cost may vary over time and across firms.

Let $N_1$ denote the measure of firms which enter at period 1 and let $N_2$ be the measure of firms which enter at period 2. The eqm we derive is one in which firms' ex ante expected profit is zero. To economize on notation, I ignore the discount factor ( implicitly assume it's equal to 1), which has no meaningful effect on the analysis or results..

At periods 1 and 2 the only available technology is the 'high cost' technology, under which the unit cost is $c_h$, $c_h < \overline{p}$ . At period 3 a new technology, the 'low cost' technololgy, becomes available which reduces unit costs to $c_l < c_h$. For now assume that adoption of this technology is costless (later we extend the analysis to the case in when adoption requires costly investment) However, not all firms are successfull at adopting it. Specifically, at period 3, a firm successfully adopts the low cost technology with exogenous probability $\sigma < 1$, which is assumed to be independent of its size or age - and with probability $1 - \sigma$ its unit cost continues to be $c_h$. For computational convenience I set $\sigma = 0.5$ but nothing of substance depends on this. A firm learns its realized unit cost at the beginning of the period, before paying the fixed cost.

I adopt the consumer inertia model of Fishman and Robb (2003) to generate a size distribution of firms in which a firm's size is separate from its cost[2]. Consumers are imperfectly informed about prices - they know the price distribution at each period, but not which firm charges what price. At her first period in the market, (whether period 1 or period 2), a consumer is randomly and costlessly matched with a firm and observes its price. All such 'new' consumers are equally distributed between all firms which are active that period. A consumer can either buy from the firm with which she is initially matched, or reject it to search - i.e., select another firm at random. She can search an unlimited number of firms but each search costs $s > 0$. At subsequent periods, it is costless for a consumer to learn the price of and buy from the firm from which she bought at the preceding

[2]By contrast, in perfectly competitive markets, size is determined by production costs.

period, but she must incur search costs to find a new firm.

At each period a strategy for a firm is whether or not to pay the fixed cost or exit, and, if it decides to be operative, what price to charge. A strategy for a consumer is a search rule specifying which prices to accept and which to reject in favor of search. In equilibrium, firms' exit decisions and prices maximize expected discounted profits given the consumers' search rule and the consumer search rule maximizes their utility given firm strategies.

It is shown by Fishman and Robb (2003), following Diamond (1971), that the above assumptions imply:

**Proposition 2.1.** *At each period $t$, $t = 1, 2, 3$ the unique equilibrium price is $\overline{p}$.*

This implies that in equilibrium consumers buy from the firm with which they are first matched. Furthermore, since it is costless for a consumer to return to buy from a firm from which it has previously bought but is costly to search for a new one, and since all firms charge the same price, consumers stay 'locked in' with that firm at succeeding periods. We refer to those "locked in" customers as the firm's "customer base". Thus for as long as the firm remains active, it retains exclusive access to its customer base inherited from the preceding period (to which other firms do not have access). Thus a firm which enters the market after period 1 has no access to period 1 consumers and, similarly, a firm which enters after period 2 has no access to consumers which enter at either period 1 or period 2.

Importantly, since it is costly for consumers to search for a new firm and since the equilibrium price extracts all her surplus, if a consumer's original firm exits, she also 'exits' the market (stops consuming the product) rather than switch to a new firm. This greatly simplifies the analysis because the number of customers a firm has at period 3 and its profit per customer doesn't depend on the number of firms in the market. I discuss this further below...

We assume $W\overline{p} > F$. This implies that $N_1 > 0$; otherwise, a lone firm which enters at period 1 could earn positive profit by monopolizing the market. However, $N_2$ could be zero, as discussed below.

Let $\pi_h = \overline{p} - c_h$ and $\pi_l = \overline{p} - c_l$ be the profit per customer when the unit cost is ch and cl respectively. We shall normalize $\pi_h = 1$ and thus $\pi_l > 1$.

Consider a period 1 entrant. At period 1 its profit is $-F + \frac{W}{N_1}$. At period 2, if it doesn't exit, it retains its customer base from period 1 and in addition gets its equal share of the $V$ new consumers (which divide equally between all firms). Thus at period 2, if it doesn't exit, its profit is $\frac{W}{N_1} + \frac{V}{N_1+N_2} - F$. At period 3, if it doesn't exit, it has the same customer base (since no new consumers enter after period 2) and its profit per customer is either 1 or $\pi_l$ . Thus a period 1 entrant's total expected profit is:

$$V_1 = -F + \frac{W}{N_1} + \frac{W}{N_1} + \frac{V}{N_1 + N_2} - F + 0.5 \max\{0, \frac{W}{N_1} + \frac{V}{N_1 + N_2} - F\}$$

$$+0.5 \ \max\{0, \frac{\pi_l W}{N_1} + \frac{\pi_l V}{N_1 + N_2} - F\}$$

where the "0" in the max operator refers to the exit option.

Note that the preceding formulation implicitly implies that a period 1 entrant does not exit at period 2. Suppose it did exit. Then its profit from remaining operative at period 2, $\frac{W}{N_1} + \frac{V}{N_1+N_2} - F \leq 0$ and thus its profit at period 1, $F + \frac{W}{N_1} < 0$ as well, and thus its total expected profit from entry is negative, which cannot be the case in eqm. In eqm, $V_1 = 0$ :

$$V_1 = -F + \frac{W}{N_1} + \frac{W}{N_1} + \frac{V}{N_1 + N_2} - F + 0.5 \max\{0, \frac{W}{N_1} + \frac{V}{N_1 + N_2} - F\} \quad (1)$$

$$+0.5 \ \max\{0, \frac{\pi_l W}{N_1} + \frac{\pi_l V}{N_1+N_2} - F\}$$

By analagous reasoning, a period 2 entrant's expected profit is:

$$V_2 = \frac{V}{N_1+N_2} - F + 0.5\max\{0, \frac{V}{N_1+N_2} - F\} + 0.5\max\{0, \frac{\pi_l V}{N_1+N_2} - F\}.$$

If $N_2 > 0$, $V_2 = 0$:

$$V_2 = \frac{V}{N_1+N_2} - F + 0.5\max\{0, \frac{V}{N_1+N_2} - F\} + 0.5\max\{0, \frac{\pi_l V}{N_1+N_2} - F\} = 0 \quad (2)$$

The following lemma shows that period 2 entrants exit at period 3 if they remain high cost and don't exit if they become low cost.

**Lemma 2.2.** *If $N_2 > 0$, then high cost period 2 entrants exit at period 3 and low cost period 2 entrants do not exit at period 3. $\frac{V}{N_1+N_2} - F < 0$ and $\frac{\pi_l V}{N_1+N_2} - F > 0$*

*of: A high cost period 2 entrant exits at period 3 exits if and only if $\frac{V}{N_1+N_2} - F < 0$ and a low cost period 2 entrant exits at period 3 if and only if $\frac{\pi_l V}{N_1+N_2} - F > 0$. If $\frac{V}{N_1+N_2} - F \geq 0$, then (since $\pi_l > 1$), a period 2 entrant's expected profit $\geq 0.5\{\frac{\pi_l V}{N_1+N_2} - F\} > 0$, which cannot be the case in equilibrium. Similarly, if $\frac{\pi_l V}{N_1+N_2} - F \leq 0$, then a period 2 entrant's expected profit from entry $< 0$, which can't be in equilibrium. End proof.*

Thus, if $N_2 > 0$, (2) can be written:

$$V_2 = \frac{V}{N_1 + N_2} - F + \{\frac{\pi_l V}{N_1 + N_2} - F\} = 0 \tag{3}$$

substituing this into (1), gives:

$$V_1 = -F + \frac{W}{N_1} + \frac{W}{N_1} + 0.5 \max\{0, \frac{W}{N_1} + \frac{V}{N_1 + N_2} - F\} + 0.5\frac{\pi_l W}{N_1} = 0 \tag{4}$$

A fortiori, low cost period 1 entrants (which have a larger customer base and hence are more profitable) don't exit at period 3.

Consider high cost first period entrants. They dont exit if:

$$\frac{W}{N_1} + \frac{V}{N_1 + N_2} - F \geq 0 \tag{5}$$

In that case (4) becomes:

$$V_1 = -F + \frac{W}{N_1} + \frac{W}{N_1} + 0.5\{\frac{W}{N_1} + \frac{V}{N_1 + N_2} - F\} + 0.5\frac{\pi_l W}{N_1} = 0$$

Solving the preceding equation and (3) gives:

$$N_1 = \frac{W}{F}\frac{(0.5\pi_l + 2.5)(1 + \pi_l)}{0.75 + 1.5\pi_l} \tag{6a}$$

and

$$N_2 = \frac{1}{F}\{\frac{2}{3}V(1 + 0.5\pi_l) - \frac{W(0.5\pi_l + 2.5)(1 + \pi_l)}{0.75 + 1.5\pi_l}\} \tag{6b}$$

$N_2 > 0$ if the RHS of (6b) >0, i.e.,

$$V > [\frac{6\pi_l^2 + 36\pi_l + 30}{16\pi_l^2 + 15\pi_l + 6}]\ W \tag{6c}$$

Substituting (6a) and (6b) into (5) gives

$$\pi_l^3 + 2\pi_l^2 - 8.5\pi_l - 8 < 0 \tag{7}$$

where the preceding inequality obtains iff $\pi_l < 2.5542$. Thus:

**Lemma 2.3.** *An eqm in which $N_2 > 0$, high cost second period entrants exit and high cost first period entrants don't exit exists if*

$$1 < \pi_l < 2.5542$$

*and (6c) obtains.*

Now consider equilibria in which high cost first period entrants do exit. This is the case if:

$$\frac{W}{N_1} + \frac{V}{N_1 + N_2} - F < 0$$

in which case (4) becomes:

$$V_1 = -F + \frac{W}{N_1} + \frac{W}{N_1} + 0.5\frac{\pi_l W}{N_1} = 0 \tag{8}$$

Solving the preceding equation and (3) gives :

$$N_1 = \frac{W}{F}\frac{(4 + \pi_l)}{2} \tag{9a}$$

$$N_2 = \frac{1}{F}\{\frac{V(2 + \pi_l)}{3} - \frac{W(4 + \pi_l)}{2}\} \tag{9b}$$

Substituting into (8) gives

$$\pi_l^2 + \pi_l - 8 > 0 \tag{2.1}$$

which obtains iff $\pi > 2.37$

Thus there is an eqm in which $N_2 > 0$ and all high cost firms exit iff

$$\pi > 2.37$$

and the RHS of (9b)>0, i.e.,

$$V > \frac{4+\pi}{2(2+\pi)}W \tag{9c}$$

**Proposition 2.4.** *If* $1 < \pi < 2.37$ *and* $\frac{V}{W} > \max\{\frac{12+3\pi}{10-4\pi}, \frac{5+\pi}{1+\pi}, \frac{6\pi_l^2+36\pi_l+30}{16\pi_l^2+15\pi_l+6}\}$, *there is a unique eqm in which there is entry at both periods 1 and 2, high cost period 2 entrants exit at period 3 and high cost period 1 entrants dont exit.*

***Proof***- *We've already seen that if* $N_2 > 0$ *and* $1 < \pi < 2.37$*, then in eqm high cost period 1 entrants don't exit. To prove the proposition it remains to show that if* $\frac{V}{W} > \max\{\frac{12+3\pi}{10-4\pi}, \frac{5+\pi}{1+\pi}, \frac{6\pi_l^2+36\pi_l+30}{16\pi_l^2+15\pi_l+6}\}$*, then* $N_2 > 0$.

If $N_2 = 0$ then

$$\frac{V}{N_1} - F + 0.5\max\{0, \frac{V}{N_1} - F\} + 0.5\{\frac{\pi_l V}{N_1} - F\} \leq 0 \tag{11}$$

where the LHS of the preceding inequality is the expected profit of a period 2 entrant which must be $\leq 0$ if there is no entry at period 2. (11) implies that $\frac{V}{N_1} - F < 0$, and thus that $N_2 = 0$ implies:

$$\frac{V}{N_1} - F + 0.5\{\frac{\pi_l V}{N_1} - F\} < 0 \tag{12}$$

If $N_2 = 0$, (1) becomes:

$$\frac{W}{N_1} - F + \frac{W+V}{N_1} - F + 0.5\max\{0, \frac{W+V}{N_1} - F\} \tag{13}$$

$$+0.5\{\frac{\pi_l W}{N_1} + \frac{\pi_l V}{N_1} - F\} = 0$$

If high cost first period entrants don't exit at period 3, then $\frac{W+V}{N_1} \geq F$ and if they do exit, $\frac{(W+V)}{N_1} < F$ .

Under the former scenario, solving 13 gives:

$$N_1 = \frac{2.5\ W + 1.5\ V + 0.5\pi_l\ W + 0.5\pi_l V}{3F} \tag{14}$$

Substituting in (12) gives

$$V < \frac{5+\pi}{1+\pi} W$$

Similarly, if high cost first period firms do exit:

$$V < \frac{12+3\pi}{10-4\pi} W$$

Thus, an equilibrium in which $N_2 = 0$ can only exist if

$$V < \max\{\frac{12+3\pi}{10-4\pi} W,\ \frac{5+\pi}{1+\pi} W\} \tag{2.2}$$

Recall from lemma...that if $1 < \pi < 2.37$, an eqm in which $N_2 > 0$ and high cost period 1 entrants don't exit exists if $V > [\frac{6\pi_l^2+36\pi_l+30}{16\pi_l^2+15\pi_l+6}]\ W$ . Thus if $\frac{V}{W} > \max\{\frac{12+3\pi}{10-4\pi},\ \frac{5+\pi}{1+\pi}, \frac{6\pi_l^2+36\pi_l+30}{16\pi_l^2+15\pi_l+6}\}$, $N_2 > 0$ in eqm. This completes the proof.

Thus, under the conditions of the preceding proposition, there is entry at both periods, all period 1 entrants - the larger incumbents - survive at period 3 while only low cost period 2 entrants - the smaller and later entrants - survive. Thus, at period 3 all the younger/smaller firms - are low cost while only half the larger/older are low cost. Thus, ignoring exit data, the data may seem to suggest that smaller, more recent entrants are more likely to innovate than incumbents , when in fact size or age has no effect - rather, in our example, incumbents are able to survive even as high cost firms because of theri competitive size advantage, while smaller high cost firms are not. Thus the researcher who has no access to exit data might erroneously conclude that smaller firms innovate with higher probability.

This intuition would seem to apply whenever earlier entry confers a competitive advantage, be it size (number of customers), as in our example, or other advantages, like learning by doing.

In particular, the analysis of our example has been greatly facilitated by the assumption that the customers of exiting firms are not absorbed by surviving firms. This implies that a firms profit from not exiting does not depend on how many other firms exit and therefore also implies that either all high cost firms of the same vintage either exit or survive. This feature does not hold in a richer setting, in which surviving firms do inherit exiting firms customers. Then, it can be the case that some high cost firms of the same vintage exit while the others, which grow in size by inheriting the exiters customers, survive as larger firms. Then we would still get that a higher proportion of high cost older firms survive, but the outcome might be more nuanced −not that all high cost firms of the same vintage surive, but that a higher proportion of those firms survive than the proportioin of high cost smaller firms. Surprisingly, analyzing such a model turns out to be several orders of magnitute more complicated than the simple example weve analyzed.