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Endogenous shakeouts☆

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ABSTRACT

Most new industries feature a shakeout, i.e. a short burst of entry soon followed by rapid exit of most early entrants. Yet, the speed, magnitude and timing of shakeouts are somewhat puzzling from the perspective of conventional entry models. In this paper, we argue that shakeouts are likely to occur as a result of the stochastic dynamics of the entry process, when firms are uncertain about their competitors' decision to enter. We show that the magnitude of such "endogenous" shakeouts can be quite large and sudden, in particular in highly competitive industries or markets with low-investment cost, low impatience and high liquidation values.

Perhaps one of the most controversial phases in the lifecycle of an industry is its early infancy. Along its first years or decades of existence, an industry typically exhibits rapid entry, soon followed by exit of the vast majority of first-phase entrants. This tumultuous phase has been described as a "shakeout" and is prevalent across time and industries (Simons, 1995; Horvath et al., 2001; Klepper and Simon, 2005). As an example, 105 firms entered the US television industry between 1946 and 1949; after this date, the number of firms steadily declined with entry close to zero (an average of one entrant every 2 years) since 1956 and exit peaking in 1948–1949 with a combined total of 88 firms exiting. Similar patterns have been documented in other industries such as, among other examples, the automobile, tire, radio, beer brewing and penicillin industries.[1]

Shakeouts are somewhat puzzling from the perspective of classical industrial organization. In the conventional view, firms enter or exit in the light of technological innovations or new information about their demand or cost (see, among others, Ericson and Pakes, 1995; Amir and Lambson, 2003). These contributions are essential for a proper understanding of stable or mature industries; however, what is problematic with shakeouts is the sheer magnitude of the reversal in net entry, one that is predictable and unique in the life of the industry; even more surprisingly, this reversal occurs before demand or even production technologies are well-settled.

In this paper, we develop a parsimonious rationale for shakeouts: in our model, a combination of entry followed by abrupt exit can occur within a very short span of time and in the absence of new fundamental information. The key to our approach is the idea that firms, when they make their decision to enter, are uncertain about whether other potential entrants will also enter. Following Shapiro and Dixit (1986), we capture this uncertainty by solving for the symmetric equilibrium of the entry game, in which firms enter with a given probability—endogenously pinned down in the model—and, as a result, the number of entrants is stochastic.[2] Because decisions to enter

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[1] These figures, as well as additional data on the automobile and tire industry, can be found in the data set used in Klepper (2002) and shared by the author.

[2] Note that the game has also many pure-strategy equilibria. In their monograph, Dixit and Shapiro (86, p.63–64) argue that these pure-strategy equilibria are unable to capture market structure in environments in which potential entrants are relatively similar: "This model has the advantage of simplicity, but suffers from many shortcomings. First, the selection mechanism is exogenous, and does not have a realistic counterpart. There may be circumstances where a selection rule arises from asymmetries among firms, such as an advantage in timing, or at least in making a public and binding commitment to enter. If there are such differences, they should be included in the structure of the game. Often, however, such differences either do not exist or cannot be observed, and each firm must decide in ignorance of the others' choices (...). The second problem is that the selected firms can make a positive profit while the others do not. Then each will have an incentive to buy the privilege of selection. This creates a new game, involving "bribery" of the selection mechanism, with similar problems with regard to its equilibrium. Finally, the industry settles into a static equilibrium a profits of pioneers, or excessive entry, such as we often see in reality."

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are independent across firms, the market may feature excess entry with positive probability.[3] Then, conditional on excess entry, firms exit in the following period, recovering the scrap value of their initial investment.

In summary, we argue that shakeouts may correspond to a form learning, but one that is driven by learning about the strategic decisions of competitors. We label these shakeouts as "endogenous" because they are induced by strategic interactions between firms and not, as in standard theories, by learning about or changes to exogenous economic fundamentals.

1. Related literature

Existing work on shakeouts falls into three broad classes of models, of which we give several representative examples. The first strand of models focuses on shakeouts caused by exogenous changes to the industry in its early stages. This approach includes, among others, Jovanovic and MacDonald (1994) and Horvath et al. (2003). The first paper assumes that some of the entrants obtain access to a superior technology. The second paper argues that changes to the profitability of the industry may cause shakeout-like exit of the least efficient entrants. A second strand of models assumes that entrants learn about characteristics of the industry. As an example, Barbarino and Jovanovic (2007) assume that the demand curve is initially unknown and the point at which entry is unprofitable becomes known only after excess entry has occurred, leading to a sudden market crash. Finally, a third set of papers focuses on shakeouts induced by externalities among firms in the industry. In a recent paper, Plehn-Dujowich (2008) shows that shakeouts can occur if the production technology is subject to a mean-reverting externality of the average technology in the industry (e.g., via the labor force or technology spillovers). Other papers that focus on shakeouts driven by externalities include Hopenhayn (1993) and Utterback and Suarez (1993), who argue that shakeouts may occur as a result of a coordination on a dominant design.

Our approach is different from these models, in that shakeouts are not caused by changes to (or learning about) the profitability of the industry. One advantage of our approach is that the amount of learning may be small over the relatively small period of time during which the shakeout occurs. Our methodology is more closely related to a few papers analyzing the consequences on market structure of strategic uncertainty, although not in the context of shakeouts; these papers are summarized in the table below.

	Dixit and Shapiro (86)	Sharkey and Sibley (93)	Elberfeld and Wolfstetter (99)	Cabral (04)	This paper
Nb. Firms	Any N	Any N	Any N	$N=2$	Any N
Welfare	No	Yes	Yes	No	No
Competition	Simulations	Bertrand	Bertrand	Any	Any
Exit	No	No	No	No	Yes
Dynamics	Simulations	No	Yes	Yes	Yes

The most closely related work to ours is Shapiro and Dixit (1986). Our paper shares with their monograph the basic premise.[4] They provide only one analytical result, comparing the number of entrants in the pure equilibria and the expected number of entrants in the symmetric equilibrium. Although they provide an extension to the dynamic case, their analysis is numerical and illustrative. In a one-shot model, Sharkey and Sibley (1993) analyze a Bertrand competition game with simultaneous choice of entry and prices and find that the resulting distribution of prices can be at odds with either marginal pricing or monopoly pricing. Two other papers focus on productive efficiency and welfare in the presence of strategic uncertainty. Elberfeld and Wolfstetter (1999) analyze the symmetric equilibrium under repeated Bertrand competition, and show that a greater number of potential entrants monotonically decrease welfare. Cabral (2004) analyzes a two-player version of our setting, and derives conditions under which a regulator may find it beneficial to subsidize or tax the industry, in part to relieve inefficient equilibrium entry. Finally, empirically, Klepper and Miller (1995) analyze how entry/exit dynamics in the early stages of an industry, as described earlier, can be explained by some form of coordination failure, with varying degrees of success.

2. Introductory model

To make the main intuitions of the model transparent, we present first a simplified one-period version of the model. In this section, our objective is to show how excess entry can arise endogenously and whether the magnitude of excess entry can be explicitly characterized as a function of the market's potential profitability. We delay until the next section the dynamic model in which firm's exit decisions and the resulting shakeout are explicitly modeled.

There is a new industry with $n>1$ risk-neutral identical potential entrants. Potential entrants decide simultaneously whether or not to make a fixed investment for a cost $\Gamma\in(0,\Pi_1)$, where $\Pi_1>0$ represents the monopoly profit in the industry.[5] When deciding not to make the investment, the firm stays out of the market and makes zero profit. For now, we assume standard price competition so that $\Pi_k=0$ for all $k\geq 2$.

The game has exactly n pure-strategy Nash equilibria, in which one firm (say firm i) enters and all other potential entrants stay out. However, these equilibria are not very appealing in the context of a new industry. As previously noted by Shapiro and Stiglitz (1984), firms that make their entry decisions in isolation (and would have an interest in claiming that they are the entrant) could not credibly or feasibly communicate that they are entering. We focus here on the symmetric equilibrium of the game, which is unique and does not have this limitation.

Let $p\in(0,\ 1)$ denote the probability that each firm enters, conditional on n potential entrants. Conditional on entering, a firm achieves an expected profit equal to its probability of becoming a monopoly minus the investment cost Γ. In equilibrium, this profit must be equal to the expected profit when staying out, which is equal to zero. This leads to the following equilibrium condition:

$$(1-p)^{n-1}\Pi_1-\Gamma=0 \tag{1}$$

Solving for p yields:

$$p=1-\left(\frac{\Gamma}{\Pi_1}\right)^{\frac{1}{n-1}} \tag{2}$$

In the symmetric equilibrium of the entry game, each firm stays out with probability $\left(\frac{\Gamma}{\Pi_1}\right)^{\frac{1}{n-1}}$. As intuitive, this probability is increasing in the cost of entry Γ and decreasing in the profitability of the market Π_1 and the number of potential entrants n. Ex-post, the number of entrants, denoted M_n, is a Binomially-distributed random variable $\mathcal{B}\left(n,1-\left(\frac{\Gamma}{\Pi_1}\right)^{\frac{1}{n-1}}\right)$ with success rate $1-\left(\frac{\Gamma}{\Pi_1}\right)^{\frac{1}{n-1}}$.

[3] Note that we do not actually mean that firms throw a dice: a firm may be deterministically entering from its perspective, but this decision may be uncertain from the perspective of a competitor (see Rubinstein, 1991, p.912–915). Another rationale for mixed strategies is that they can often be purified, i.e. the distribution that they generate can be interpreted as the limit of pure strategies of a problem with a small amount of asymmetric information (Harsanyi, 1973).

[4] The authors provide an extensive discussion of the pros and cons of pure versus mixed-strategy equilibria, which we only selectively quoted here. We urge the interested reader to refer to their work for a more comprehensive discussion.

[5] If entry is sequential, the equilibrium number of entrants will coincide with the pure-strategy equilibrium of the game. However, in many settings, there is no clear rule as to which firms should move first or wait. More generally, credibly disclosing entry is not instantaneous and should require a certain time lapse (e.g., time to commit to invest).