Technology Choice in Dynamic Competition

Competition among firms is one of the main drivers of innovation and improvement of consumer welfare. Many such competitions take the form of a winner-takes-all contest, where the firm with a better or more innovative product dominates the market. The pharmaceutical industry offers a good example: firms innovate to develop new drugs and the drug with the best performance beats the competition and receives a significant market share.

Innovation, of course, is a highly uncertain process: firms experiment with different approaches and these approaches lead to (stochastically) different outcomes. The choices of which approaches to use—which, in turn, are affected by the available technologies and the competitive environment—are vital to the firm’s competitive edge and market performance.

This paper considers how firms choose their technologies over time in winner-takes-all competitions. Technologies are characterized by uncertain returns, with some technologies being riskier than others. Firms compete over a finite horizon by choosing which technologies to use over multiple periods, and the firm that develops a better product by the end of the horizon wins. In particular, we consider settings where new technologies become available and study the impact of these technologies on competition and consumer welfare.

An example of new technology introduction in the pharmaceutical industry is the development of combinatorial chemistry, which has made it exponentially easier to evaluate the efficacy of different antibiotics. The technology relies on efficiently combining different chemical compounds that are known to target specific bacteria and to test the effectiveness of these new compounds to see if there is a new combination with higher efficacy. The introduction of this technology has reduced the risks associated with new drug development and made it easier to produce better and more effective drugs on average. In our setup, we will refer to a technology like combinatorial chemistry as a safe technology and to the old technology (i.e. the technology that existed before the introduction of this safe technology) as a risky technology.

This paper answers the following questions in the context of new technology introduction into a competitive environment. First, how do firms choose which technologies to use over time in order to maximize their chances of winning the competition? Second, how does the interaction between competition and new technology introduction affect consumer welfare? Finally, we are also
interested in how information impacts the answers to the previous two questions. In particular, we are interested in how firms make their choices if their experimentation outcomes are publicly vs. privately observable, and how consumer welfare changes under these two scenarios.

The focus of this paper is on how competitors select risk levels through their choices of technologies. Because technologies have different risk profiles (i.e. different means and variances), the problem can be viewed as one where firms select risk levels over time in order to maximize their chances of winning. Gaba et al. (2004) starts with a multi-player one-stage contest where only a single player is allowed to make choices between two technologies with the same means but different variances. We extend this model by allowing the players to choose among different technologies with different means and variances and to do so over more than one period.

Tsetlin et al. (2004) numerically studies the strategic choice of variability in multi-round contests where players have access to different normal distributions with the same means but different variances and the firms compete over cumulative results. Our paper analytically analyzes the firms’ strategies for a large class of distributions when the maximum result, i.e. the value of the best innovation, over the entire horizon is what matters.

The previous papers attempt to characterize the players’ strategies but do not address the problem from a planner’s perspective: how can a planner design these competitions so that the experimentation choices of players maximize the expected outcome? Erat and Krishnan (2012) considers the design of a static contest where a firm delegates the search for the best technology to a group of agents. They find that the competitive structure leads to an inefficiency where players cluster around a small subset of the available technologies and leave a large space of technologies unexplored. Konrad (2014) shows that introducing local competition is helpful to solve the clustering problem, but similar to Erat and Krishnan (2012), again considers a single stage competition with the main goal of increasing the breadth of the search rather than considering the risk-taking behavior.

Because we consider the problem in a dynamic setting, the role of information becomes an important design lever. Firms behave differently if they know their competitors’ interim results compared to when they do not. We examine both of these cases, when firm’s experimentation outcomes are public and private information, and relate how the expected outcome changes as a function of the information disclosure regime and the risk profiles of the available technologies.

**Contribution.** The paper makes the following contributions by answering the questions laid out earlier in the introduction. First, we analytically characterize the players’ strategies and technology choices for a general class of distributions and show how these choices differ under both the public and private information regimes.
We then use this characterization to determine how consumer welfare changes under the introduction of a new technology like combinatorial chemistry. We find that these improved technologies can lead to a reduction in consumer welfare in both the public and private information competition. While this is somewhat surprising, it is aligned with empirical observations from the pharmaceutical industry: Bennani (2011) points out that one possible reason for the decrease in effectiveness of truly new drugs is that firms and researchers tend to be more conservative in the process of drug discovery, opting for technologies that produce more effective drugs on average instead of taking a chance with a technology that might produce a very effective drug but also carries with it a higher chance of failure (and consequently, of losing the competition).

We then investigate the impact of different information disclosure regimes. We show that when the risky technology is variable enough, making information private until the end of the competition could help decrease the loss incurred by introducing the safe technology. We also show that these results extend to competitions with multiple players when all players have the same technology and a new technology becomes available to a single player.

Finally, we show how a social planner can use intermediate awards (prizes given to the leader in the middle of competition) as a tool to implement an information disclosure rule that increases consumer welfare, and we provide an optimal mechanism to achieve this implementation.

References


