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RESEARCH STATEMENT

My research studies firms’ behavior and its implications for society in the markets where firms have to continuously invest into building and maintaining their competitive advantage.

Many rapidly growing firms in modern industries lose money for years; some succeed in becoming starts of the new economy, like Amazon or Facebook, and some don’t. This protracted period of initial losses is typically necessary to build up the critical mass of customers, perfect the technology or business process, or develop other form of competitive advantage. Moreover, a successful firm cannot rest on its laurels as rivals will try to emulate its success, requiring the firm to invest continuously into maintaining its market position—Microsoft and Apple regularly release new versions of their products. On one hand, such continued progress benefits the society in general. On the other hand, the need for such extensive investment could discourage entry and even enable market leader to force rivals out of the market, raising the concern about reduced competition.

Continuous investment into building and maintaining a competitive advantage is an inherently dynamic phenomenon, and cannot be adequately described by simple models like two-period invest-and-compete game, or a patent race. Due to this, these industries are often poorly understood by anti-trust regulators or researchers in other fields.

My research uses a more realistic approach to modeling such industries: the Dynamic Stochastic Games (DSG), using the modeling framework of (Ericson & Pakes 1995) that had spawned a substantial literature within the Industrial Organization field. These models have the flexibility of unlimited time horizon, multiple levels (or a continuous scale) of competitive advantage, as well as exit and entry, depreciation of competitive advantage, and other features. Industry structure and firms’ levels of competitive advantage are fully endogenous and are determined by the Markov-Perfect Equilibrium of the game.

A Dynamic Stochastic Game—like any game—can have multiple equilibria. This poses a problem for both theory and estimation, a set of parameter values does not lead to a unique prediction about firms’ behavior or its outcome. Multiplicity also has nontrivial implications for policy: on one hand, nudging the industry towards a more beneficial equilibrium becomes a new policy option; on the other, a policy can lead to several possible outcomes, some more favorable than others. In part due to my work, researchers can no longer ignore multiplicity; a popular approach is to impose some kind of equilibrium selection rule, which might or might not be justified in the context of the model. Instead, I treat multiplicity as an integral
feature of the industry, and incorporate it into my analysis. For example, in [2], the industry can have equilibria leading to either duopoly or monopoly; certain policies can eliminate a number of monopoly-inducing equilibria, but they also worsen the welfare of the duopoly outcome.

As DSG models are rarely tractable, I employ the existing numerical methods, and develop new ones. My contribution is an implementation of the homotopy path-following method (Watson et al. 1997), which lets me compute multiple equilibria in a systematic way. Moreover, homotopy lets me compute the equilibria that would elude conventional methods, which are often variants of (Pakes & McGuire 1994), and require local stability to converge. Finally, I have developed methods that automate computation of solutions for hundreds and even thousands of parameterizations, spanning full range of values for every parameter of interest, and thus overcoming the traditional criticism that computational results are limited to a few isolated parameterizations. I have introduced the homotopy method to the DSG community in [4]; I always make my code publicly available and make an effort to help others implement it. As a result, homotopy has been applied by other researchers: (Besanko et al. 2010a, Besanko et al. 2010b, Abito et al. 2012).

Below I present five of my papers (grouped by research program), as well as my plans for future research.

1 Price as investment: learning-by-doing

The bulk of my research is dedicated to industries where current sales translate into a future advantage for the firm, making price take on the role of an investment. One example of that is learning-by-doing (LBD), defined as marginal cost of production decreasing with cumulative experience. Another example is network externalities making the value of a product proportional to the existing customer base. Similar argument can be made for switching or adjustment costs. While this research program focuses on LBD, its insights apply to any industries where price serves as investment.

I started investigating LBD in the paper entitled ‘Learning-by-doing, organizational forgetting, and industry dynamics’, coauthored with David Besanko, Ulrich Doraszelski and Mark Satterthwaite, published in Econometrica in 2010, and referred to as [1]. Learning-by-doing is well-documented (Wright 1936, Alchian 1963, Irwin & Klenow 1994), and is commonly associated with industry dominance (Cabral & Riordan 1994), since the firm with the most experience (the market leader) has the lowest cost, and can use it to underprice the less experienced follower firm(s), denying them opportunities to learn. Organizational forgetting (OF) refers to loss of experience as the result of inactivity, evidenced by (Argote, Beckman & Epple 1990, Benkard 2000). In [1], I find that instead of
negating learning-by-doing, organizational forgetting can amplify its effects, and give rise to long-term market dominance and extremely aggressive price competition to become the leader. Furthermore, OF can lead to multiplicity: the dominance-inducing equilibria can coexist with solutions that lead to symmetric market shares in the long term, and almost no competition for leadership. Finally, in certain cases, cost leader uses aggressive pricing to keep the follower firm from ever moving down the learning curve. This was reminiscent of predation, and served as motivation for the next paper in this research program.

Study of predation in the LBD context is the primary goal of my paper entitled ‘Efficiency or predation: What drives pricing behavior when there is learning-by-doing?’, which is coauthored with D. Besanko and U. Doraszelski, published in American Economic Review in 2014, and referred to as [2]. The model of this paper combines learning-by-doing with well as exit and entry. There is no organizational forgetting, both to give the follower its best chance at survival, and to keep model features to a minimum necessary to investigate predation, which is informally defined as a reduction in price that is intended to eliminate a competing firm from the market, and is otherwise unprofitable.

Economists have devoted much attention to predation (Ordover & Willig 1981, Cabral & Riordan 1997), but formally defining it is particularly challenging in industries with other intertemporal trade-offs such as learning-by-doing or network effects. A firm may set a low price to improve its cost position or customer base over time, and not necessarily to eliminate competitors. The resulting tension between predatory pricing and mere competition for efficiency often comes to the fore when predation is alleged, e.g. during the “semiconductor wars” between the U.S. and Japan in the 1970s and 1980s.

In [2], I establish the widespread existence of equilibria involving a behavior that resembles conventional notions of predatory pricing in the sense that aggressive pricing is present, and is associated with the exit of the weaker firm, turning the market leader into a monopolist. The prevalence of such predation-like behavior challenges the view (popularized by the Chicago School) that economic theory can rarely rationalize predatory pricing. Moreover, I show that equilibria involving predation-like behavior can often coexist with equilibria involving much less aggressive pricing and no exit. Which equilibrium is being played depends on firms’ expectations regarding the evolution of the industry. Creating a business environment in which firms anticipate that predatory pricing “does not work” can thus be a powerful tool for competition policy.

To disentangle predatory pricing from mere competition for efficiency on a learning curve I decompose the equilibrium pricing condition into terms reflecting current profitability, building up competitive advantage of the pricing firm, and denying the rival firm a chance to gain advantage for itself. This decomposition lets me characterize firm’s predatory pricing incentives, and measure their impact on industry structure, conduct, and perfor-
formance. A policy-like intervention forcing each firm to ignore the predatory incentives in its price-setting can have a nontrivial impact, a large part of which stems from eliminating equilibria with predation-like behavior. Along with the predation-like behavior, however, a fair amount of competition for the market is eliminated. A competition authority thus has to carefully balance the negative impact from predation-like behavior on competition in the market in the long run with the positive impact on competition for the market in the short run, as the net effect can be both negative and positive.

The difficulty of conclusively demonstrating the negative effect of predation-like behavior in [2] suggested that eventual monopolization of the industry is not necessarily inefficient. I investigate this further in ‘Is Dynamic Competition Socially Beneficial? The Case of Price as Investment’, a working paper coauthored with D. Besanko and U. Doraszelski, and referred to as [3]. In it, I note that sales translate into some form of competitive advantage, turning low price into a form of investment. Existing literature is not clear on whether the investment role of price would benefits or hurts the overall welfare, as there are a number of economic forces at work. For example, while firms to have the incentives to move down the learning curve, succeeding at doing so enables a firm to drive its rival out of the market.

In [3], I solve the first-best problem for model of [2] and study the deadweight loss that it implies. Confirming the motivating conjecture, the first-best outcome is likely (but not certain) to have no more firms than the market equilibrium, suggesting that concentration is indeed efficient in many cases. The resulting deadweight loss appears small in the sense that eliminating the investment motive from pricing decision leads to a much worse outcome. Moreover, eliminating price competition has a similar effect, and eliminating both competition and investment role of price leads to even larger losses. I conclude that competition and dynamic incentives generated by the investment role of price are two equally important and distinct economic forces that both work to improve efficiency of the market outcome by a substantial degree. Further investigation into the components of deadweight loss shows that while pricing distortions are the key driver of it, they are partially offset by more beneficial industry structure, as the equilibrium often keeps more firms in the market than the first-best solution. While this does cause some war-of-attrition losses from duplicated effort, it benefits the industry in the long term.

The work on this paper is ongoing, as explained in Section 3 below.

2 Direct investment: quality ladder

While learning-by-doing has price driving both current profits and future benefits, I am also interested in investment decisions that are separable from the current profit. I started
investigating such investment in the paper entitled ‘A user’s guide to solving dynamic stochastic games using the homotopy method’, coauthored with Ron Borkovsky and Ulrich Doraszelski, published in *Operation Research* in 2010, and referred to as [4]. This paper aims to make the homotopy method accessible to DSG community: it discusses the theoretical foundations of homotopy and uses it to find multiple equilibria in two example models; the code is made public, along with instructions on adapting it to reader’s own problem. The first example was the LBD-OF model of [1], while the other is a simplification of the quality ladder model of (Pakes & McGuire 1994). To my surprise, even that simple model revealed a non-monotone relationship between model parameters and industry concentration, along with several instances of multiple equilibria.

This warranted further study, which I undertook in the paper entitled ‘A dynamic quality ladder model with entry and exit: Exploring the equilibrium correspondence ...’, which is coauthored with R. Borkovsky and U. Doraszelski, published in *Quantitative Marketing and Economics* in 2012, and referred to as [5]. In it, I take an in-depth look at the (Pakes & McGuire 1994) model, which has been widely used as a template for dynamic models of investment, but has never had its equilibrium behavior fully characterized for all the possible combinations of the key parameters of the model. In the model, forward-looking oligopolistic firms compete with each other in the product market and through their investment, as well as the entry and exit decisions. By investing in the present a firm hopes to increase the quality of its product—and thus profits—in the future, while its rival is doing the same.

I find that the more costly and/or less beneficial it is to achieve or maintain a given quality level, the more a leader invests in striving to induce the follower to give up; the more quickly the follower does so; and the more asymmetric is the industry structure that arises. Also, the possibility of entry and exit gives rise to preemptive and limit investment. The latter, is the additional expense by a stronger firm (or monopolist) intended to prevent a weaker rival from trying to catch up. Likewise, limit investment by a monopolist attempts to discourage a potential entrant.

Finally, I investigate the potential for existence of multiple equilibria, which was alluded to in (Pakes & McGuire 1994) but never fully explored. I do find multiplicity, some of which involves exit and entry, such as an industry with an outdated monopolist that can remain as it is, or see a more modern entrant take over the market. Still, the impact of multiplicity is fairly minor in the sense that (A) multiple equilibria arise only for a small subset of parameter space, (B) the differences between multiple equilibria are limited to a few states that might not even be visited by many equilibrium paths, and (C) are not likely to affect long-term industry outcome even if they were visited: in the presented example, industry ends up as monopoly under either scenario.
While this result seems anti-climactic, it does provide an important insight that multiplicity might not be a major concern in the basic quality ladder model. This enables papers like (Samano & Santugini 2015) and (Goettler & Gordon 2014) to study expansions of this basic model without worrying about multiplicity, or at least with lower chance of it (since my research shows that additional model features could generate multiple equilibria).
References to own work


Other references

[1]


