Dynamic Oligopoly Models: From Tirole's Foundations to Empirical Applications

Jaap H. Abbring

TILBURG UNIVERSITY

Symposium honoring Jean Tirole
ACM, The Hague
December 9, 2014

Policy Analysis in Imperfectly Competitive Markets

Dynamics are important ...

- Uncertainty, sunk costs, and option values
- Entry, competition, and exit
- Mergers
- R&D and other investments
- Commitment
- ...

Policy Analysis in Imperfectly Competitive Markets

Dynamics are important ...

- Uncertainty, sunk costs, and option values
- Entry, competition, and exit
- Mergers
- R&D and other investments
- Commitment
- ...

... but hard to handle

- General dynamic games have many equilibria (solutions) that are hard to characterize and compute

Ongoing research rooted in Tirole's work may one day bring the econometrics of dynamic oligopoly models to The Hague

Tirole's Foundations

Econometrica, Vol. 56, No. 3 (May, 1988), 549–569

A THEORY OF DYNAMIC OLIGOPOLY, I: OVERVIEW AND QUANTITY COMPETITION WITH LARGE FIXED COSTS

BY ERIC MASKIN AND JEAN TIROLE[1]

The paper introduces a class of alternating-move infinite-horizon models of duopoly. The timing is meant to capture the presence of short-run commitments. Markov perfect equilibrium (MPE) in this context requires strategies to depend only on the action to which one's opponent is currently committed. The dynamic programming equations for an MPE are derived.

The first application of the model is to a natural monopoly, in which fixed costs are so large that at most one firm can make a profit. The firms install short-run capacity. In the unique symmetric MPE, only one firm is active and practices the quantity analogue of limit pricing. For commitments of brief duration, the market is almost contestable. We conclude with a discussion of more general models in which the alternating timing is derived rather than imposed.

Our companion paper applies the model to price competition and provides equilibrium foundations for kinked demand curves and Edgeworth cycles.

KEYWORDS: Markov perfect equilibrium, short-run commitment, reaction, natural monopoly, contestability, endogenous timing.

Tirole's Foundations

Markov perfect equilibrium (MPE)

Restricts firms' (entry, investment, ...) strategies to depend on small number of "payoff-relevant" state variables

- Comparatively "simple" (yet rational) behavior
- Focus on dynamic effects of interest
- Clearer predictions

Tirole's Foundations

Markov perfect equilibrium (MPE)

Restricts firms' (entry, investment, ...) strategies to depend on small number of "payoff-relevant" state variables

- Comparatively "simple" (yet rational) behavior
- Focus on dynamic effects of interest
- Clearer predictions

How does this help the applied researcher?

In MPE, each firm solves a Markov decision problem given other firms' strategies

- Theory, computational methods, and econometrics for such decision problems can be applied

A First Step towards Application

Review of Economic Studies (1995) **62**, 53–82 0034-6527/95/00030053$02.00
© 1995 The Review of Economic Studies Limited

Markov-Perfect Industry Dynamics: A Framework for Empirical Work

RICHARD ERICSON
Columbia University

and

ARIEL PAKES
Yale University and NBER

First version received March 1990; *final version accepted July* 1994 (*Eds.*)

This paper provides a model of firm and industry dynamics that allows for entry, exit and firm-specific uncertainty generating variability in the fortunes of firms. It focuses on the impact of uncertainty arising from investment in research and exploration-type processes. It analyses the behaviour of individual firms exploring profit opportunities in an evolving market place and derives optimal policies, including exit, in this environment. Then it adds an entry process and aggregates the optimal behaviour of all firms, including potential entrants, into a rational expectations, Markov-perfect industry equilibrium, and proves ergodicity of the equilibrium process. Numerical examples are used to illustrate the more detailed characteristics of the stochastic process generating industry structures that result from this equilibrium.

Applications Exist ...

Table 30.4
Applications of EP's framework

Application	Paper(s)
Advertising	Doraszelski and Markovich (2006), Dube, Hitsch and Manchanda (2005)
Capacity accumulation	Besanko and Doraszelski (2004), Ryan (2005), Beresteanu and Ellickson (2005)
Collusion	Fershtman and Pakes (2000, 2005), de Roos (2004)
Competitive convergence	Langohr (2003)
Consumer learning	Ching (2003)
Firm size and growth	Laincz and Rodrigues (2004)
Learning-by-doing	Benkard (2004), Besanko et al. (2004)
Mergers	Berry and Pakes (1993), Gowrisankaran (1999), Chen (2004)
Network effects	Jenkins et al. (2004), Markovich (2004), Markovich and Moenius (2005), Chen, Doraszelski and Harrington (2004)
Productivity growth	Laincz (2005)
R&D	Gowrisankaran and Town (1997), Auerswald (2001), Song (2002), Judd, Schmedders and Yeltekin (2002), Fershtman and Markovich (2006)
Technology adoption	Schivardi and Schneider (2005)
International trade	Erdem and Tybout (2003)
Finance	Goettler, Parlour and Rajan (2005), Kadyrzhanova (2006)

... but Face Considerable Challenges

Complications with Ericson and Pakes's Approach

Their general model's MPE are hard to characterize and compute

- Empirical methods that rely on solving the model for its predictions cannot be used
- Large-scale computational policy evaluation not feasible

... but Face Considerable Challenges

Complications with Ericson and Pakes's Approach

Their general model's MPE are hard to characterize and compute

- Empirical methods that rely on solving the model for its predictions cannot be used
- Large-scale computational policy evaluation not feasible

One Recent Advance

In a range of papers with Jeff Campbell and (former) students, we find that specific, interesting variants of Ericson and Pakes's model have

- unique or limited number of MPE
- ... that can be computed quickly

Measuring Toughness of Competition and Barriers to Entry

Abbring & Campbell (Econometrica 2010) show that Bresnahan & Reiss's (JPE 1991) static approach to measuring competition from cross-sectional data on firm and population numbers across geographic markets fails in markets with sunk costs and uncertainty

STATIC PROBIT ANALYSIS OF MARKET STRUCTURE[a]

	Implied Static Entry Thresholds						
σ	$C_1^\star$	$C_2^\star$	$C_3^\star$	$C_4^\star$	$C_5^\star$	$C_6^\star$	$C_7^\star$
0.05	0.43	0.87	1.32	1.78	2.24	2.70	3.13
0.10	0.39	0.83	1.29	1.75	2.20	2.62	
0.15	0.34	0.81	1.26	1.70	2.05		
	Implied $\pi(N)/\pi(1)$ for $N =$						
σ	1	2	3	4	5	6	7
0.05	1.00	0.98	0.97	0.96	0.95	0.95	0.95
0.10	1.00	0.94	0.92	0.90	0.89	0.90	
0.15	1.00	0.85	0.82	0.81	0.83		

Toughness of Competition Motion Picture Theaters

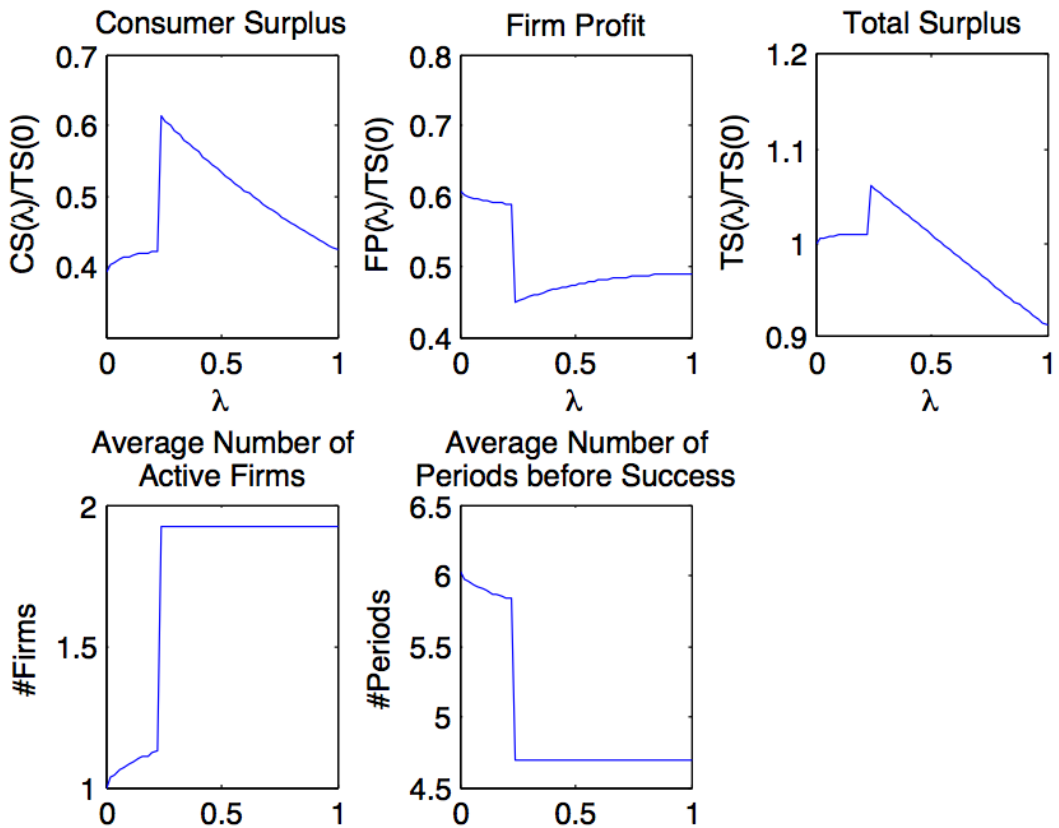
Abbring et al. (2014) provide a full econometric implementation of a dynamic model of entry, competition, exit in oligopoly and apply it to competition between cinemas in U.S. μSAs from 2000–2009

		Geographic Preference Diversity	
	All μSAs	Diversity $>$ 13.4 miles	Diversity $\leq$ 13.4 miles
$1/\left(k(1)\times 10^3\right)$	26.36	29.42	25.97
	(3.50)	(4.00)	(3.65)
$k(2)/k(1)$	0.54	0.60	0.48
	(0.14)	(0.14)	(0.20)
$k(3)/k(2)$	0.82	0.84	0.78
	(0.06)	(0.06)	(0.10)
$k(4)/k(3)$	0.77	0.79	0.66
	(0.08)	(0.08)	(0.21)
Number of Markets	573	287	286

R&D Investment and Product Market Regulation

Abbring, Campbell, Yang (2010) explore the tradeoff between product market competition and R&D incentives

Figure 5: Welfare Analysis for Various Levels of Collusion



Dynamic Merger Analysis

- Nocke and Whinston (JPE 2010) provide conditions under which a myopic review of horizontal mergers (ignoring dynamics, including future mergers) is optimal
- This way, they also highlight the many conditions under which truly dynamic merger review is needed
- Such a dynamic review can rely on merger simulation, as suggested early on by Berry and Pakes (AER 1993)
- Mermelstein et al. (2014) give one example, for a dynamic model with scale economies in which firms can reduce costs by investing in capital or by merging