

Jean Tirole's Nobel Prize in Economics: The Rigorous Foundations of Post-Chicago Antitrust Economics

BY STEVEN C. SALOP AND CARL SHAPIRO

THE 2014 NOBEL MEMORIAL PRIZE IN Economic Sciences was awarded to Toulouse School of Economics Professor Jean Tirole “for his analysis of market power and regulation.” The Swedish Academy of Sciences, in its press release announcing Tirole’s Nobel Memorial Prize, explained that his work is about “The Science of Taming Powerful Firms,” and provided this image:



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This is an exciting development for industrial organization and antitrust economics. The last time the Nobel Prize in Economic Sciences was awarded in the field of industrial

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organization was over 30 years ago when University of Chicago Professor George Stigler received the 1982 prize “for his seminal studies of industrial structures, functioning of markets and causes and effects of public regulation.”¹

This article describes Tirole’s Nobel prize-winning contributions to the development of competition policy and regulation. Tirole’s work is voluminous—his CV lists well over 200 research articles and publications along with a dozen books—so the discussion here is highly selective.² We focus on how Tirole’s work has influenced competition policy, especially in the United States and the European Union. We stress three themes.

First, Tirole’s work exemplifies how economists now commonly use game-theoretic models to study a wide diversity of business strategies and markets. Indeed, Tirole has provided the rigorous intellectual foundations for many of the game-theoretic models and ideas that modern antitrust economists employ. This approach has become known as “Post-Chicago Antitrust Economics” to distinguish it from the earlier price-theoretic models generally associated with the Chicago School.

Second, Tirole and his co-authors have made seminal contributions to many topics of central importance to antitrust economics and antitrust law. We illustrate the impact of his work in four areas of ongoing relevance to antitrust practitioners: vertical foreclosure; tacit collusion and coordinated effects in horizontal mergers; two-sided markets and platform competition; and the patent/antitrust intersection. This list is incomplete, however. Tirole also has made important contributions to the analysis of predation, strategic investments and entry deterrence, innovation races, and the theory of the firm, among other topics. In each area, Tirole has focused on the fundamental economic logic.

Third, in a highly influential line of work with his late colleague Jean-Jacques Laffont, Tirole greatly advanced the theory of optimal regulation to control monopoly power. Their articles and book offer valuable guidance and warnings for regulators in natural monopoly markets and other markets lacking effective competition. Laffont and Tirole’s work reveals the difficulties faced by imperfectly-informed regulators in their efforts to promote consumer or total welfare. By highlighting the limits of regulation, their work reaffirms the importance of vigorous antitrust enforcement in maintaining competitive and contestable markets by controlling mergers and preventing dominant firms from engaging in exclusionary practices.

Jean Tirole, Game Theory, and Post-Chicago Antitrust Economics

Jean Tirole received his Ph.D. in Economics from the Massachusetts Institute of Technology in 1981. At that time, the traditional structure-conduct-performance framework, with its heavy emphasis on market shares and market concentration as indicators of market performance, had come under withering attack by influential Chicago School schol-

When it comes to real-world cases and policy analysis, Tirole believes that rigorous economic analysis using the tools of game theory and information economics is enormously helpful. His remark about “social responsibility” recognizes the danger that an expert economist may concoct a model designed to reach the conclusion desired by his client or his political ideology.



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ars including George Stigler, Harold Demsetz, Robert Bork, and Richard Posner, among others. Their work sharply challenged the structural approach used by courts during the 1950s and 1960s. As Tirole put it in his Nobel Prize Lecture, “By the late 70s and early 80s, the antitrust and regulation doctrine was in shambles and had to be rebuilt.”³

By happy coincidence, MIT in the late 1970s and early 1980s exposed Tirole and other students to major advances in game theory and information economics.⁴ These new tools proved very well suited to the field of industrial organization. In Tirole’s own words:

But I claim credit for being in the right place at the right time. . . . I decided to sit in fascinating lectures given by Paul Joskow and Dick Schmalensee, and I started fruitful collaboration with Drew [Fudenberg]. A stroke of good fortune indeed, as the required tools, game theory and information economics, were witnessing a series of breakthroughs.⁵

Game theory and information economics proved to be the building blocks for Post-Chicago antitrust economics. Jean Tirole may be less well known to antitrust practitioners than some other economists who have spent more time as government officials, economic consultants, or expert witnesses, but he has been systematically developing the rigorous intellectual underpinnings of Post-Chicago antitrust economics for some 35 years. In addition to his many peer-reviewed publications, he is known worldwide for his 1988 book, *The Theory of Industrial Organization*, which offered the first systematic approach to industrial organization using these new tools.⁶ Most of today’s younger antitrust economists were trained using this textbook and even more have been greatly influenced by it. At the same time, because Tirole’s focus has been the logical economic underpinnings of the ideas, his work is somewhat less accessible and more subject to misinterpretation by antitrust practitioners.

A defining feature of the Post-Chicago approach is the use of different models for different market situations. The rigorous grounding developed by Tirole and others relies on the methodology provided by game theory combined with traditional assumptions from neoclassical economics, notably profit maximization by for-profit firms.⁷ But real-world markets differ significantly in their institutional features. Furthermore, competition policy is concerned with a wide range of conduct.

As a result, different detailed “extensive form games” and correspondingly different empirical approaches (depending on the available data) are useful for predicting the likely effects of specific conduct. A single metric such as market concentration cannot reliably be used across all markets and all modes of behavior.⁸ In describing Tirole’s contributions, The Royal Swedish Academy of Sciences stated:

There are no simple, standard solutions for regulation and competition policy, as the most appropriate ones will vary from one market to another. Jean Tirole has therefore also studied the conditions of specific markets, and contributed new theoretical perspectives.⁹

Tirole put it this way in his Nobel Prize Lecture:

This most fortunate of circumstances led to a new paradigm. As was emphasized by the Prize Committee’s Scientific Background Report, this paradigm is rich and complex. First, counting the number of firms or their market shares provides only a very rough indication of whether the market is competitive. Second, industries have their specificities. Economists accordingly have advocated a case-by-case or rule-of-reason approach to antitrust, away from rigid per se rules, which mechanically either allow or prohibit certain behaviors.¹⁰

The variety of game-theoretic models and the inherent flexibility of game-theoretic tools match the diversity and complexity of the real-world markets and strategies that antitrust practitioners encounter. However, as with any powerful tool, these models must be used with care and judgment. Indeed, Tirole himself emphasizes that the economist must select a model well matched to the industry under study, if his or her analysis is to be reliable:

Economists’ message, however, comes with a social responsibility. First, *economists must offer a rigorous analysis of how markets work, taking into account the specificities of particular industries*, what regulators do and do not know. This latter point calls for “information-light” policies, that is, policies that do not require information that is unlikely to be held by regulators. Second, economists must participate in the policy debate. . . . But of course, here, the responsibility goes both ways. Policy makers and the media must also be willing to listen to economists.¹¹

Much is packed into Tirole’s notion of what constitutes a “rigorous analysis of how markets work, taking into account

the specificities of particular industries.” Colleagues have often seen Tirole dispense with arguments that are imprecise or are poorly matched to the case at hand. As a conference discussant over many years, Tirole, while always gracious, is penetrating, and does not mince words when he sees a poorly conceived or sloppy line of argument.

When it comes to real-world cases and policy analysis, Tirole believes that rigorous economic analysis using the tools of game theory and information economics is enormously helpful. His remark about “social responsibility” recognizes the danger that an expert economist may concoct a model designed to reach the conclusion desired by his client or his political ideology. Tirole’s antidote is “rigorous analysis” well suited to the industry at hand. For Tirole’s vision of an economist’s social responsibility to work in practice, decision makers also must be able to distinguish reliable and appropriate analysis from opportunistic and undisciplined assertions. This is, of course, an issue for all expert testimony. The body of work developed by Tirole and others over the past several decades provides the necessary scientific foundation for courts and other decision makers to ensure that decisions are indeed made based on “rigorous analysis.”

Tirole and the Foundations of Modern Antitrust Economics

Tirole has been a truly prolific scholar. He has produced a huge number of high-quality articles, many of them in the top peer-reviewed economics journals.¹² He has made major contributions in many areas of economics, not just industrial organization, and his industrial organization articles have a wide breadth. We focus on four specific areas in which Tirole has developed fundamental economic models that have had a major influence on modern competition policy.

Vertical Foreclosure. Tirole has written a series of important articles on vertical integration and contracts going back nearly 30 years. In fact, in his Nobel Prize Lecture, Tirole used the “foreclosure doctrine” as applied in the railroad industry to illustrate how public policy can curb market power to the benefit of consumers.¹³ These articles include collaborations with Patrick Rey and Oliver Hart that have provided a rigorous structure and a masterful summary of the economic logic of foreclosure.¹⁴ Rey and Tirole’s “Primer on Foreclosure” surveys the field, unifying the economic analysis of vertical integration, exclusive dealing, customer exclusives, and horizontal foreclosure. They analyze the potential roles of scale economies, commitments, coordination failures, and non-discrimination rules. These papers show the clear limits of the “single monopoly profit” theory and emphasize that foreclosure is a fundamental policy concern. As the Nobel committee explained:

Formerly, the belief was that such companies may well make monopoly profits in their own area, but that competition prevents them from benefitting from their position in the next link of the production chain. . . . Tirole has demonstrated that this belief is not justified; mastering one link of

a chain can allow a monopolist to make profits in the market of the next link. In reality, it is often by distorting competition in a neighboring market that a monopolist is able to make a profit.¹⁵

Rey and Tirole similarly show why “competition for exclusivity” is not a panacea for anticompetitive concerns. While bidding for distribution in the market can provide rivals with some protection from vertical foreclosure, it is limited. Various bidding advantages flow to the dominant firm, and coordination failures may limit its competitors. As a result, Rey and Tirole identify various circumstances under which bidding competition will not deter anticompetitive foreclosure strategies.

At the same time, Tirole’s work recognizes that vertical integration and exclusive contracts can reduce costs and increase innovation. This implies that antitrust should apply the rule of reason, not a standard of per se legality or illegality, to this category of conduct.

Tacit Collusion and Coordinated Effects in Horizontal Mergers. Tirole’s work with Eric Maskin in the 1980s helped provide more rigorous principles and structure for modern oligopoly theory. By the late 1970s, game theory had made great advances in the treatment of dynamic games that were very well suited to the study of dynamic oligopoly.¹⁶ Stigler’s seminal 1964 paper had defined the field for 20 years but was based on a number of very specific assumptions that limited its generality.¹⁷

Tirole’s work with Maskin on dynamic oligopoly theory is central to questions of tacit collusion that commonly arise in Sherman Act Section 1 cases. Their work uses rigorous economic analysis to derive equilibrium outcomes observed in oligopolies and previously explained using less rigorous and less general models.¹⁸ Their main conceptual innovation was to depart from “supergame” models, in which firms set price each period in a never-changing environment. Those models tended to have low predictive power because a very wide range of equilibrium outcomes can arise. Maskin and Tirole focused on settings in which prices are sticky: once a firm sets its price, that price is fixed for at least a short period of time, during which the firm’s rivals can change their prices. The Maskin and Tirole approach provided a natural and elegant way to capture the notion of one firm “responding” to another firm’s price. Importantly, their approach generates more testable hypotheses than did the supergame approach that preceded it. While economic theory alone can never replace case-specific evidence regarding tacit or express collusion, their work provides a more rigorous theoretical framework for the dynamic pricing and output behavior of oligopolists.¹⁹

Central to their approach is the method of solving dynamic games known as “Markov Perfect Equilibrium.” In a Markov Perfect Equilibrium, firms set their prices based solely on the current state of the market, not based on previous actions that no longer directly affect market conditions. This behavior does not constitute what one would normally call an “agreement” among the oligopolists. Nor

does it involve “deterrence” or “punishment,” whereby one firm takes actions costly to itself in order to reduce the profits of another firm in retaliation for something that second firm did in the past. Under Markov Perfect Equilibrium, each firm takes the action that is best for that firm, given the current state of the market and given that it expects the other firms to do likewise in the future.

While agreement, deterrence and punishment clearly are important to understanding certain coordinated oligopoly conduct, Maskin and Tirole offered a very valuable middle ground: a rigorous way of analyzing oligopoly behavior that was both richer and more realistic than static oligopoly theory (which by definition does not include time and thus cannot study how one firm reacts to another) and more useful in practice than supergames (which admit so many equilibria that they have low predictive power). The concepts of parallel accommodating conduct and conscious parallelism are rooted in this middle ground. Firms in concentrated markets typically respond to each other; those responses can lead to more or less competitive outcomes; and all of this can happen without any behavior corresponding to “deterrence” or “punishment.” In this sense, Maskin and Tirole built upon and added to the oligopoly framework that Stigler had pioneered 20 years earlier.

Maskin and Tirole’s work provided the rigorous foundation for the treatment of parallel accommodating conduct in the coordinated effects section of the 2010 Horizontal Merger Guidelines. As defined there,

[P]arallel accommodating conduct includes situations in which each rival’s response to competitive moves made by others is individually rational, and not motivated by retaliation or deterrence nor intended to sustain an agreed-upon market outcome, but nevertheless emboldens price increases and weakens competitive incentives to reduce prices or offer customers better terms.²⁰

Two-Sided Markets with Network Effects. In recent years, many antitrust cases have involved “two-sided markets” with network effects. Payment systems provide a leading example. The payment networks like Visa provide value to merchants because many consumers carry Visa cards. Likewise, Visa provides value to consumers because many merchants accept Visa cards. Merchants comprise one “side” of the payment systems network market and cardholders are the other “side.” Google’s search engine is another important example, with consumers conducting searches on one side and advertisers seeking to reach consumers on the other side. In the case of Google, advertisers provide direct value to some consumers, namely those who value the presence of relevant ads next to algorithmic search results. Google advertisers also provide substantial indirect value to consumers since advertising revenues provide Google with both the ability and the incentive to make its search engine available to consumers for free.

Two-sided markets with network effects are not new. Newspapers and radio stations provide two venerable exam-

During the past decade, Tirole has turned his attention to intellectual property and, in particular, the relationship between patents and antitrust.

ples, with consumers on one side and advertisers on the other. But two-sided markets with network effects have taken on a broader role in recent times. Indeed, Tirole picked two-sided markets as the first of two specific areas to discuss in detail in his Nobel Prize Lecture.²¹ His examples of “platforms” in two-sided markets were payment systems (bringing together cardholders and merchants), video game consoles (gamers and game developers), computer operating systems (users and application developers), and web “portals, newspapers, and television (viewers and advertisers).”

In a series of papers with Jean-Charles Rochet using payment systems as a paradigm, Tirole studied the economics of two-sided markets with network effects. Rochet and Tirole derived the basic equations governing pricing in two-sided markets.²² Rochet and Tirole subsequently developed some potential antitrust implications of their theories for payment systems.²³ Because payment systems involve collaborations among competitors with considerable collective market power, they have generated substantial antitrust activity around the world.²⁴ Economic experts on both sides of those various matters use the Rochet-Tirole articles as important reference points.

The Patent/Antitrust Intersection. During the past decade, Tirole has turned his attention to intellectual property and, in particular, the relationship between patents and antitrust. Reflecting his recent interest in this area, Tirole chose intellectual property as the second specific topic to discuss in detail in his Nobel Prize Lecture.²⁵ This is an area where Tirole was not the pioneer but nonetheless has contributed with his typically deep and insightful analysis.

Most of Tirole’s work in this area is with Josh Lerner. Lerner and Tirole have focused on two related topics that are squarely at the intersection of patents and antitrust: patent pools and standard-setting organizations (SSOs). They tackled patent pools first, addressing a key antitrust issue: how can one distinguish efficient, procompetitive patent pools from anticompetitive patent pools?²⁶ Their analysis supports an approach that is lenient toward the formation of patent pools so long as pool members retain the ability to license their patents independently from the pool and so long as the pool is not used to facilitate collusion that undermines such independent licensing. This is another example of how Tirole has contributed to the rigorous economic foundation for the antitrust approach to patent pools that is generally now in

use.²⁷ Lerner and Tirole also have studied empirically the licensing terms associated with patent pools, confirming their theory that pools consisting solely of complementary patents are more likely to allow firms to engage in independent licensing.²⁸

Lerner and Tirole have also studied SSOs, improving our understanding of how they function and how to treat SSO rules requiring participants to license their patents on fair, reasonable, and non-discriminatory (FRAND) terms. Along with Benjamin Chiao, they have studied empirically the factors that influence the patent rules chosen by SSOs.²⁹ In his Nobel Prize Lecture, Tirole emphasized the importance of “creating a real commitment (not a vague promise of FRAND licensing).”³⁰ Lerner and Tirole’s work in this area is ongoing.³¹

The Limits of Regulation and the Need for Vigorous Antitrust Enforcement

The Economic Sciences Prize Committee, in its *Scientific Report*, devoted as much space to Tirole’s work on the regulation of dominant firms as it did to his work on antitrust economics.³² The core of his work on regulation was carried out in collaboration with his close friend and colleague Jean-Jacques Laffont.³³ Laffont and Tirole studied “optimal regulation,” meaning the regulatory system that best serves the public interest. They recognized that there is usually significant *asymmetric information* between the regulator and the regulated firm, with the regulator suffering from more limited information about the operation of the regulated firm, including its level of costs and its ability to lower those costs or improve the quality of its product or service over time by making investments. Their methodology is now known as the “mechanism design” approach to regulation because they applied the sophisticated economic tools of mechanism design theory to sector-specific regulation.³⁴

Sector-specific regulation often involves regulatory controls on the firm’s prices or its rate of return on investment. While this type of regulation often is necessary to serve the public interest, especially in natural monopoly markets, relying on price or rate-of-return regulation all too often means that competitive forces are relegated to a secondary role in determining pricing, investment, and other key decisions in the industry. If such regulation were highly effective, this would not sacrifice much in efficiency. Alas, Laffont and Tirole’s work warns us that sector-specific regulation, even when very cleverly designed, tends to be highly imperfect. In the popular version of its report, the Economic Sciences Prize Committee summarized this work on regulation with the understated heading, “Regulation is Difficult.”³⁵

Laffont and Tirole’s work also highlights the danger that powerful firms in the regulated industry will “capture” the regulatory process so that it serves their interests rather than the public interest. In some cases, they warn that the “optimal regulations” they derive (under the assumption that the regulator acts in the public interest) will fail due to regulato-

ry capture. In particular, while “high-powered incentives,” i.e., large rewards to the regulated firm for achieving certain specified goals, can be quite useful to motivate the regulated firm to make investments to reduce its costs, or to lower its prices toward competitive levels, high-powered incentives cannot be safely used in the presence of regulatory capture.

This work has significant implications for antitrust. It suggests that agencies and courts must be skeptical about the efficacy of price and rate-of-return regulation as a means of controlling monopoly power, even if the regulations are very carefully designed. This makes it all the more important that antitrust policy prevent firms from acquiring or maintaining durable monopoly power through merger or exclusionary conduct. Once that monopoly power is achieved, it is very difficult to control.

Laffont and Tirole’s approach also has application to the formulation of antitrust standards. For example, building on these insights about mechanism design, several authors have suggested the adoption of consumer welfare as the regulatory (or legal) standard, even if the overarching goal is total welfare (which includes profits as well as consumer welfare). By using a consumer welfare standard in a world of asymmetric information and bargaining power, the firms’ resulting decisions are more likely to maximize total welfare as well as increase consumer welfare.³⁶

Conclusion

Jean Tirole’s work has deeply influenced competition policy. Because Tirole has worked mostly on the *foundations* of competition policy, rather than on specific cases or applications, his influence probably exceeds his visibility with most antitrust practitioners. Tirole’s work also has greatly influenced many economists, ourselves included, to think more rigorously about a multitude of economic issues in industrial organization that form the basis for antitrust, competition policy, and regulation. Tirole’s work stresses the need for serious scientific analysis, rather than the repetition of old and simplistic economic claims, such as the “single monopoly profit” theory, that fail to capture the real-world complexities that influence business decisions and determine market outcomes. We hope and expect that Tirole’s influence will keep growing, so that economics can continue to be a positive agent for improving the effectiveness of competition policy. ■

¹ During the intervening 32 years, a number of laureates have received the prize for work relevant to antitrust economics. These include: Ronald Coase in 1991 “for his discovery and clarification of the significance of transaction costs and property rights for the institutional structure and functioning of the economy”; John Harsanyi, John Nash, and Reinhard Selten in 1994 “for their pioneering analysis of equilibria in the theory of non-cooperative games”; George Akerlof, Michael Spence, and Joseph Stiglitz in 2001 “for their analyses of markets with asymmetric information”; and Oliver Williamson in 2009 “for his analysis of economic governance, especially the boundaries of the firm.”

- ² For a detailed description of the work for which Tirole was awarded the Nobel Prize, see Scientific Background on the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2014, JEAN TIROLE: MARKET POWER AND REGULATION, compiled by the Economic Sciences Prize Committee of the Royal Swedish Academy of Sciences (Oct. 13, 2014) [hereinafter *Scientific Background*], available at http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2014/advanced-economicsciences2014.pdf.
- ³ Jean Tirole Nobel Prize Lecture, *Market Failures and Public Policy* (Dec. 8, 2014) [hereinafter *Tirole Nobel Prize Lecture*], available at http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2014/tirole-lecture.html around 7:00. The slides accompanying Tirole's Nobel Prize Lecture can be found at http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2014/tirole-lecture-slides.pdf [hereinafter *Tirole Slides*].
- ⁴ Many other economists who have influenced antitrust economics and policy over the past 30 years spent time at MIT during the decade 1975–1985, including Doug Bernheim (1982 Ph.D.), Jeremy Bulow (1979 Ph.D.), Dennis Carlton (1975 Ph.D.), Joseph Farrell (Professor), Drew Fudenberg (1981 Ph.D.), Frank Fisher (Professor), Jerry Hausman (Professor), Paul Joskow (Professor), Eric Maskin (Professor), Nancy Rose (1985 Ph.D.), Michael Salinger (1982 Ph.D.), Garth Saloner (Professor), Richard Schmalensee (Professor), Carl Shapiro (1981 Ph.D.), and Michael Whinston (1984 Ph.D.).
- ⁵ *Tirole Nobel Prize Lecture*, *supra* note 3, around 8:00.
- ⁶ JEAN TIROLE, *THE THEORY OF INDUSTRIAL ORGANIZATION* (1988).
- ⁷ As the Economic Sciences Prize Committee noted, Tirole also has contributed to the advancement of game-theoretic tools, especially earlier in his career. *Scientific Background*, *supra* note 2, Section 6.1, “The Toolbox: Game Theory and Mechanism Design.” The 2005 Nobel Prize in Economics was awarded to Robert Aumann and Thomas Schelling “for having enhanced our understanding of conflict and cooperation through game-theory analysis.”
- ⁸ We now understand that while the level and change in market concentration can be informative for horizontal mergers, these metrics must be interpreted in the context of other evidence regarding a merger's likely effects. For example, see Carl Shapiro, *The 2010 Horizontal Merger Guidelines: From Hedgehog to Fox in Forty Years*, 77 *ANTITRUST L.J.* 701 (2011).
- ⁹ The Royal Swedish Academy of Sciences, *The Prize in Economic Sciences, Popular Science Background: Market Power and Regulation 4* (2014) [hereinafter *Popular Science Background*], available at http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2014/popular-economic-sciences2014.pdf.
- ¹⁰ *Tirole Nobel Prize Lecture*, *supra* note 3, at 8:45.
- ¹¹ *Id.* at 9:30 (emphasis added).
- ¹² Tirole's Curriculum Vitae (CV) is available at <http://idei.fr/member.php?i=3>. His productivity is truly mind-boggling to mere mortal economists. Quite apart from his 182 research articles and publications in English, he has published 12 books, including *THE THEORY OF INDUSTRIAL ORGANIZATION* (1988); *GAME THEORY* (with Drew Fudenberg 1991); *THE THEORY OF INCENTIVES IN REGULATION AND PROCUREMENT* (with Jean-Jacques Laffont 1993); *THE PRUDENTIAL REGULATION OF BANKS* (with Matthias Dewatripont 1994); *COMPETITION IN TELECOMMUNICATIONS* (with Jean-Jacques Laffont 1999); and *THE THEORY OF CORPORATE FINANCE* (2006).
- ¹³ *Tirole Nobel Prize Lecture*, *supra* note 3, at 12:00, and slides #13 and #14.
- ¹⁴ Patrick Rey & Jean Tirole, *The Logic of Vertical Restraints*, 76 *AM. ECON. REV.* 921 (1986); Oliver Hart & Jean Tirole, *Vertical Integration and Market Foreclosure*, *BROOKINGS PAPERS ON ECON. ACTIVITY* 205 (1990); Patrick Rey & Jean Tirole, *A Primer on Foreclosure*, 3 *HANDBOOK OF INDUSTRIAL ORGANIZATION* 2145 (Mark Armstrong & Robert Porter eds., 2007).
- ¹⁵ *Popular Science Background*, *supra* note 9, at 6–7.
- ¹⁶ A fine summary of the key tools of game theory used in industrial organization during the 1980s (and since) can be found in Drew Fudenberg & Jean Tirole, *Non-Cooperative Game Theory for Industrial Organization: An Introduction and Overview*, in 1 *HANDBOOK OF INDUSTRIAL ORGANIZATION* 259 (Richard Schmalensee & Robert Willig eds., 1989). For an overview of how these tools and others were used in oligopoly theory during the 1980s, see Carl Shapiro, *Oligopoly Theory*, in *HANDBOOK OF INDUSTRIAL ORGANIZATION*, *supra*, at 329.
- ¹⁷ George J. Stigler, *A Theory of Oligopoly*, 72 *J. POL. ECON.* 44 (1964). Stigler's paper was extraordinary for the time and greatly influenced William Baxter, who was Assistant Attorney General for Antitrust when the 1982 Merger Guidelines were drafted.
- ¹⁸ See especially Eric Maskin & Jean Tirole, *A Theory of Dynamic Oligopoly II: Price Competition, Kinked Demand Curves, and Edgeworth Cycles*, 56 *ECONOMETRICA* 571 (1988).
- ¹⁹ See especially Eric Maskin and Jean Tirole, *A Theory of Dynamic Oligopoly III: Cournot Competition*, 31 *EUR. ECON. REV.* 947 (1987).
- ²⁰ See U.S. Dep't of Justice & Fed. Trade Comm'n, *Horizontal Merger Guidelines § 7* (2010), available at <http://www.justice.gov/atr/public/guidelines/hmg-2010.pdf>.
- ²¹ *Tirole Slides*, *supra* note 3, at 24–28.
- ²² Jean-Charles Rochet & Jean Tirole, *Cooperation Among Competitors: Some Economics of Payment Card Associations*, 33 *RAND J. ECON.* 549 (2002); Jean-Charles Rochet & Jean Tirole, *Platform Competition in Two-Sided Markets*, 1 *J. EUR. ECON. ASS'N*, 990 (2003).
- ²³ See, for example, Jean-Charles Rochet & Jean Tirole, *Competition Policy in Two-Sided Markets, with a Special Emphasis on Payment Cards*, 543 *HANDBOOK OF ANTITRUST ECONOMICS* (Paolo Buccirossi ed., 2008).
- ²⁴ One recent example is the Department of Justice challenge to certain practices by American Express relating to merchant acceptance of American Express cards. The recent decision by Judge Garaufis, which cites Tirole's work with Rochet, resoundingly supports the complaint brought by the Department of Justice. *United States v. Am. Express Co.*, No. 10-CV-04496, 2015 WL 728563 (E.D.N.Y. Feb. 19, 2015). Another is the recently settled class action (and ongoing optout cases) against Visa and MasterCard involving the collective setting of interchange fees and the honor-all-cards rule. *In re Payment Card Interchange Fee and Merchant Discount Antitrust Litig.*, 986 F. Supp. 2d 207 (E.D.N.Y. 2013).
- ²⁵ *Tirole Slides*, *supra* note 3, at 30–35.
- ²⁶ Josh Lerner & Jean Tirole, *Efficient Patent Pools*, 94 *AM. ECON. REV.* 691 (2004).
- ²⁷ Tirole continues to work in this area. See Patrick Rey & Jean Tirole, *Cooperation vs. Collusion: How Essentiality Shapes Cooperation* (Working Paper, Toulouse School of Economics 2013), available at http://www.idei.fr/doc/wp/2013/wp_idei_801.pdf.
- ²⁸ Josh Lerner, Marcin Strojwas & Jean Tirole, *The Design of Patent Pools: The Determinants of Licensing Rules*, 38 *RAND J. ECON.* 611 (2007).
- ²⁹ Benjamin Chiao, Josh Lerner & Jean Tirole, *The Rules of Standard Setting Organizations: An Empirical Analysis*, 38 *RAND J. ECON.* 905 (2007).
- ³⁰ *Tirole Nobel Prize Lecture Slides*, *supra* note 3, at 35.
- ³¹ Josh Lerner & Jean Tirole, *Standard Essential Patents*, *J. POL. ECON.* (forthcoming 2015).
- ³² Section 2 in the *Scientific Background*, *supra* note 2, “The Regulation of Dominant Firms,” occupies pages 4–18. Section 3, “Industrial Organization: Strategic Behavior in Imperfectly Competitive Industries” and Section 4, “Competition Policy,” together occupy pages 18–32.
- ³³ This extensive line of research was initiated with Jean-Jacques Laffont & Jean Tirole, *Using Cost Observation to Regulate Firms*, 94 *J. POL. ECON.* 614 (1986). The most complete description of this line of research, and its implications for regulators, can be found in Jean-Jacques Laffont & Jean Tirole, *A THEORY OF INCENTIVES IN REGULATION AND PROCUREMENT* (1993).
- ³⁴ Mechanism design theory concerns the optimal design of incentive systems under circumstances of imperfect information. The 2007 Nobel Prize in Economics was awarded to Leonid Hurwicz, Eric Maskin, and Roger Myerson “for having laid the foundations of mechanism design theory.” Mechanism design theory has proven powerful in a wide range of applications. Laffont and Tirole also applied mechanism design theory to other problems that are close cousins to regulation, including privatization and procurement.
- ³⁵ *Popular Science Background*, *supra* note 9, at 1.
- ³⁶ See Joseph Farrell & Michael L. Katz, *The Economics of Welfare Standards in Antitrust*, *COMPETITION POL'Y INT'L* (Oct. 2006) and the references cited therein.