# Toulouse network for information technology : 2005

# Executive report

The Toulouse network was launched in 2005. We managed to attract an excellent team of researchers. All the researchers who were contacted accepted to be part of the network, the majority of them works in a top 5-economics department, and one of them was awarded the John Bates Clark medal, which rewards the most outstanding U.S. economist below 40, and is awarded by the American Economic Association every other year.

The list of the network researchers during 2005 is:

**Daron ACEMOGLU** is Charles P. Kindleberger Professor of Applied Economics in the Department of Economics at the Massachusetts Institute of Technology and a member of the Economic Growth program of the Canadian Institute of Advanced Research. He has received numerous awards and fellowships, including the award for best paper published in the Economic Journal in 1996 for his paper "Consumer Confidence and Rational Expectations: Are Agents' Beliefs Consistent With the Theory?", the inaugural T. W. Shultz prize at the University of Chicago in 2004, and the inaugural Sherwin Rosen award for outstanding contribution to labor economics in 2004. He was also awarded the John Bates Clark Medal in 2005, given every two years to the best economist in the United States under the age of 40 by the American Economic Association.

**Susan ATHEY** is the Holbrook Working Professor of Economics at Stanford University and Research Associate at the NBER. She was previously the Castle Krob Career Development Associate Professor of Economics at MIT. She is a Fellow of the Econometric Society. In 2000, she received the Elaine Bennett Research Award, given by the American Economic Association every second year in recognition of research accomplishments by a young woman. She does theoretical and empirical research in industrial organization, including models of dynamic competition and market dominance.

**Glen ELLISON** is Professor of Economics at MIT. He also served as Editor of the premier economics journal, Econometrica and of the top Industrial Organization journal, RAND Journal of Economics, and held visiting positions as the Institute for Advanced Study and the Center for

Advanced Study in the Behavioral Sciences. His work spans game theory and theoretical and empirical industrial organization. Two specialties in which he is a leader are e-commerce and the dissemination of scientific knowledge. He has taught classes on e-commerce at MIT.

**Luis GARICANO** teaches MBA and Executive MBA courses in Competitive Strategy and the Economics of Organizations at the University of Chicago Graduate School of Business, where he has been a member of the faculty since 1998. He has also taught these courses at MIT, where he was a visiting professor during the academic year 2003-2004, and the London Business School, where he visited in 2005. He holds a PhD in Economics from the University of Chicago. Garicano's research activities focus on the acquisition and transmission of knowledge in organizations and the impact that technology has on these issues.

**Chad JONES** is a Professor of Economics at the University of California at Berkeley. He received his Ph.D. in economics from M.I.T. in 1993 and his B.A. from Harvard in 1989. Professor Jones' research is focused on long-run economic growth. He seeks to understand questions such as "Why is per capita income in the United States more than 10 times higher today than it was 125 years ago?" and "Why is per capita income in the richest countries of the world 40 times higher than per capita income in the poorest?". He is the author of _Introduction to Economic Growth_ (W.W. Norton, 2002), an undergraduate-level textbook exploring the answers to these questions.

**Joshua LERNER** is the Jacob H. Schiff Professor of Investment Banking at Harvard Business School, with a joint appointment in the Finance and Entrepreneurial Management Units. His work examines, among other topics, policies towards intellectual property protection, particularly patents, and how they impact firm strategies in high-technology industries. He founded, raised funding for, and organizes two groups at the National Bureau of Economic Research: Entrepreneurship and Innovation Policy and the Economy. His work has been published in a variety of top academic journals and several books, most recently, *Innovation and Its Discontents*. He serves as the School’s representative on Harvard University Patent, Trademark and Copyright Committee and on the Provost’s Committee on Technology Transfer.

**Kiminori MATSUYAMA** is Professor of Economics at Northwestern University. He has received numerous professional honors, including a Fellow of the Econometric Society, the Nakahara Prize from the Japanese Economic Association, and has delivered the inaugural Fukuzawa lecture and Lawrence R. Klein Lecture. He has served on the editorial boards of the Journal of International Economics, Journal of Development Economics, Review of Economic Studies, and the Journal of Economic Theory, and Journal of the Japanese and International Economies. He has written extensively on the causes and consequences of innovation and technical changes in international trade, economic growth and development, and business cycles.

**Ariel PAKES** is the McArthur Heller professor of economics at Harvard University. He is an elected member of the American Academy of Arts and

Sciences, and of the Econometric Society. He won the latter society's Frisch Medal in 1986 for his work on the value of patent rights, and gave the Fisher-Schultz lecture at the Econometric Society's World Congress in 2005 on his work on empirical modelling of market equilibrium.

**Robert PORTER** is William R. Kenan, Jr. Professor of Economics at Northwestern. He has conducted research on a variety of topics in industrial organization, including theoretical and empirical studies of collusion, price wars, and bidders' behavior in auctions. He has investigated firms' bidding strategies, the formation of bidding consortia and joint ventures, and statistical methods for detecting the presence of a bid rigging scheme. He is a Fellow of the Econometric Society and of the American Academy of Arts and Sciences.

**Suzanne SCOTCHMER** is Professor of Economics and Public Policy at the University of California, Berkeley, and previously taught at Harvard University. Her graduate degrees are in economics and statistics. She has held visiting appointments at University of Auckland, University of Cergy-Pontoise (Paris), Tel Aviv University, University of Paris I (Sorbonne), University of Auckland, University of Southern California, Boalt School of Law, the University of Toronto Law School, Yale University, Stanford University, and the New School of Economics, Moscow. She has published on intellectual property law, rules of evidence, tax enforcement, cooperative game theory, club theory, and evolutionary game theory. She is currently a member of the Board on Science, Technology and Economic Policy of the National Academy of Sciences, and a Research Associate of the National Bureau of Economic Research. The Department of Justice Antitrust Division has used her as a consultant on antitrust matters, and she has been a scholar in residence at the Court of Appeals for the Federal Circuit.

**Ilya SEGAL** is the Roy and Betty Anderson Professor in the Humanities and Sciences at the Economics Department at Stanford University. His research is in the design of economic mechanisms and contracts, both from the viewpoint of aggregating information and providing incentives to economic agents. In particular, he has examined the potential efficiency and competitive effects of various bilateral and multilateral contractual arrangements. Segal's awards include Fellowship from the John Simon Guggenheim Memorial Foundation, Membership at the Institute for Advanced Study at Princeton, and Fellowship in the Econometric Society.

**Michael WHINSTON** is the Robert E. and Emily H. King Professor of Business Institutions in the Department of Economics at Northwestern University. He also holds courtesy appointments in both Northwestern's Kellogg School of Management and the Law School. His work in the areas of industrial organization and microeconomic theory includes many articles related to antitrust on topics such as exclusive dealing, tying, horizontal mergers, as well as more general work on contracting. His is also a coauthor of the leading graduate microeconomics textbook, *Microeconomic Theory.*

We also set up a 3-member Scientific Committee, in charge of monitoring the scientific quality and independence of the research undertaken in the context of the network. This Scientific committee consists of three established economists:

**Robert E. HALL**, Stanford University

**Richard SCHMALENSEE** , MIT

**Jacques-François THISSE**, CORE, Université Catholique de Louvain

The network's annual meeting took place on Sep. 19-20 at Institut d'Economie Industrielle in Toulouse. The meeting's programme is reported in Appendix I.

The papers generally square well with the focus of the network, while reflecting the researchers' scientific interests. As an example, the following topics have been dealt with:

- The interaction between Antitrust laws and technological innovation
- The impact of information technology on the firm's organization
- The dynamics of open-source contributions
- Biases against unskilled workers in innovation and trade
- The role of information as a determinant of economic growth
- Model estimation under network effects
- IP protection and digital rights management
- Intellectual Property and the structure of competition

The contributions range from direct applied discussions of the software industry or of the role of intellectual property, to the analysis of more general phenomena that have a bearing on these topics. Examples of the first type of paper include the paper by Joshua Lerner, Parag Pathak, and

Jean Tirole, where the authors predict that the share of corporate contributions to Open Source projects should be more sensitive to the growth of the project than those of the hobbyists and that this effect should be particularly strong when the commercial prospects of the project are favorable; and the paper by Yooki Park and Suzanne Scotchmer, which analyzes the impact of alternatives to Intellectual Property such as shared encryption systems on the structure of competition and prices. In the second category fall the papers by Kiminori Matsuyama, which helps understand how progress in information technology fosters globalization and increases the demand for sophisticated export activities, which in turn affects the demand for skills; and by Ariel Pakes and coauthors, who provide a path-breaking method for estimating the economic properties of systems where a small number of economic agents interact within a network—these authors show, for example, how their technique may be used to understand the dynamics of ATM location choices by banks.

# APPENDIX I – Programme of the first annual meeting of the Toulouse Network for Information Technology

Monday, September 19th

9:30-9:45: Opening remarks, Jacques Lawarree, Microsoft
9:45-10:45: Michael Whinston, Ilya Segal: Antitrust in innovative industries
10:45-11:15: Coffee Break
11:15-12:15: R. Porter, offshore oil exploration and IT

12:30-13:45: Lunch at restaurant "Le café du Midi"
14:00-15:00 Kiminori Matsuyama: On some negative consequences of IT revolution
15:00-15:30: Coffee Break
15:30-16:30: Chad Jones: The value of information in growth and development
16:30-17:30: Daron Acemoglu: 1. Equilibrium Bias of Technology; 2. Disclosure and Licensing Versus Patent Protection
17:30-19:00: Brainstorming session: teams and prospective themes

20:00 Dinner at restaurant "Le 19"

Tuesday, September 20

9:30-10:30: Josh Lerner: Open Source contributors
10:30-10:45: Coffee Break
10:45-11:45:Suzanne Scotchmer: Digital rights management
11:45-12:45: Susan Athey: project on open source

13:00-14:15 Lunch at restaurant "Le café du Midi"

14:30-15:30 Glenn Ellison: Sales Taxes and E-Commerce
15:30-16:00 Coffee Break
16:00-17:00 Ariel Pakes: Estimating parameters under complex network effects
17:00-18:00 Luis Garicano: Codes in organizations (joint with Andrea Prat and Jacques Crémer).

# APPENDIX II – The Network's papers in 2005

## "Antitrust in innovative industries", by Ilya Segal and Michael Whinston.

(Under revision, *American Economic Review*)

*Abstract*

We study the effects of antitrust policy in industries with continual innovation. Antitrust policies that restrict incumbent behavior toward new entrants may have conflicting effects on innovation incentives, raising the profits of new entrants, but lowering those of continuing incumbents. We show that the direction of the net effect can be determined by analyzing shifts in innovation benefit and supply holding the innovation rate fixed. We apply this framework to analyze several specific antitrust policies. We show that in some cases, holding the innovation rate fixed, as suggested by our comparative statics results, the tension does not arise and policies that protect entrants necessarily raise the rate of innovation.

## "Language and the Theory of the Firm" by Jacques Crémer, Luis Garicano, and Andrea Prat.

*Abstract*

An organization will often use a specialized technical language that is understood by its members but not by the rest of the world. We develop a theory of optimal organizational languages and identify a key trade-off between facilitating internal communication and encouraging communication with other organizations. Dialects tend to be suboptimal: two organizations will either share the same language or develop two entirely distinct set of technical words. This endogenous discontinuity in communication structure is reflected in a discontinuity in firm structure. We explore a number of predictions of our model and we relate them to changes in firm structure associated to technological progress. Our theory reconciles two recent phenomena within organizations: the increase in information centralization and the reduction in hierarchical centralization ('empowerment').

## "Dynamics of Open Source Movements", Susan Athey and Glenn Ellison

*Abstract*

This paper considers a dynamic model of the evolution of open source software projects, focusing on the evolution of quality, contributing programmers, and users who contribute customer support to other users. Our model has a public good problem that is partially mitigated by altruism. Programmers who have used features from open source software in the past are motivated to publish their own improvements, and the anticipation of these altruistic feelings may even lead them to choose to use open source rather than a commercial alternative that provides higher direct value. We consider two variants of the model, one in which programmer altruism is derived from the instrinsic quality improvement of the code, the other in which programmer

altruism is related to the benefits end users derive from using the new code. In our model, end users require customer support to adopt open source, and this is provided by other users who received support themselves in the past. We show that to avoid a zero-quality steady state, projects require an initial critical mass of features and individuals willing to provide customer service. We derive additional comparative statics on the dynamics of this system. Finally, we analyze competition by commercial .rms with OSS projects, showing that for many (but not all) parameter values, far-sighted commercial .rms reduce their prices in order to slow the growth of OSS projects or even cause OSS projects to change trajectories towards the zero-quality steady-state.

## "Equilibrium Bias of Technology", Daron Acemoglu

*Abstract*
The study of the bias of new technologies is important both as part of the analysis of the nature of technology adoption and the direction of technological change, and to understand the distributional implications of new technologies. In this paper, I analyze the equilibrium bias of technology. I distinguish between the relative bias of technology, which concerns how the marginal product of a factor changes relative to that of another following the introduction of new technology, and the absolute bias, which looks only at the effect of new technology on the marginal product of a factor. The first part of the paper generalizes a number of existing results in the literature regarding the relative bias of technology. In particular, I show that when the menu of technological possibilities only allows for factor-augmenting technologies, the increase in the supply of a factor always induces technological change (or technology adoption) relatively biased towards that factor. This force can be strong enough to make the relative marginal product of a factor increasing in response to an increase in its supply, thus leading to an upward-sloping relative demand curve. However, I also show that the results about relative bias do not generalize when more general menus of technological possibilities are considered.
The second part of the paper contains the main results. I show that there are much more general results about absolute bias. I prove that under fairly mild assumptions, an increase in the supply of a factor always induces changes in technology that are absolutely biased towards that factor, and these results hold both for small changes and large changes in supplies. Most importantly, I also determine the conditions under which the induced-technology response will be strong enough so that the price (marginal product) of a factor increases in response to an increase in its supply. These conditions correspond to a form of failure of joint concavity of the aggregate production function of the economy in factors and technology. This type of failure of joint concavity is quite possible in economies where equilibrium factor demands and technologies are decided by different agents.

## "Beyond Icebergs: Globalization as Biased Technical Change", Kiminori Matsuyama.

*Abstract*
International trade generates more demand for certain factors than domestic trade. Exporting naturally requires more intensive use of skilled labor with the expertise in the areas such as international business, language skills, and maritime insurance, and the transoceanic

transportation is more capital intensive than the local transportation. In the presence of such bias in factor demands, globalization caused by innovations in communication and information technology leads to a *world-wide* increase in the relative prices of the factors used intensively in international trade. Furthermore, a *world-wide* increase in the factors used intensively in international trade leads to globalization.
To understand these effects, we develop a flexible approach to model costly international trade, which includes the standard iceberg approach as a special case. More specifically, we extend the Ricardian model of trade with a continuum of goods (Dornbusch, Fischer and Samuelson, 1977) by introducing multiple factors of production and by making technologies depend on destinations, i.e., whether they are supplied to the domestic market or the export market. If the two technologies differ only in total factor productivity, the model becomes isomorphic to the DFS Ricardian model with the iceberg cost. By allowing them to differ in the factor intensities, our approach enables us to examine the impacts of information technology on factor prices and globalization through channels, which cannot be captured by the iceberg approach.

## The Value of Information in Growth and Development, by Charles I. Jones

*Abstract*
This paper explores the role of information in the theory of economic growth and development. They way it is used here, .information. refers to every feature of an economy, including not only the economic environment, but also the institutions like markets and government policies that affect the allocation of resources. The first half of the paper considers a model where consumers are faced with an enormous range of possible goods they can purchase, so many that they do not know exactly how much utility they would get from consuming each good. Improvements in this information possessed by consumers increases welfare by making the allocation of resources more efficient, and these effects may be large in some cases. The second half extends these ideas to the production side of the economy and argues that a model where different kinds of information are crucial to successful production can lead to an information-based theory of TFP. In the theory outlined here, large differences in incomes can be explained by small differences in the ease with which people in a given country can acquire four different kinds of complementary knowledge.

## “Organization and Inequality in a Knowledge Economy”， by Luis Garicano and Esteban Rossi-Hansberg

(forthcoming, *Quarterly Journal of Economics*)

*Abstract*
We present a theory of the organization of work in an economy where knowledge is an essential input in production: a knowledge economy. In this economy a continuum of agents with heterogeneous skills must choose how much knowledge to acquire and may produce on their own or in organizations. Our theory generates an assignment of workers to positions, a wage structure, and a continuum of knowledge-based hierarchies. Organization allows low skill agents to ask others for directions. Thus, they acquire less knowledge than in isolation. In contrast, organization allows high skill agents to leverage their knowledge through large teams. Hence,

they acquire more knowledge than on their own. As a result, organization decreases wage inequality within workers, but increases income inequality among the highest skill agents. We also show that equilibrium assignments and earnings can be interpreted as the outcome of alternative market institutions such as firms, or consulting and referral markets. We use our theory to study the impact of information and communication technology, and contrast its predictions with US evidence.

## "The Dynamics of Open Source Contributors", Josh Lerner, Parag Pathak, and Jean Tirole

Shorter version forthcoming in *American Economic Review*, May 2006

*Abstract*
This paper examines contributions to open source projects. We predict that the share of corporate contributions should be more sensitive to the growth of the project than those of the hobbyists and that this effect should be particularly strong when the commercial prospects of the project are favorable. We then test these ideas empirically using a panel data-set of activity in one hundred open source projects between 2001 and 2004. We find several patterns consistent with theoretical predictions.

## "Moment Inequalities and Their Application" A. Pakes, J. Porter, Kate Ho, and Joy Ishii

*Abstract*
This paper provides conditions under which the inequality constraints generated by either single agent optimizing behavior, or by the Nash equilibria of multiple agent problems, can be used as a basis for estimation and inference. We then add to the econometric literature on inference on the parameters of models defined by inequality constraints by providing a new, easy to use, specification test and method of constructing confidence intervals. The paper concludes with two applications which illustrate how the use of inequality constraints simplify the problem of obtaining estimators from complex behavioral models.

## "Digital Rights Management and the Pricing of Digital Products" by Yooki Park and Suzanne Scotchmer

*Abstract*
As it becomes cheaper to copy and share digital content, vendors are turning to technical protections such as encryption. We argue that if protection is nevertheless imperfect, this transition will generally lower the prices of content relative to perfect legal enforcement. However, the effect on prices depends on whether the content providers use independent protection standards or a shared one, and if shared, on the governance of the system. Even if a shared system permits content providers to set their prices independently, the equilibrium prices will depend on how the vendors share the costs, and may be higher than with perfect legal protection. We show that demand-based cost sharing generally leads to higher prices than

revenue-based cost sharing. Users, vendors and the antitrust authorities will typically have different views on what capabilities the DRM system should have. We argue that, when a DRM system is implemented as an industry standard, there is a potential for "collusion through technology."

## "Still Looking for Lost Profits: The Case of Horizontal Competition", by Mark Schankerman and Suzanne Scotchmer

*Abstract*
When infringement of a patent dissipates profit relative to the licensing agreement that would otherwise occur, damages under the lost-profit rule deter infringement, and otherwise not. We develop this point in a general model and give two examples. However, joint profit might not be dissipated by infringement. An important example is where there are restrictions on licensing that arise from competition policy.

## "Picking Winners in Rounds of Elimination", by Suzanne Scotchmer

*Abstract*
A defect of intellectual property as an incentive mechanism is that researchers must pay the costs of research long before receiving a reward. Self-finance is often not an option. For potential funders such as venture capitalists and public sponsors, the problem is to find the most promising researchers or projects, and to do so before the research is complete or the commercial prospects certain. Funding involves rounds of elimination, which serve as a screening mechanism. In this paper I study elimination mechanisms with and without memory, and show how the structure of elimination rounds involves a tradeoff between screening and costs. Public sponsors and venture capitalists may deviate in different ways from what is optimal.

## "Open Source software : The new intellectual property paradigm", Stephen M. Maurer and Suzanne Scotchmer

*Abstract*
Open source methods for creating software rely on developers who voluntarily reveal code in the expectation that other developers will reciprocate. Open source incentives are distinct from earlier uses of intellectual property, leading to different types of inefficiencies and different biases in R&D investment. Open source style of software development remedies a defect of intellectual property protection, namely, that it does not generally require or encourage disclosure of source code. We review a considerable body of survey evidence and theory that seeks to explain why developers participate in open source collaborations instead of keeping their code proprietary,

## “The Steady-State Growth Theorem: Understanding Uzawa (1961)”, by Charles I. Jones and Dean Scrimgeour

*Abstract*
This note revisits the proof of the Steady-State Growth Theorem, first given by Uzawa in 1961. We provide a clear statement of the theorem and a new version of Uzawa's proof that makes the intuition underlying the result more apparent. For example, in the special case of factor-augmenting technical change, the effective inputs BK and AL must grow at the same rate in steady state; otherwise trends in the factor shares are induced. The fact that effective inputs must balance suggests a new interpretation of balanced growth. Because capital accumulates and therefore inherits the trend in AL, the balance condition implies that technical change must be purely labor augmenting.