

THE TOULOUSE SCHOOL OF ECONOMICS MAGAZINE

TSE MAG

Living economics

THE FUTURE OF FINANCE

#16
SPRING
2018

Daniel Ershov on
the Google Play
Store

Johannes Hörner
on how Waze uses
its users

Ariel Pakes on
why industrial
organization matters

Patrick Pouyanné
on the energy
challenge

Looking to the future

Last year marked TSE's 10th anniversary, a milestone in the long history of economics in Toulouse. 2017 also saw our endowment strengthened through the renewal of our *Laboratoire d'Excellence* status and an exciting new certification for our "CHESS" graduate school project - Challenges in Economics and Quantitative Social Sciences. We are grateful for and proud of these strong signals of support which will help our institution tremendously.

TSE wasn't built in a day. It took more than 30 years for Jean-Jacques Laffont and the leading academic peers he convinced to join him to accomplish his dream of building a world-class economics department in Toulouse with bright, intense academic life. We are lucky to be now living that dream, but our ambition for this new year does not waver. We want to aim higher and attract the very best talents to the south of France. Our minds are focused on the future; our new building, now almost complete, will be another great asset in making our community one of the best places in Europe to do research. As will the "10-vision project" committee which is currently coordinating a community-wide effort here to map out our new 10-year strategic path for both research and education.

The TSE community is working hard on the economic impact of cutting-edge technologies and this edition features a special dossier on the future of finance. Financial institutions and regulations have always rapidly evolved, yet the ongoing changes led by automation, blockchain technology, cryptocurrencies, tax reforms, shadow banking and such forth are reshaping the finance world like never before. To help readers better understand and assess these changes, we present here some of the latest work and perspectives from the TSE faculty.

We are also delighted to include in this edition an extensive interview with the CEO of Total Patrick Pouyanné on the future of the energy industry, as well as an in-depth interview with Ariel Pakes, the 2017 Jean-Jacques Laffont Prize laureate, on industrial organization and its policy implications, as well of course as the latest news and results from our faculty.

Wishing you a pleasant read, and a very happy new year 2018,

Christian Gollier, TSE Director
Jean Tirole, TSE Chairman



Christian Gollier

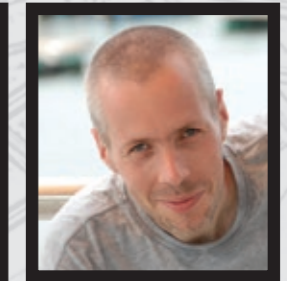


Jean Tirole

The ongoing changes led by automation, blockchain technology, cryptocurrencies, tax reforms, shadow banking and such forth are reshaping the finance world like never before.

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Trimestrial magazine of Toulouse School of Economics
21, allée de Brienne - 31015 Toulouse Cedex 6 - FRANCE - Tél. : +33 (0)5 67 73 27 68

Publication Director: Christian Gollier - Managing Editor: Joël Echevarria
Editor in chief: Jennifer Stephenson - Production Manager: Jean-Baptiste Grossetti
With the help of: Claire Navarro - James Nash
Graphic design and layout: Yapak
Pictures: ©Studio Tchiz, ©Fotolia, ©Istock, ©Total.

1000 magazines printed on offset paper from renewable forests. ISSN: 2554-3253

Appointments & prizes



📍 TSE celebrates award of €10.8 million for CHES project

The international jury of the "Ecoles universitaires de recherche" chose to support TSE's project Toulouse Graduate School Challenges in Economics and Quantitative Social Sciences (CHES) with €10.8 million over 10 years.

📖 Two new books

by Jean-François Bonnefon

Reasoning Unbound, Thinking about Morality, Delusion and Democracy, was published by Palgrave Macmillan at the end of 2017 and details the way human reasoning is aimed at cooperative social life. Jean-François Bonnefon (TSE-CNRS-CRM) has also co-edited *Moral Inferences*, featuring the latest research on the relationship between morality and reason.



📍 Ethical Asset Valuation and the Good Society

In his latest book, TSE vice-president Christian Gollier builds a bridge between welfare economics and finance theory to provide a framework for ethical valuation capable of establishing what asset prices should be on the basis of our shared moral values. *See pages 20-21.*



📍 New international partnership with National University of Singapore

TSE and the University of Toulouse Capitole are delighted to announce they have signed a new collaboration with the National University of Singapore (NUS). Starting in 2018, this new agreement will allow students to complete semester or year-long exchanges. NUS is consistently ranked as one of the world's top universities.



📍 Milo Bianchi wins funding for financial literacy project

The TSE-UTC researcher will have the support of the Think Forward Initiative for a research project on the impact of financial literacy on financial vulnerability. The Initiative brings together a range of experts and research to find out how and why we make financial choices.

📍 TSE helps to project a new voice for research in Europe

EconPol Europe (the European Network for Economic and Fiscal Policy Research) is a unique collaboration of policy-oriented university and non-university research institutes that will contribute their scientific expertise to the discussion of the future design of the European Union. The network was commissioned by the Federal Ministry of Finance and founded in 2017 by the Ifo Institute together with eight other renowned European research institutes.

With its cross-border cooperation on fiscal and economic issues, EconPol Europe aims at promoting growth, prosperity and social cohesion in Europe and, in particular, at providing research-based contributions to the successful development of the European Economic and Monetary Union (EMU).



📍 Vincent Réquillart discusses food economics

The TSE-INRA researcher engaged with Nutrition & Santé CEO Didier Suberbielle to debate Vincent's recent work on the importance of public policies on the nutritional and environmental impact of food.



📍 Ingela Alger presents her research at 'Women in Science' event

This CNRS-sponsored series of events aims to shed light on female scientists in different disciplines. Ingela Alger (TSE-IAST-CNRS) talked about her research on motivation and morality.

Save the date

29-30 MARCH 2018

10th Biennial Postal Economics Conference

17-18 MAY 2018

Environmental regulation and industrial performance

24-25 APRIL 2018

CGD Working Group on Global Health Procurement

18-19 MAY 2018

16th Joint Workshop on Industrial Organization

4-5 MAY 2018

Financial Econometrics Conference

24-25 MAY 2018

6th Toulouse Economics and Biology Workshop

tse-fr.eu/events

DANIEL ERSHOV ON THE GOOGLE PLAY STORE NATURAL EXPERIMENT

Reducing search costs

Daniel Ershov joined TSE in September 2017 as an assistant professor. His main research interests are firm competition, market regulation, and online markets. He recently worked on the Google Play Store re-categorization of applications and tells TSE Mag about his main findings.



Daniel Ershov
TSE assistant professor

Contrary to expectations, the Internet did not eliminate consumer search costs. Indeed, with the proliferation of product varieties, “discoverability” online is a major concern for consumers, firms and regulators. Firms may not want to enter or invest in high quality products if they cannot be found by consumers. Regulators are concerned that platforms, by changing search algorithms and consumer search costs, can influence firm entry, investment incentives and the degree of online competition. These considerations played a role in the European Commission’s 2.4 billion euro fine to Google.

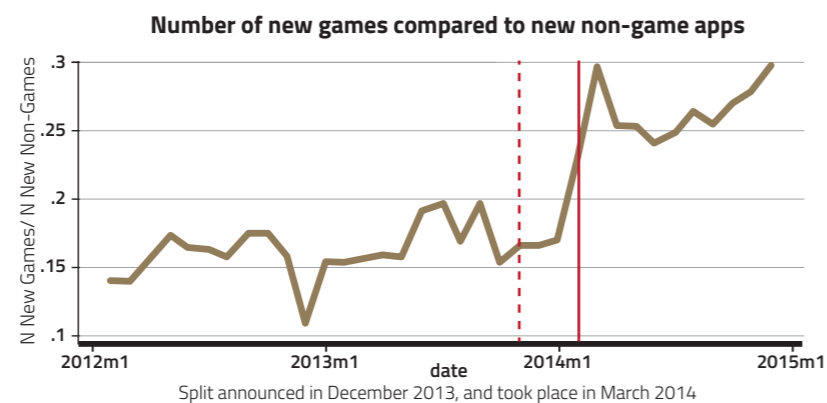
I empirically study these effects using new data from the Google Play mobile app store, a large online market where most products are free to download. App stores have a large number of products: thousands of new apps appear every week, and it is costly for consumers to search for new products.

App stores are broadly separated into “game” and “non-game” areas, and surveys suggest that consumers primarily search for apps by browsing through categories in the app store (e.g., “Productivity Apps”). I take advantage of a natural experiment: a re-categorization of part of the Google Play store. In March 2014, Google split its game categories from 6 to 18. Industry observers believe that this reduced consumer search costs. Before the change, consumers browsing through the categories would see different app types together (e.g., Family Games and Action Games). Consequently, consumers looking for an app type would not necessarily find it easily.

The re-categorization of the store was a surprise to game developers. Additionally, it did not affect the “non-game” area of the store and non-game developers. I use difference-in-differences to capture three key effects: First, 33% more games enter relative to non-games after the re-categorization. Second, most entry effects are driven by “niche” app types that were more difficult to find before the re-categorization. Lastly, the quality of the new games – as measured by consumer ratings – fell after the split relative to new non-games. These results

App stores have a large number of products: thousands of new apps appear every week, and it is costly for consumers to search for new products

While there is a large existing literature on search costs, it mostly focuses on the effects of search costs on prices and largely ignores non-price effects such as entry or product quality. These non-price effects are important, particularly in the numerous online markets where prices are uniform (e.g., iTunes) or are zero (e.g., SoundCloud). In a working paper, titled “The Effect of Consumer Search Costs on Entry and Quality in the Mobile App Market”, I examine how consumer search costs in online markets affect market structure, product variety, quality, and consumer welfare.



confirm existing theoretical predictions, but are new to the empirical literature.

I show that welfare increases by almost 60% following the re-categorization, and most of the welfare gains come from reduced search costs

The overall impact of the re-categorization on consumer welfare is not easily measured since most apps are free. In addition, the different effects of re-categorization can point in opposite directions.

Consumer welfare should improve due to more product variety and lower marginal search costs. However, consumers should also like quality. Conditional on the number of products, a greater share of low quality products would reduce consumer welfare. A larger share of low quality products could also make it harder to find high quality products.

To measure and decompose the welfare implications of the re-categorization, I set up a structural model of consumer search and demand, and firm entry. I show that welfare increases by almost 60% following the re-categorization, and

most of the welfare gains come from reduced search costs. Nonetheless, about 25% of the welfare gains are from increased product variety, which overwhelm the small negative effect of the change in quality. These results have important implications for anti-trust cases in online markets. They are the first evidence suggesting that when consumer search costs increase (the inverse of the decrease I observe), consumer welfare can decrease via two channels: a direct decrease due to higher search costs, and an indirect decrease due to a foreclosure effect that reduces product variety.

JOHANNES HÖRNER ON SOCIAL LEARNING AND INTERNET PLATFORMS

Why would Waze send you off-track?

A specialist in economic theory, Johannes Hörner joined TSE in September 2016 from Yale through the AXA chair, attracted by the Toulouse lifestyle, the TSE project and its unique environment. We asked him about his forthcoming article in the *Quarterly Journal of Economics*, written with Yeon-Koo Che on the optimal design for social learning, or how to implement systems that are better for everyone collectively, even when they put more strain on some individuals.

What was the idea behind this article?

I met Yeon-Koo Che (Columbia University) at Yale in 2014 when he came visiting. He is a specialist in recommendation systems and I have spent a lot of time working on experimentation. From our discussions rose the idea that it could be interesting to have a look at the social learning aspects of recommendation systems, especially for internet platforms.

Waze has an interest in sending an individual driver to a road that could be blocked or slow if the service doesn't have any information on its status

We know that recommendation systems, such as Google, Pandora or Waze, need a lot of information to improve their results. They need to know, from user feedback, that a website isn't pertinent or about the quality of a recent music album. This need for information incites them to skew their recommendations for some users so they can learn what they need to know and in return propose overall better recommendations, and we wanted to understand

how these two different optimums, the overall optimum and the individual optimum, balanced each other.

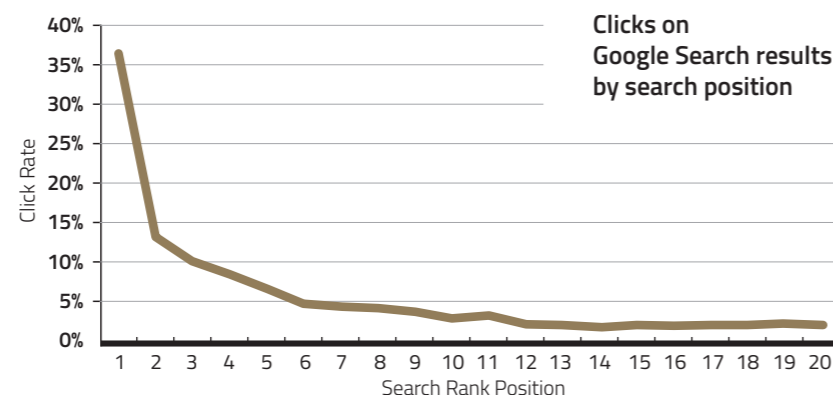
What are possible strategies for recommendation companies?

It depends a lot on the market they're into, and on their recommendations. An example of how to circumvent this issue is, when possible, to ask experts to weigh in on the recommendations that should be issued. For instance, Pandora asks musicologists to dissect music and assess numerous characteristics, such as rhythm, instruments, etc. This data allows the radio website to give better recommendations on newly released music without having to skew some users' playlists to try to get their



feedback. Michelin, for example, gives out restaurant recommendations based only on their experts' taste and opinion.

But in many cases, experts can't be used, and the ideal strategy then is to send skewed recommendations to a few users when the company needs to know something. For example, Waze has an interest in sending an individual driver to a road that could be blocked or slow if the service doesn't have any



Companies should consider incentives more seriously when they plan their recommendation strategy

information on its status. This driver's GPS will then let Waze know whether the road is slowed and then allow the service to update its recommendations for all the users.

What are the issues with such a strategy?

There are two issues with such a strategy. First, it means that some users will sometimes receive terrible recommendations so that other users can benefit from their information. This is a classic case when firms should try to subsidize individuals for these types of recommendations.

The second issue is that users might understand and recognize a skewed recommendation. In the Waze example, the individual could know or estimate that the road Waze recommends isn't the best one and decide not to follow the service's directions. This makes users less confident about the service. Even worse, users can understand that the service is sometimes using them as guinea pigs, and then assess, for each recommendation, whether it's a real or test one.

So we tried to understand what happens when Pandora or Waze know that users shouldn't realize that they are being used as guinea pigs, because if the information they deliver is too obviously a test, it will make users very wary of their services. We tried to find out how far companies can go before hurting consumers' trust.

What are the main results from your article?

One of the main conclusion is that companies should consider incentives more seriously when they plan their recommendation strategy. Another key insight is that their capacity to use their users to receive information depends on their credibility. The more credible they are perceived (and, usually, then, the more pertinent are their recommendations), the more tolerant users will be with skewed results. Finally, we show that their credibility is proportional to their consumers' knowledge of being tested, and of their capacity to get information without using consumers' feedback. Something that would be very interesting to analyze in the future, is how those platforms' recommendations can sometimes affect themselves, such as when Waze tells all its users to take a road and thus causes new traffic pressures.

ARIEL PAKES, HARVARD

Industrial organization finally matters

Every year, the Jean-Jacques Laffont Prize rewards an internationally renowned economist whose work combines both theoretical and empirical research. Last year's recipient was Ariel Pakes, professor of economics at Harvard. Much of his impressive methodological work has been incorporated into the way government agencies evaluate the impact of policy changes. TSE Mag caught up with him to discuss his work.

What future do you see for empirical industrial organization?

It's getting richer all the time; it can explain many things. Certain subfields are picking up on IO and using the tools that we have developed to analyze different policies. For example, in the US, where health insurance is a big issue, there has been a lot of work on the implications of the entitlement program and its cost, and on the incentive schemes that could make the cost of US healthcare go down at no cost to quality.

Many IO tools are also being used for environmental policies - carbon taxes, standards on cars for emissions, coal plants - and public finance. For instance, for the study of the implementation of taxes and other government policies, demand systems developed in IO are used to evaluate welfare.

Other than when I do methodology rather than actual applications, there are several issues open for people like me, such as moving to a more careful analysis of dynamics which will require

More and more lawyers are learning economics and you have to be able to explain it in words that aren't equations. If it's a good model, you should be able to do that

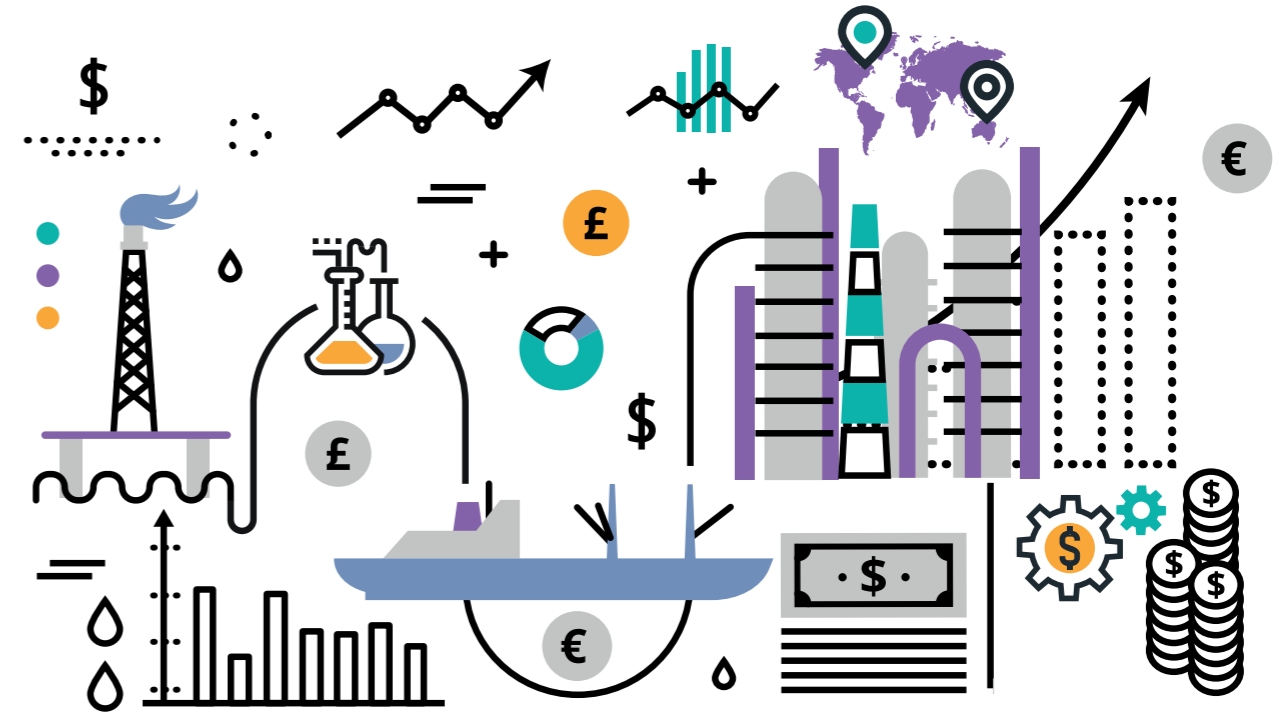
more theory as well as more econometrics and data.

Dynamics in our field means the development of products, R&D, telecommunication. We do not quite have our models ready to analyze that, but we're getting closer! You don't stop doing research because you are not at a place where you can give answers yet, or you will never get to a place where you have answers.

What are your thoughts on current antitrust policy, especially in the light of increasing corporate consolidation?

The institutions and courts have become more and more able to listen to economists and economists' models. I'm actually quite surprised! Fifteen years ago, nobody used our tools. You would go in, one side would argue one thing, the other side would argue the other thing and there would be no model and no data.

Now the courts listen quite frequently and attempt to use our tools. Most of the time they don't have the time to do the research that we would consider for an article, but they listen very carefully



At the time of the Microsoft case, I was asked to be on the government's side. I thought about it for a while and I said: "I don't know the answer and neither do you, and you won't know the answer in the next three years"

the judge. It was just like I was giving a class on the topic. I must admit I was rather impressed. More and more lawyers are learning economics and you have to be able to explain it in words that aren't equations. If it's a good model, you should be able to do that.

Is there any particular methodology that you would like to see being used for antitrust policies?

The basic issue for antitrust authorities is that they have limited time: they would use our tools all the time if they could. However, shortcuts have been developed, like the diversion ratio. If you increase your price a little bit, you get an extra dollar from people who stay, and you lose price minus marginal cost from the people that leave due to the price increase. When you do a merger,

these people who leave might actually go to the product of the other merging firm. A big factor, if you do the demand system appropriately, will be the fraction of people who leave and go to the other product. The higher that proportion, the higher the price increase, according to the theory.

They make serious attempts, when they don't have time to do a whole demand system, just to estimate the fraction of people who would leave and go to the other products. They do a survey asking, "If we took this product out of the market, what other products would you go to?" That's an attempt to mimic the demand system, and you can do that relatively quickly, especially if it's a business firm, where there aren't that many consumers. It makes sense from the point of view of the model, at least for some things.



Jean Tirole and Ariel Pakes

...

There are mergers of content providers with cable television networks, and the authority that had to sign off on these mergers started using very complicated economic models to figure out what would happen after the merger. While they don't bring these models to court, it can allow them decide whether or not it's worthwhile going forward with the case. The fact that the models aren't brought out in court doesn't mean they haven't been used in the process of deciding what goes to court.

How do you think antitrust authorities can respond to tech firms such as Google?

At the time of the Microsoft case, I was asked to be on the government's side. I thought about it for a while and I said: "I don't know the answer and neither do you, and you won't know the answer in the next three years." Somebody has to make a decision and in cases like that, people who are closer to the industry are likely to know more than me, if I don't have the tools to investigate it in the appropriate way.

A similar question came to me when we worked with General Motors. They gave us their data, took our models and started using them for their own stuff. Their head of research came to me one day and said: "What about dynamics? What should we do dynamically? What new products do we produce?" And I said: "At this stage, you know better than me!" There are things for which we are not really able to help very much yet.

On collusion and cartels, we are much more able – we've had quite a bit of theory and a bit of empirical work. The policy issues are often related to the courts who find it very difficult to bring a case unless there's what's called a "smoking gun", for instance, when somebody has

taped somebody about doing something like setting prices in a meeting.

In the ADM case [Lysine antitrust case], the reason they were able to get a conviction is they actually sent someone in with a tape recorder to one of the meetings. We know of mechanisms that can support cartel-like behavior. So for an IO economist, a cartel-like behavior is a behavior that is above our equilibrium prices.

The equilibrium we usually think about is: I set my price to do the best I can given what everybody else is doing; they set their prices the same way, and then nobody has an incentive to deviate.

A cartel will set a price above the equilibrium price, so you have to ask, "Why do other people follow?" Because if it's above the equilibrium price, it means that the other people are not in equilibrium, and they have incentives to price lower and make more money. The reason they don't is that there is some punishment scheme in the future: it becomes a dynamic problem. They know that if they decrease their price, then tomorrow I will kill them. Price much lower and you will have a price war.

We know a lot about how to handle cartels. One of the problems is that the courts have typically needed some smoking gun. They must be able to tell that you have done something illegal.

If this is the case, in the US it's a "per se violation", which means that it doesn't matter if it has harmed society or not, you're guilty. In Europe, that's not the case, it's the "rule of reason" which says that maybe it was productive for society to have a cartel. Prices are higher, so consumers pay more – that's bad. On the other hand, as prices are higher you may develop new products and now there is an incentive to build new products.

If you look at the dynamics, it's not always the case that collusion is a bad thing, hence "the rule of reason" rather than "per se violation". The problem with doing that more generally is that you will get a whole load of court cases, because it's very hard to distinguish between what's in society's interest and what's just raising price to make more money!

We know about analyzing the cartel issue, but the issue is that you have to make judgments on whether this tradeoff between more products or more investment versus prices going up is good or bad for consumers. Often it will be good for some consumers but bad for others. It's a very complicated tradeoff but we know how to make it; whether the courts or the government listen to us is different.

As a member of the TSE scientific council, what is your view on its evolution?

I've watched it grow a lot. Jean-Jacques Laffont invited me to the first conference in 1992, when he invited a bunch of people from the US who he thought were doing interesting things. Most of my famous stuff wasn't yet published.

TSE has grown a tremendous amount and the big difference in the last few years has been the number of junior faculty here. That's terrific! Older people like me accumulate responsibilities, we have to run around a lot, we're on boards of editors and various other things. The fact that you have a large young group that interacts with each other and keeps each other excited is very important and it's very new. They look like they're having a blast. It feels like a dynamic institution. There aren't that many places with this many young people doing research, both empirical and theoretical. ■

Jean-Jacques Laffont Prize laureates



2017

Ariel Pakes



2016

Susan Athey



2015

Elhanan Helpman



2014

Joseph Stiglitz



2013

Eric Maskin



2011

Robert Townsend



2010

Robert Wilson



2009

Roger Myerson



2008

Richard Blundell



2007

Stephen Ross



2006

Daniel McFadden



2005

Peter A. Diamond



2004

James Heckman



2003

Olivier Blanchard



2002

Tony Atkinson



2001

Dale Jorgenson



2000

James Mirrlees



1999

William Nordhaus



1997

Hayne Leland



1996

Paul Samuelson



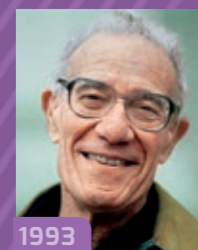
1995

Kenneth Arrow



1994

Jacques Dreze



1993

Robert Solow

THE FUTURE OF FINANCE

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JEAN TIROLE ON THE POST-CRISIS ENVIRONMENT

Is the financial system safe?

The 2008 financial crisis, like the euro crisis, had its origin in the failure of regulatory institutions. Despite heavy scrutiny and sweeping reforms, is the financial system now any safer? In these edited extracts from his book 'Economics for the Common Good', TSE chairman Jean Tirole looks for answers in the post-crisis financial landscape.

No financial instrument or transaction is bad in itself, provided that a) the risk is well understood by the parties using it, and b) it is not used to put an uninformed third party at risk. Properly used, financial instruments contribute to the dynamism of the economy. It is more constructive to engage in the inevitably technical debate about market and regulatory failures than to reject wholesale the achievements of modern finance.

What if low interest rates leave us unable to reenergize the markets and prevent recessions and unemployment?

But it is undeniable that these instruments make financial supervision more complex, that "financial innovation" is often just a way of getting around the rules and exposing small investors or

taxpayers to major risks, and that the numerous abuses should be eliminated.

Low interest rates

Very soon after the 2008 crisis began, the US, European, and British central banks provided much liquidity and thereby reduced interest rates to close to zero — in other words, to negative levels allowing for inflation. Japan has had an interest rate below 1 percent since the mid-1990s; in 2017, it is zero.

Low interest rates in downturns provide liquidity. Yet low interest rates have gigantic redistributive effects (for example, from savers to borrowers) that are not always desirable. They can also encourage financial bubbles and risk-taking, laying the foundation for the next crisis. And when nominal rates hit zero, the central bank can no longer use them to boost the economy.



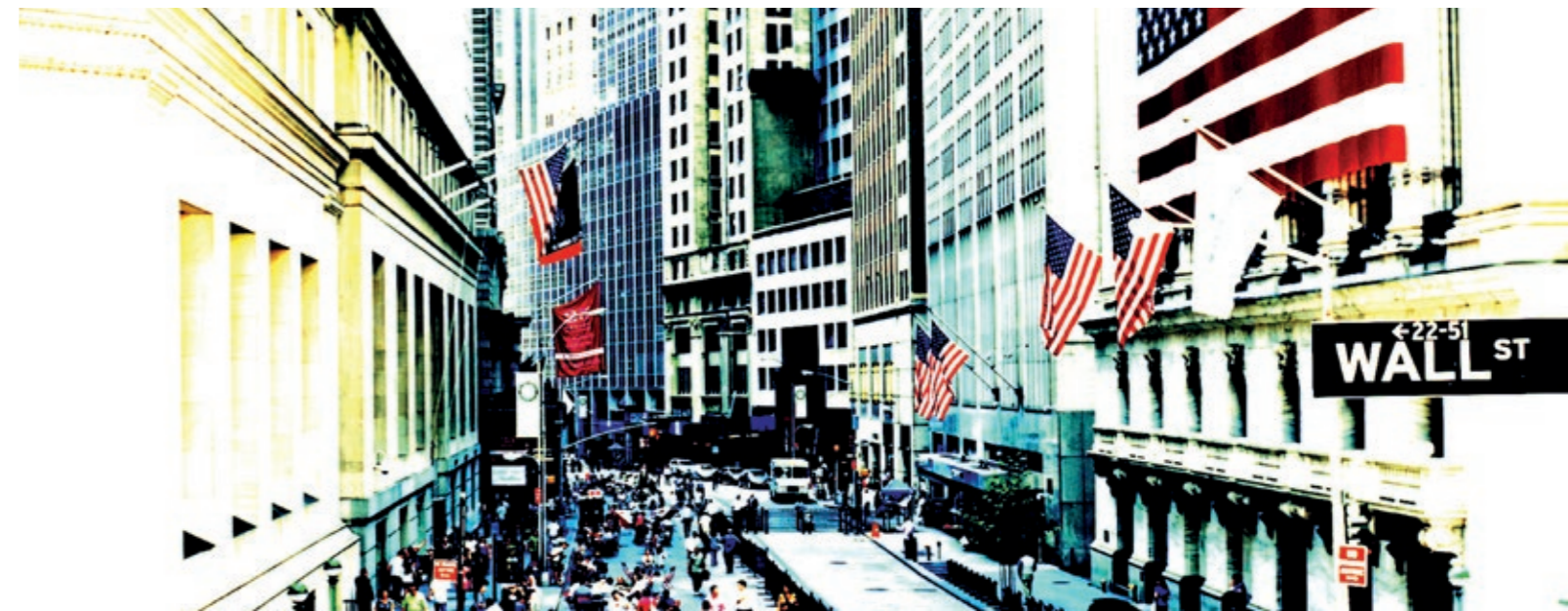
Jean Tirole
TSE Chairman

What if low interest rates are not a temporary phenomenon? What if monetary policy is unable to reenergize the markets and prevent recessions and unemployment? One certainty is that there has been a decrease in interest rates on safe assets since the 1980s. If low interest rates are here to stay, we will have to rethink macroeconomic policies.

Nothing is without risk

We need to respond vigorously to the failures of financial regulation, and to reduce the frequency and scale of crises, but we cannot eliminate the danger. Prudential regulation and supervision are more art than science, but there are some general principles we can use.

In 2008, a number of economists, including myself, recommended protecting regulated institutions against the risk of contagion from the unregulated sector; increasing their levels of equity capital and putting greater emphasis on liquidity; making regulation more countercyclical; monitoring the pay structures of senior bank officers so as not incentivize excessive risk taking; allowing securitization, but supervising how it is used; monitoring the rating agencies; rethinking the "regulatory infrastructures"; and, in Europe, creating a supervisor on the European level within the ECB. Regulatory reforms have gone in part in this direction.



If reforms are implemented, the financial system will be less risky: Basel III seems to be headed in the right direction

Safer systems

Regulators, central banks, and governments have been forced to intervene to rescue financial institutions they did not regulate through bailouts, buying up toxic products, and loosening monetary policies. Reforms should now aim to prevent as much as possible the shadow banks difficulties from spreading to the regulated sphere.

The current state of our knowledge should encourage us to be humble. Economists still do not know enough about how prudential regulation ought to operate, including the extent to which investors should be held responsible for their investments in regulated institutions and, of course, about the proper calibration of capital and liquidity requirements.

However, if the reforms are implemented, the financial system will prove to be less risky than before: the Basel III reforms seem to be headed in the right direction. An increased requirement of equity capital, the introduction of a minimum liquidity ratio, the inception of macroprudential

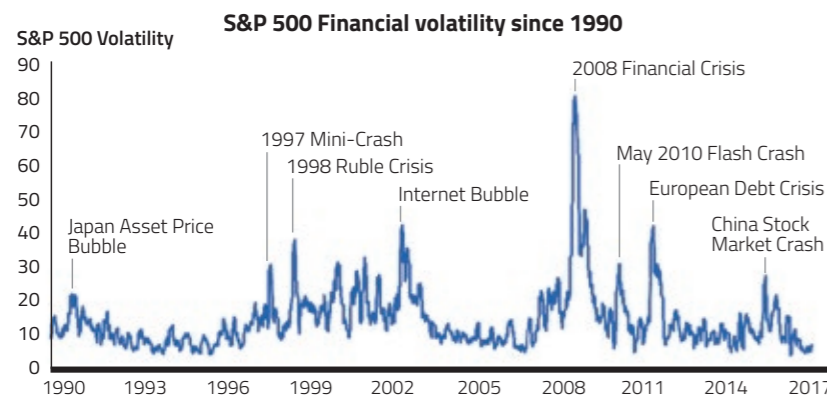
measures in the form of countercyclical equity capital buffers, a greater use of centralized exchanges instead of over-the-counter markets, institutional reforms (for example, the creation of the European Single Supervisory Mechanism) — all are genuine improvements.

Danger areas

There are still, however, major areas of risk. For one thing, regulatory principles differ from their implementation and supervision. It is important that the transposal of international accords into national laws and the supervision of banks by national regulatory authorities not vitiate the spirit of the accords.

Macroeconomic concerns include slower global growth, more volatile financial markets, and the challenge of how to exit low interest-rate policies without compromising growth.

Other concerns stem from the combination of geopolitical risk and local economic conditions — for example, in Europe political shocks such as the UK's Brexit vote, the political uncertainty over the EU, the structural weakness of certain economies, the significant proportion of unproductive loans still on European (especially Italian) banks' balance sheets, and the intimate connections between banks and sovereign states. There is uncertainty about how China will transition from a catch-up economy to one on the frontiers of technology and institutional design (including managing its credit bubble and reforming financial markets). In the emerging economies, over-indebtedness in foreign currencies may put businesses and banks in difficulty if the local reliance on commodities is associated with inadequate risk management.



Shadow banks

The current growth of the unregulated "shadow" financial sector is likely to pose problems in the future, mirroring the lack of oversight of the great investment banks before 2008.



For Jean's latest research in this area, read his paper with Emmanuel Farhi 'Shadow Banking and the Four Pillars of Traditional Financial Intermediation' at www.nber.org/papers/w23930

Blockchain: a miner miracle

Originally designed to validate transactions in the Bitcoin virtual currency network, blockchain technology looks set to revolutionise 21st-century finance. Expected effects include the disappearance of obsolete intermediaries, improved security and drastic reduction in transaction costs. Catherine Casamatta teamed up with fellow TSE researchers Bruno Biais and Christophe Bisière, as well as McGill University's Matthieu Bouvard, to analyse the stability of blockchain protocol using game theory.

Blockchain technology represents a very effective solution to a generic problem: how to maintain a decentralised, shared register of transactions and assets when its participants do not necessarily trust each other?

How do we maintain a decentralised, shared register when its participants do not necessarily trust each other?

How does a proof-of-work blockchain protocol work?

In a blockchain, the flow of transactions to be validated is directed to participants called "miners". Each miner stores these transactions in a block, adds a special transaction corresponding to his reward for that block, then tries to validate that block. To do this, the miner must solve a difficult numerical problem, using the brute force of trial and error. The successful miner disseminates this block and its solution (the "proof-of-work") within the network. The other miners check the solution is correct, and the transactions in the block are valid, and mark their acceptance by abandoning

their current block and by mining a new block of transactions, attached to the winning "parent" block. The process of searching for and sharing solutions continues, creating a sequence of validated blocks, representing the current state of the register. A single chain reflects a perfect consensus among participants about validated transactions.

Wasteful forks

Miners, however, may choose to discard certain blocks, starting a fork that deviates from the original chain. This creates competing versions of the ledger, reducing the credibility and reliability of the blockchain, especially if the fork is persistent. Even if, eventually, all miners agree to attach their blocks to the same chain, the occurrence of the fork is not innocuous. The blocks in the chain eventually abandoned are orphaned. They have been mined in vain, and the corresponding computing power and energy have been wasted. Moreover, the transactions recorded in the orphaned blocks may be called in question.

Coordination game

To analyse blockchain's stability, Catherine and her colleagues build a model in which miners instantaneously observe



Catherine Casamatta
UTC - TSE

transactions and solved blocks, and are only rewarded for solving blocks. Their analysis uncovers two important economic forces at play in the blockchain. First, miners' actions are strategic complements. Indeed, their rewards depend on the credibility of the chain on which they are solving blocks. This credibility is higher if more miners are active on it. Hence, miners benefit from coordinating on a single chain, which they can achieve by playing the "longest chain rule", that is by considering the longest chain to be the correct one (Nakamoto, 2008). However, the same coordination motives sustain equilibria with forks. If a miner anticipates all other miners will create a fork, his best response is to follow them.

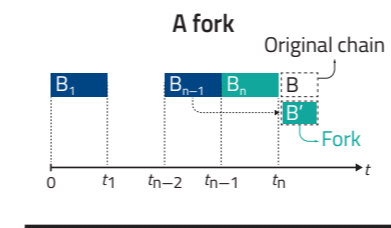
Second, they identify a countervailing force: if a miner has accumulated rewards on a given chain, the miner has a "vested interest" in this chain remaining active. Vested interests may counteract



Formal analysis suggests blockchain design, by generating complementarities and vested interest, is subject to instability

coordination motives, inducing miners to keep working on a minority chain, and sustaining persistent forks. Unlike temporary forks that only rely on coordination motives and would arise with atomistic miners, equilibria with persistent forks depend on miners taking into account how their actions affect the value of their rewards.

Overall, this analysis suggests that the blockchain design, by generating complementarities and vested interest, is subject to instability.



Consensus and dissensus

The researchers also investigate how frictions typically associated with dissensus and forks relate to these economic forces. For instance, communication delays may generate transient forks as some miners do not immediately realise that a new block has been solved. Some miners may also derive extrinsic benefits from creating a fork: it can allow them to void previous transactions and recover the corresponding cryptocurrencies ("double-spending"), or to push technical solutions that give them a competitive edge ("upgrades"). The researchers incorporate these frictions in their model and show that while they may act as triggers (instead of sunspots), the same fundamental interplay of coordination motives and vested interests as in the frictionless case underlies equilibria with forks.

Finally, they look at the computing capacity that each miner installs. Because the difficulty of the mining process is typically adjusted upwards when the total computing capacity in the network increases, a miner's investment in computing power

exerts a negative externality on all other miners. This gives rise to an arms race in which each miner ends up over-investing. This analysis points to another source of inefficiency in blockchain's decentralised design.

Summing up

The researchers' analysis suggests that miners' incentives are key to the production of a robust consensus in a blockchain. While miners benefit from coordinating on a single chain, thereby maintaining consensus, coordination motives may also lead them to abandon portions of the blockchain. This jeopardises the blockchain's key function, i.e., producing a stable and immutable history of transactions. In addition, vested interests, by counteracting coordination motives, may lead to the persistence of multiple active chains.

For more details, see 'The Blockchain Folk Theorem' a working paper by Bruno Biais, Christophe Bisière, Matthieu Bouvard and Catherine Casamatta.

We need to better invest for the future

By controlling the allocation of capital, financial markets hold the key to the great challenges of our time, such as the fight against poverty, climate change, and cancer. In his latest book, 'Ethical Asset Valuation and the Good Society', TSE co-founder Christian Gollier suggests that this power can only be harnessed if we can determine the financial prices that are compatible with the public good. In particular, he shows how the valuation of long-term risk and time, based on transparent moral principles, can help to guide our choices for the future.

Can financial markets decentralize an efficient allocation of scarce resources? There are strong arguments, well-studied at TSE, for believing that markets are not good at eliciting our collective values or aligning private interests with the public good. Agency problems such as moral hazard and adverse selection inhibit market efficiency, and the inability to trade with future generations prevents markets from efficiently valuing assets and investments that benefit future generations. More importantly, corporate profits do not fully internalize the impacts from production on social welfare. For example, the emission of greenhouse gases remains mostly free of charge, despite their destructive impact.

Two prices drive most financial decisions: the price of time, which is the interest rate, and the price of risk

If markets are unable to aggregate our collective values, how can we evaluate private and public acts? How should we, for example, compare environmental protection with job protection, lives in Bangladesh versus purchasing power

in Europe, workplace safety against corporate profits, reduced inequality versus growth, or more consumption today or in 200 years? Debating social values should be at the root of our democracy. If these values are incompatible with observed market prices, then public authorities should implement corrective actions.

The price of time

Two prices drive most financial decisions: the price of time, which is the interest rate, and the price of risk. The choice of interest rate determines whether we do too much, or too little, for future generations. Too high an interest rate inhibits investment for the future. Too low an interest rate induces excessive investment, forcing people to sacrifice too much current well-being.

The level of our collective aversion to inequality is a key determinant of the socially desirable interest rate. In a growing economy, investing for the future increases intergenerational inequality. So the interest rate should be the minimal rate of return on a safe investment that compensates for this increased inequality. If Western consumption per capita continues to grow at 2 percent per year, people living two centuries from now



will be more than 50 times wealthier. This context justifies a high discount rate of 4 per cent per year.

However, deep uncertainty engulfs the distant future. Just as households make sacrifices by saving more when their future income becomes more uncertain, we should collectively make more effort to improve a more uncertain future. To encourage investment, we need to lower the discount rate slightly below twice the anticipated growth rate of consumption for risk-free benefits materializing within the next two to three decades. For more distant time horizons, deep uncertainty justifies discount rates close to 0 per cent.

The price of risk

Many investments for the future increase collective risk, as their benefits are larger when consumption is greater. Penalizing risk-increasing actions therefore reduces investment, which inhibits



innovation and growth. Has the tradeoff favored the maximization of growth, or the minimization of risk?

As well as improving our decisions, cost-benefit analysis is an important tool in the fight against populism

It is socially desirable to adjust the discount rate to the risk profile of each investment project by adding an investment-specific risk premium. In keeping with the calibration of the interest rate, a risk premium of around 1 percent should be used at short maturities, for projects whose risk profile is similar to the macroeconomic risk. But because of the deep uncertainty surrounding the

distant future, an aggregate risk premium of 2.5 percent should be used for very long maturities.

Financial markets penalize firms that increase the aggregate risk by raising their cost of capital. A 1-to-2.5 percent risk premium is in line with the equity premium imposed by markets on riskier firms. Much more worrying is the absence of any formal penalization of risk in the evaluation of public policies in most countries.

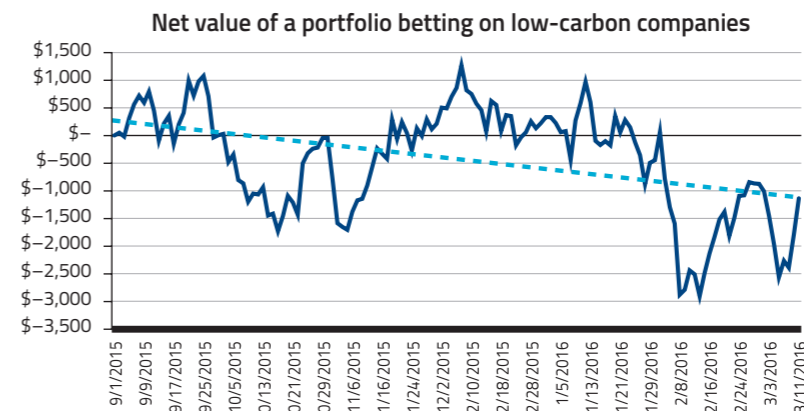
Cost-benefit analysis

Many countries have established implicit prices to evaluate the actions of public institutions. These include prices for human lives, time lost, natural assets, and carbon, in sectors as diverse as

energy, transportation, health, science, and education. These prices are subject to much debate among experts; but these debates remain inaccessible to the public, and this is unacceptable.

Ultimately, collective decisions should be made by comparing costs and benefits, using a coherent system of values. This includes a value for delaying consumption (an interest rate), a value for risk acceptance (a risk premium), and values for all the non-monetary impacts of our actions.

As well as improving our decisions, cost-benefit analysis is an important tool in the fight against populism. Lack of evaluation reinforces the impression that policies are driven by ideology rather than the common good. Instead, democracy can be strengthened by forcing politicians to make explicit the values on which their decisions are made.



Find out more
Christian refers quantitatively frustrated readers of Ethical Asset Valuation to his other recent book, Pricing the Planet's Future (2012), which provides more extensive technical details.



MARIANNE ANDRIES ON OPTIMAL INFORMATION

Who's afraid of news?

Fear of disappointment can make us fearful of new information, says TSE researcher Marianne Andries, and this has important implications for our understanding of investor behavior. In a new working paper, she proposes a theory of inattention based on the idea of information aversion. Sometimes, her results suggest, withholding information may serve us better than transparency.

When information costs are due to technological limitations, finding ways to provide more information can greatly improve market efficiency. But Marianne's research suggests such policies are not always desirable. "Experiencing the roller coaster of life can be stressful," she says. "A natural way to avoid this stress is to close your eyes for the ride."

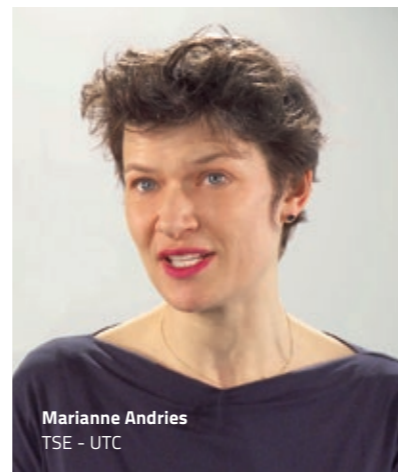
Experiencing the roller coaster of life can be stressful. A natural way to avoid this stress is to close your eyes for the ride

This idea that people might want to stay away from information draws a very different picture to that provided by standard models of inattention. In her

recent working paper, titled 'Information Aversion', Marianne's theory of inattention is solely based on fear of information, rather than on cognitive limitations or the external costs of acquiring information. In her model, disappointment-averse agents optimally decide to stay away from some sources of information. This framework has rich implications reflecting key observations on information and risk-taking behavior in the lab and in the field, among participants in financial markets.

Information costs

Together with co-author Valentin Haddad (UCLA), Marianne starts by characterizing the endogenous information costs implied by disappointment aversion, and finds them to differ fundamentally



from both the cognitive constraints and the exogenous costs commonly used in the economics literature on inattention.

Under disappointment aversion, agents inflate the probabilities of outcomes that disappoint. As information arrives, each piece of news creates scope for disappointment. The agent therefore prefers to receive less fragmented information and observe simultaneous bundles of news in which good news can cancel out bad,

disappointing, news. Such information aversion is a direct consequence of the agent's attitude towards risk.

Fearful thinking

To analyze how agents cope with their fear of information, Marianne looks at how the frequency of information observations impacts the valuation of risky lotteries. She finds her model justifies the experimental evidence that shows agents' valuations of risky assets decrease when they are given more frequent and more detailed information.

Financial institutions can foster more investment by providing 'distress' signals following sharp market downturns

She also studies how agents balance the cost of paying attention to the economic environment with the benefits of making better informed decisions. In an illustrative example, Marianne considers an information-averse investor who manages his or her wealth to finance consumption over time, allocating savings between a risk-free asset, and a risky asset yielding higher average returns.

Marianne shows that this investor optimally decides to observe the value of the risky portfolio at equally spaced points in time. In between observations, the investor consumes deterministically from a risk-less portfolio, and allocates any remaining wealth to the

risky asset. The marginal cost of infrequent observation is due to the loss in expected returns when more wealth is placed in the risk-free asset. Unique to Marianne's model, the marginal benefit comes from a relief from the stress of receiving information.

More risk-averse investors are also more inattentive, Marianne finds. Attention decreases in periods of high volatility, even when higher expected returns keep the difference between risk-adjusted returns and the risk-free rate constant. This prediction reflects an increase in the marginal cost of information as risk increases and is in line with recent empirical evidence.

Information supply

How can suppliers of information best serve the needs of information-averse investors? Marianne's model provides the basis for a theory of optimal information. Her results suggest financial institutions can foster more investment by providing "distress" signals following sharp market downturns. While an in-depth treatment of this area is left for future research, she outlines a few implications.

One way to help information-averse agents is to lump news together in bundles delivered at precise points in time. Such behavior is consistent with company disclosure policies organized around scheduled earnings announcements. Similarly, monetary policy and other macroeconomic announcements, such as employment numbers or quarterly growth, are disclosed at precise points in time, and mostly scheduled in advance.

Agents do not want to receive information too often. However, when they do observe information, they want it to be as precise and "transparent" as possible. In Marianne's framework, it can be beneficial if suppliers sometimes refrain from releasing information; but the release of partial or distorted information is not beneficial.

However, Marianne warns that this form of information withholding generates asymmetric information, and agency problems are likely to arise (for example, between an investor and her wealth manager). To account for information aversion, optimal compensation contracts need to provide the necessary incentives, while minimizing the information needed to enforce them. ■

The price of uncertainty

Economic models generally assume that investors are no more averse to immediate than to delayed risks, but a new working paper by Marianne, 'Horizon-Dependent Risk Aversion and the Timing and Pricing of Uncertainty', suggests that allowing for a decline in risk aversion at longer time horizons can be an invaluable new tool for future research in macro-finance.

PATRICK POUYANNÉ, TOTAL CHIEF EXECUTIVE OFFICER

Tackling the energy challenge

At the helm of Total since 2014, Patrick Pouyanné answered our questions about the company, the energy industry and its main challenges, including climate change. The CEO also shares his career advice for TSE students and graduates.

What are the current challenges for Total?

The oil industry, and Total in particular, have been able to adapt, since mid-2014, to the drop in oil prices and to the new business environment that came with it. In such an environment, our size and our integrated model are clearly assets, allowing us to mitigate the financial impact of the oil price cycle thanks to the decoupling between our upstream and downstream results; the strength of our balance sheet is also an advantage.

Faced with strong volatility in the energy markets, we went back to some basic ideas. We must excel in the things we control, our operational excellence, our costs, and our capital allocation in order to manage the break-even cost of the company's assets.

We are price takers - we can't influence the prices - but we can manage our investments and our costs, and we continue to manage Total based on an oil price of 50\$ per barrel.

In 2014, our break-even was 100\$ per barrel; in 2017 it has fallen below 30\$ per barrel (before payment of dividends). This improvement is the result of hard work. It meant putting into place a viable investment policy covering the whole price cycle, ensuring a competitive cost structure, maintaining a high level of operational excellence and, most importantly, being exemplary when it comes to safety. Because safety is critical to all

our activities, it is more than a priority, it is a cardinal value, it is the key to the success and durability of our activities.

What trends or uncertainties are you most focused on?

For more than three years now, the oil market has been highly volatile. Even though supply and demand have started balancing again, this underlying volatility will not disappear tomorrow.

Coal fueled the 19th century and oil fueled the 20th century. The 21st century will be powered by gas and renewables.

Yet, as 2018 begins to unfold, our world is witnessing very strong geopolitical uncertainties, with many conflicts and a general trend towards isolationism... a shift to every-man-for-himself. The Middle-East immediately comes to mind, with the issues in Syria, Iraq, Yemen and Libya but there are also significant tensions in eastern Ukraine or in Korea. International terrorism also remains a threat to consider.

In these uncertain times, companies have the choice between two stances: to delay important decisions awaiting clarifications that may never come, or to take bolder decisions, to seize opportunities while balancing risks. One thing is clear: the best approach, for our industry, is to be agile and flexible, to be able to adapt and thrive in any scenario.



Arctic Lady gas carrier

What are the main stakes for the energy sector in the years to come?

In the coming decades, the oil & gas industry will have to collectively confront a dual challenge: provide reliable and available energy at a low cost to the world's growing population while tackling the challenges posed by the climate and the environment. Tomorrow's energy must be low cost, readily available and clean; the three criteria are equally important.

- Energy should be cheap because low-cost energy is required to generate economic development & social progress for billions of people who rightly seek to improve their lives.
- It must be readily available because customers have come to expect energy to be easy to access and to use at any given time.
- And it must be clean, obviously, because energy is central to climate issues.

Our industry works on a long-term horizon. The decisions we make today shouldn't hinder our long-term strategy. In other words, we should invest today

to ensure our own ability to meet tomorrow's demand, be it in a few years or in several decades. Ignoring our long-term perspectives would threaten our future and ultimately our very existence.

We already know that, oil reserves won't be fully developed due to the challenges of climate change. That's why we must focus on developing the lowest cost and most competitive assets first; those that are both cleaner as well as profitable (even when prices are low).

With this in mind, we tend to favor natural gas. It is the cleanest and most flexible fossil fuel, which makes it the ideal partner for renewables that have intermittent operations. The substitution of coal by gas in electricity production will be the simplest and fastest way to cut CO₂ emissions. Carbon pricing mechanisms would be very useful in this regard, making gas more competitive than coal by setting a CO₂ price, in addition to cutting the gas supply costs.

We must also develop new technologies, such as carbon capture, usage and storage (CCUS) which will allow us to reach carbon neutrality in the second half of the century as fossil fuel use continues.

What are the climate challenges of the energy industry?

The climate is a fundamental issue for our societies, and especially for companies in the energy sector such as Total. Fossil fuels account for a significant part of CO₂ emissions and, thus, of global warming. Total understands this responsibility and has also identified the opportunities that it raises.

Being concerned about climate change means caring about the evolution of energy markets. Coal fueled the 19th century and oil fueled the 20th century. The 21st century will be powered by gas and renewables. These technological advances are slow and very progressive. There will be no overnight revolution, we must be prepared to patiently and resolutely back them for the long run. Such changes require effort, innovation, investment and cooperation.

The Paris Climate Agreement has been fundamental to driving the energy transition, because energy is at the heart of the climate debate but also because energy is a vector of economic development and social progress. When they signed the Paris Agreement in December

Patrick Pouyanné
CEO Total

...

2015, the individual countries committed to playing a major role to tackle climate change and, more broadly, to support sustainable development. However, beyond the countries themselves, one must keep in mind the action that will be taken by companies. Most of the implementation of the Paris agreement will be undertaken directly by private enterprises! As investors are needed to achieve the ambitions of the Paris Agreement, ecological progress can only come in concert with economic growth.

How does Total react to climate change?

Total's ambition is to become the responsible energy major. At a 20-year horizon, our ambition takes into account the International Energy Agency's (IEA) 2°C scenario and anticipates a portfolio of assets that includes 20% low-carbon energies in 2035 (as opposed to 5% currently) and a larger share of gas than oil in the remaining 80%. According to the IEA's outlook, oil & gas will still cover 40 to 50% of world energy needs in 20 years' time, even following the implementation of the Paris Agreement. While world electricity demand is growing faster than overall energy demand, gas and renewables will make key contributions

to meeting the expansion in generation. Total's strategy takes account of these trends. In 2035 we will produce more gas as well as more electricity, notably via renewables, and less oil! This is also why we completely abandoned coal in 2016.

Today, Total is developing a low-carbon business, including energy efficiency, biofuels, solar power, energy storage and innovative energy solutions & services for our customers. These strategic activities are gathered in our new GRP branch (Gas, Renewables and Power) in which we are investing close to a billion dollars every year.

Total actively contributes to industry initiatives such as the Oil & Gas Climate Initiative, a collective engagement in favor of the climate from 10 companies representing more than 20% of the global production. The Initiative recently launched a 1 billion dollar fund dedicated to the development of carbon capture usage and storage (CCUS) which will be necessary to reach carbon neutrality in the second half of the 20th century. We also recently signed a deal with Statoil and Shell to cooperate on these technologies in Norway.

That's how, within our Group, we want to contribute to the climate challenge and to

turn this issue into an opportunity to develop new businesses: in 20 to 30 years, Total will still be a major player in the oil & gas industry, much more focused on gas than oil, and more integrated across the value-chain, though our business activities will have evolved so as to capitalize on growth opportunities in renewables.

What would be your advice to TSE graduates?

In the open, constantly-evolving world we live in, one must be determined, bold, and team-spirited.

In today's business, you need solid training to respond appropriately, and sometimes urgently, to immediate problems. You need a taste for hard work because, more than ever, nothing comes easily for anyone and finding one's place only comes through one's skill and contribution. Nothing is ever easy in the company because the subjects are often complex and need in-depth analysis and critical assessment to find the appropriate answers. One must not be put-off by the first stumbling-block. You have to rise to the challenges and nurture a desire to progress.

You must also be bold, show imagination, make proposals, share ideas, and be innovative, because, at the speed at which the world is changing today, yesterday's solutions won't fit to today's challenges, and even less so tomorrow's. You must dare, dare to stand up and speak, dare to express what you believe to be right, that's how you will contribute to solving problems.

Finally, you must be a team-player, because a company is a collective endeavor which isn't fit for mavericks or individualists: the optimum of the whole is greater than the sum of optimums for each individual. ■



La Mede bio-refinery



Solar plan in Chile

GRADUATE PLACEMENT FIGURES

Results of a poll
conducted 6 months
after graduation
March 2017

81%



hold an executive
position

68%

sign their employment
contract before
graduation

53%

find a job in a different
country from their origin



67%

are hired in a
permanent position



93%

feel that their positions
match their Master
specialty

CLASS
of 2016



KEY EMPLOYERS

Airbus, Air France KLM,
Capgemini Consulting, Deloitte,
Engie, European Central Bank,
Google, L'Oréal, OECD, Regulatory Bodies
(ARCEP, ARAFER, ...), Société générale,
Suez, United Nations,
World Bank, ...

88%



find a job within
6 months

For more
information
and to submit
internship or job offers:
careers@tse-fr.eu

Career-smart students

Knowledge is the key to enter the professional world, and our students are extremely well-prepared in this regard. Professional behavior is also crucial in building an excellent career. Since its inception, TSE has been very active in making sure students master the entire job application process, from writing impressive motivation letters and résumés to performing brilliantly in interviews. Teamwork is another vital skill, especially under stress on intense projects. TSE has implemented numerous initiatives to help students develop their careers, team-spirit and knowledge of the professional world.

Business Networking Day 2017

The sixth edition of the TSE Business Networking Day took place on November 24, bringing together more than 50 companies and institutions from across Europe as well as more than 600 TSE students. The wide range of career opportunities offered by these companies and institutions were presented at 24 conferences. Career workshops dedicated to econometrics and statistics were also organised with guests from the banking, insurance and consulting sectors. For the first time at BND, 22 companies conducted interviews at the forum, recruiting for both internships and full-time jobs. This annual event is also an opportunity for students to improve their résumés and motivation letters through the Université Toulouse Capitole services and to get a new picture taken by a professional photographer. Finally, a workshop on the evolution of job searching took place to provide students with the latest tips and platforms for contacting companies and institutions.

"The Business Networking Day was extremely helpful to me during my time at TSE."
Maria Paula Caldas, TSE 2016 graduate, Economist at Deloitte

Energy trading challenge in London

Several teams from TSE took part in this challenge which gathers students from French business schools and British universities. Organized by the ESCP Europe Energy Society, it allows students to experiment with trading through simulations and to attend high-level conferences and workshops on the banking industry, led by professionals from international companies such as BNP, BP, EDF, ENGIE and TOTAL. TSE is proud to support the event and encourages its students to participate every year.

Career courses

To assist students in the job market, TSE shows them how to determine and present their strengths and weaknesses in preparation for interviews. The courses let students practice job interviews, learning how to convince future employers. Networking techniques, job search and professional orientation are developed during the classes, ensuring TSE students are well prepared for a stimulating and successful career.

High-level talks

TSE offers its students Business and Academic Talks, given by economists and researchers from a wide range of sectors. These events allow students to learn about new economics theories or practices but also, through the IAST Distinguished Lectures, to learn from other social sciences. TSE firmly believes that the future of social sciences lies in interdisciplinarity and students are always encouraged to broaden their perspective on the issues they study through the help of sociology, political science, psychology, and other social sciences.

"All these events have been very helpful and allowed me to better prepare for the interviews."

Anna Maria Hupa, TSE 2016 graduate, Analyst at Google

More information on the BND:

tse-fr.eu/careers



Is blockchain the future of finance?

GIVE YOUR OPINION ON DEBATE.TSE-FR.EU

RECENT POLL RESULTS FROM TSE DEBATE:

54%

think economic growth is necessary to eliminate poverty


88%

believe tomorrow's Europe will be federal

80%

would regulate more strictly the food industry

debate.tse-fr.eu



Team player

Creative

Impactful

WHERE ARE THE BEST ECONOMISTS?

Nina, future graduate in law and economics

At TSE, chaired by a Nobel laureate in economics,
we are training tomorrow's experts in quantitative analysis.
Our graduates are ready to solve your complex economic issues.