TNIT newsletter

Toulouse Network for Information Technology

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Dear Readers

We are very happy to welcome Matthew Gentzkow as a new member of the Toulouse Network for Information Technology.

Matthew is a very renowned economist but to make you know him better we asked him to answer a few questions about himself and his work. Besides this interview, the current issue features a piece by Renato Gomes on auction design in two-sided markets, and a "How" article by Daron Acemoglu on the economic approach to network security.

Please feel free to send us any ideas or reactions you may have upon reading this Newsletter.

Jacques CRÉMER and Yassine LEFOUILI

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Interview with **Matthew Gentzkow**

TNIT: Matt, you are the latest addition to the TNIT. Congratulations. Can you give us a quick rundown on your background and interests?

MG: Well, a quick biography would be: grew up in a little town near Seattle, went to Harvard as an undergrad, spent some time not doing economics (a year living in India and a couple of years directing plays), came back to Harvard for grad school in economics, and have been at the University of Chicago ever since.

My research to date has mostly focused on media. That includes both current media like online news and blogs and historical media like early TV and nineteenth century newspapers. Much of this work has been joint with Jesse Shapiro. What I've always found particularly exciting is the interplay of economics and politics. You can think of media as a product like ice cream or automobiles, and apply standard economic tools to analyze it. But it is also a product that we think has a unique role in democracy and society more broadly informing people, persuading people, disciplining government, shaping culture. You can't really understand the economics of media markets without taking account of the politics, and you certainly can't make sense of the politics without understanding the economics.

More recently, I have been interested in a couple of areas that are related to media but take me further afield. One is the theory of strategic communication and persuasion. The same issues that show up in thinking about the way a news outlet might persuade its audience are also relevant to thinking about how advertisers persuade consumers, politicians persuade voters, or CEOs persuade investors. A topic I've been working on with my colleague Emir Kamenica is the limits of persuasion when the audience is rational. To what extent can a political campaign ad, say, systematically change the beliefs of a voter even when the voter is sophisticated and fully aware of the motives of the advertiser? You might think such a voter would "filter out" the partisan messages in the ad and so not be affected. It turns out that complete filtering is not typically possible, and so the politician can systematically affect even rational voters. Of course voters are not always so sophisticated, but as in many contexts the rational case gives us an informative benchmark.

Another area I've been thinking about is the formation of preferences. For example, I've long been fascinated by preferences for brands. People are willing to pay lots of money for branded Tylenol rather than generic acetaminophen, Coke rather than Pepsi, a Fidelity mutual fund rather than a Vanguard mutual fund, and so on. In the early days of online retail, Erik Brynjolfsson and Michael Smith showed that people would pay big premiums to buy books from Amazon or Barnes and Noble, even when they were looking at a price comparison site that showed them the same book at lower prices elsewhere. In economics, we tend to take preferences as "exogenous" a fixed feature of the world that we don't have much to say about. But it's hard to believe people are born with an innate preference for barnesandnoble.com. Rather, these preferences must arise from some combination of learning, habit formation, exposure to advertising, and perhaps observations of other consumers. Although creating these preferences seems to be one of the main thing firms think about, it's not something that has figured very prominently in economics.

TNIT: The readers of the TNIT newsletter might be interested in a quick summary of the conclusions of your work with Jesse Shapiro on "ideological segregation" - they do go against received wisdom!

MG: Well, the jumping off point for that paper is some

pessimistic stories we often hear about what the Internet may be doing to democracy. In particular, there is a claim first advanced by Cass Sunstein that the proliferation of choices online may lead to a situation where people are only exposed to sites that match their pre-existing views - everyone will be in an "echo chamber," with conservatives only hearing conservative news, liberals only hearing liberal news, environmentalists only hearing environmental news, and so on.

Our research question is just: "is this actually happening?" We use Internet browsing data to see how different the news diets of conservatives and liberals really are, and then we bring in other data sources to see how this compares to offline media and face-to-face interactions. The measurement approach is borrowed from the literature on racial segregation of neighborhoods. We apply a standard metric to compute the extent of ideological segregation - basically, the extent of overlap in the sets of sites visited by conservatives and liberals.

The answer is, the extent of segregation online looks quite low. The news seen by the average conservative looks about like USA Today, while the news seen by the average liberal looks about like CNN. Although plenty of people go to sites with more ideologically tilted audiences, like Fox News or Huffington Post, these are typically part of a news diet with heavy doses of more moderate sites. Someone who only visited Fox News (or similar sites) would have a more conservative news diet than 99% of Americans. Someone who only visited the New York Times (or similar sites) would have a more liberal news diet than 95% of Americans.

It's true that the Internet is more segregated than most other media, but only slightly (It is actually less segregated than national newspapers). And the Internet, like other media, is far less segregated than peoples' face-to-face interactions. By our measure, face-to-face political conversations more than five times more segregated than Internet news viewership.

There are two underlying forces that explain why segregation is low online. First, most people get most of their news from a small number of big sites with relatively balanced audiences Yahoo, CNN, and so on. Although it's true that the long tail of political blogs and activist sites includes many with very extreme ideological tilts, very few people visit such sites. Second, a significant share of consumers get news from multiple outlets. This is particularly true for the kind of people who do visit smaller sites. If you see someone visiting a political blog with an extreme ideology, you know they are probably a heavy Internet user and a political junky who consumes a lot of news all across the political spectrum. Someone who visits glennbeck.com (the most conservative site in our sample) is actually more likely than an average Internet news consumer to have read nytimes.com. Someone who visits thinkprogress.org (the most liberal site in our sample) is more likely to have read foxnews.com than an average Internet news consumer.

A big caveat we are only analyzing segregation of online audiences. We don't, in this paper, bring in any measures of content. So when we say nytimes.com is a liberal site and foxnews.com is a conservative site, that is purely a statement about the share of their visitors who are liberal and conservative. Another caveat is that the fact that liberals and conservatives are seeing the same sites does not mean they interpret the information they see in the same way. We know people do end up with very different beliefs. The fact that what they are exposed to is so similar just deepens the puzzle of why this is.

TNIT: Anything exciting you are working on at present?

MG: Well, I don't know if any of it's exciting, but I can tell you a few things that are on the front burner. One is some follow-up work with Jesse on ideological segregation online. After writing the paper I just described, we wanted to think more about

the underlying economic forces that determine Internet segregation.

What do the results say about the nature of demand? Are people actively seeking out contrasting viewpoints, or does the range of sites people land on just reflect idiosyncratic preferences? What forces determine the supply of news sites? Is the pattern of big centrist sites pulling everybody to the middle a fluke? Or is it something we should expect to be a persistent feature of the Internet long into the future. Our goal is to build a model of both the demand and supply sides that will let us speak to the economic forces at work.

Another is continuing my interest in automated text analysis. Jesse and I are working with a statistician named Matt Taddy to analyze the Congressional speeches from the late 1800's to the present. We have the full text of every word said on the floor of Congress, and we are using text mining techniques to look at the evolution of partisan language. Everybody knows that parties today choose language for strategic effect "death tax" vs. "estate tax," "illegal alien" vs. "undocumented worker," and so on. We want to know to whether this has always been true or whether it's a new phenomenon, and if so to understand how it arose.

A third, which is more of an idea than a project at this point, is studying competition in online advertising markets. In traditional markets, we have well developed intuitions about how market concentration will affect the price level. Competition policy revolves around being able to predict how a particular change in competition will affect prices. But theory tells us that the nature of competition in advertising markets will be very different. To what extent do Microsoft Ad Network and DoubleClick compete for advertisers? Does the entry of new online news sites drive down the prices for ads on cnn.com? How much does the rise of the Internet have to do with the rapid decline of offline ad prices? These are questions that theorists have made a lot of progress on, but that remain relatively unstudied empirically. We are hoping to launch some new projects soon that will fill some of that gap.

TNIT: Now, a few personal questions: What proportions of your news do you get online and offline?

MG: 70/30

TNIT: Coffee, tea or water?

MG: All three. But mostly coffee.

TNIT: Your favorite restaurant in Chicago?

MG: Alinea. And Harold's Chicken Shack.

TNIT member Matthew Gentzkow is the Richard O. Ryan Professor of Economics and Neubauer Family Faculty Fellow at the University of Chicago Booth School of Business.

Optimal Auction Design in Two-Sided Markets *by Renato Gomes*

In the last decade, a growing number of media companies have turned to auctions for selling advertising space. In the online world, search engines run billions of simultaneous auctions for selling the "sponsored links" displayed alongside and above the search results. In 2010, these auctions raised more than $30 billion for the three largest search engines, Google, Yahoo! and Microsoft's Bing. Auctions are also used by the recently created Ad Exchanges to sell display advertising on web portals, blogs and commercial web sites. In 2010, their revenues were more than $8 billion.[1]

Sponsored links are only profitable if consumers click on them. The consumers' clicking behavior, however, depends on their expectations that sponsored advertisers are relevant to their queries. If consumers believe that sponsored links are not useful, they make few clicks, and the platform's profits are reduced.

The dependence of the platform's profits on the expectations of consumers about the quality of sponsored links creates a "two-sided" market. In the long run, the platform faces a trade-off between extracting rents from advertisers and engaging consumers to click. In a recent paper (see the bibliography at the end) I study how a search engine should design its auction rules to maximize profits, and show that "scoring auctions" are the right way around this trade-off.

To fix ideas, I consider a monopolistic platform that has a single sponsored link to sell to one of many advertisers. Each advertiser has two important attributes: how much she is willing to pay for a click, which reflects the profit generated by an extra visit on her web site, and her relevance, which reflects the value that consumers obtain by clicking on the advertiser's link. Only the advertiser knows how much she is willing to pay for a click. In contrast, the relevance of an advertiser is known both by the platform and the advertiser (which is a reasonable assumption, given the wealth of information - such as relevance estimates, historical click-through rates, etc - available to search engines).

In order to capture the long run behavior of consumers, my analysis assumes that consumers anticipate correctly, at least in expectation, the relevance of the sponsored link. I also assume that consumers have different opportunity costs of clicking on sponsored links, and that they click only if this cost is lower than their expected gain from so doing. As a consequence, the click-through rate is higher when the platform selects more relevant advertisers, in expectation.

The platform designs an auction that maximize its profits, taking into account the fact that the click-through rate depends on the way in which it selects advertisers. The difficulty faced by the platform is that the advertiser with the highest willingness to pay per click is not necessarily the most relevant one. This "adverse selection" problem, which exists in many advertising markets, is particularly acute for search engines: because the most relevant web sites do not have to pay to find a place in the organic search results (that is, in the left hand column of the page), the advertisers with the highest willingness to pay for sponsored links are likely to have minor, or even doubtful, relevance. As a consequence, standard auctions, such as first-price or second-price sealed-bid auctions, induce too small a click-though rate.

My research considers the platform's problem in two alternative settings. In the benchmark setting, which I consider first, the platform can charge or subsidize consumers on a per-click basis. In this case, the mechanism that maximizes profits is a scoring auction that assigns to each advertiser a score which is the average of her relevance and willingness to pay for a click. It then selects the advertiser with the highest score. The platform pays consumers for clicking if the price paid by the advertisers is greater than their relevance, in expectation. It makes them pay in the opposite case.

Search engines have sometimes tried to pay for clicks. Bing, for instance, subsidizes consumers through its "Bing rewards" program. Attempts to make transfers per click are, however, more the exception than the rule in online businesses. Researchers and practitioners often argue that

1. Offline, many newspapers, TV's and radio stations have switched, at least partially, from the traditional agency-based model for selling advertising space to automated auction processes. In 2006, Google launched its Audio Ads program, which applies the technology of sponsored search auctions to the sale of advertising space in radio stations. Since 2007, Google AdWords runs daily auctions for advertising spots on several US television and cable networks.

click-contingent transfers are prone to fraud, and that the overall cost of implementing such transfers would make it impracticable in most instances.

It is therefore important to study the platform's problem when it is not possible to pay/charge for clicks. In this case, my research shows that the platform will also use a scoring auction. Interestingly, the scoring rule of this auction crucially depends on the consumers' click-through rate elasticity (which measures how click-through rates increase as the relevance of sponsored links increases). In particular, the higher is this elasticity, the higher is the weight assigned to the relevance of advertisers. Importantly, this new scoring rule differs from the scoring rule that the platform would use were it able to subsidize or pay consumers for clicking. For instance, were the platform willing to pay consumers for clicking, it will compensate consumers by giving more weight to the relevance of advertisers. On the other hand, were the platform willing to subsidize consumers for clicking, it will give more weight to the willingness to pay of advertisers. By trading-off rent extraction and clicking volume, this auction works as a cross-subsidization device between consumers and advertisers.

And indeed, all three major search engines have adopted scoring auctions to sell sponsored advertising: Google was first to do so in 2004, followed by Microsoft's LiveSearch (Bing's predecessor) in 2006, and by Yahoo! in 2007.

Reference:

Gomes, R., *2012,"Optimal Auction Design in Two-Sided Markets",* TSE Working paper, available at:

sites.google.com/site/northwesternrenatogomes/Home/research

Renato Gomes is Assistant Professor at the Toulouse School of Economics.

HOW the Economics of Network Security Works

by Daron Acemoglu

Computer and communication networks depend on some degree of security for their operation. For example, a virus that infects a set of connected computers or a malfunction in a router, domain or switch may adversely influence the entire network and in the worst case scenario, will create contagion of failures by spreading from one part to the rest of the network. The classical approach to this problem focuses exclusively on the engineering design challenges of ensuring the security of the network against viruses and intruders. However, almost all modern networks involve a human element: they are overrated or used by individuals. Network security then depends on the choices of individuals making use of the network. For example, the security of a network of computers will depend on the extent to which individuals making up this network use virus scans and refrain from visiting websites that appear suspicious. There has recently been much greater recognition of the importance of this human element, and the incentives that individual users face.

Anderson and Moore in their review of network security, for example, concluded:

"Security failure is caused at least as often by bad incentives as by bad design."

A particularly important aspect of individual decisions in this context is their security investments, which are costly investments reducing the likelihood of individual infection (and other decisions, such as more cautious operating behavior to reduce the likelihood of infection can also be considered as a form of investment).

A burgeoning literature at the boundary of economics and computer science investigates how the incentives for security investments are determined and how they affect the resilience of networks. At the root of the economic problem is an externality in security investments. An agent that fails to protect itself adequately not only increases the probability of its own infection but also increases the likelihood that infection will spread to other agents. Therefore, an agent that increases its own investment will create a positive externality and improve the performance of others in the network.

Positive externalities generally lead to underinvestment. When an agent chooses its own security investments, it ignores the beneficial impact that this will create on others. Based on this intuition, the burgeoning literature on economic incentives in network security has so far presumed that there will be underinvestment in security. Such underinvestment would have important implications. First, it would imply a reason why decentralized networks would tend to underperform in terms of their security. Second, it would call for intervention by government or a centralized body to correct for the underinvestment problem and improve the performance of the network. It is therefore important to understand when such underinvestment will emerge and become an important burden on the operation of a network. For example, which structural properties of networks (density and clustering of connections, who is connected to whom, etc.) make underinvestment in network security a particularly pernicious problem?

The conclusions regarding underinvestment in network security are generally based on analyses of "symmetric networks," however. In symmetric networks, either there is no network structure and all agents interact with all others or, loosely speaking, all agents occupy the same position in the network as all others. Such symmetric networks are neither realistic nor conducive to an understanding of the role of the structure of the network on equilibrium (and optimal) security investments. The lack of realism is obvious: there is considerable heterogeneity across agents in all of the aforementioned networks; domains and routers differ in terms of their size and importance, and computer users are typically connected to very different numbers of users and occupy different positions in the overall network. The importance of analyzing the impact of network structure is also equally salient, and has long been recognized as central for the study of network security.

Anderson and Moore's review also notes:

"Network topology can strongly influence conflict dynamics... Different topologies have different robustness properties with respect to various attacks."

Recent work I have been conducting with Azarakhsh Malekian, postdoctoral fellow at the Electrical Engineering and Computer Science department at MIT and Asuman Ozdaglar, professor at the Electrical Engineering and Computer Science at MIT investigates these issues in general networks.

How, What, Why, When, Who?

We first show that, the powerful intuitions on underinvestment notwithstanding, there can be overinvestment in security. The reason for this is that in addition to creating positive externalities as explained above, security investments are also strategic substitutes. When an individual invests less, this encourages others to invest more. As a result, decentralized equilibria may involve underinvestment by some agents and overinvestment by others. Furthermore, these overinvestments may be sufficiently substantial to reduce the overall likelihood of contagion in the network relative to what a social planner wishing to maximize the welfare of all network participants would have chosen.

Nevertheless, underinvestment remains more pervasive than overinvestment. We establish sufficient conditions on costs of investment and the structure of a network to ensure that the decentralized equilibrium does indeed feature underinvestment. We also show how the likelihood of cascading infections can be compared across networks as a function of structural properties of the networks.

We also identify a complementary reason for overinvestment in network security: when malicious attacks can target different parts of the network as a function of their network security investments, such investments turn into an "arms race". The more an individual invests, the less likely he is to be attacked, and the more likely is the attack to go to some other part of the network. This leads to a negative externality complementing the positive externality discussed above: greater investment by an agent increases the likelihood of other agents being exposed to an attack. This negative externality can lead to more pervasive overinvestment.

We view this work as a first step in a systematic analysis of economic incentives and their implications for the secure functioning of large communication and computer networks. More work at the intersection of economics and computer science can shed light on important problems related to the healthy functioning of such networks.

References:

- Daron Acemoglu, Azarakhsh Malekian and Asuman Ozdaglar (2013) *"Network Security and Contagion"* MIT working paper.
- Ross Anderson and Tyler Moore (2006) *"The Economics of Network Security"* Science, October 2006.

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