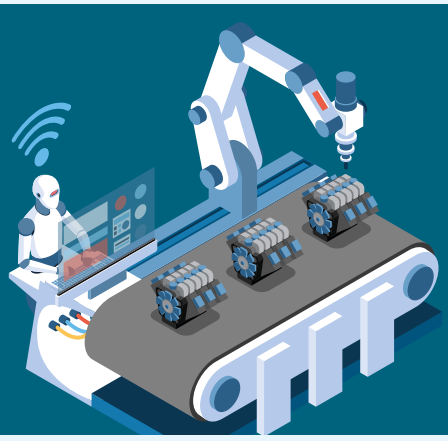
TNTNews

TOULOUSE NETWORK FOR INFORMATION TECHNOLOGY

Where are the financial innovators?

Racial diversity and private capital

Josh Lerner - *Harvard*



Automation and inequality

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Pierre Pestieau - *University of Liège*

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Digital Center

Microsoft

TNIT members in 2010. *Top row, from left: Josh Lerner, Ilya Segal, Susan Athey, Daron Acemoglu, Suzanne Scotchmer, Glenn Ellison, Jonathan Levin, Michael Whinston. Bottom row, from left: Luis Garicano, Nicholas Bloom, Jacques Crémer, Jacques Lawarrée.*

TNIT members in 2019. *From left: Jacques Crémer, Susan Athey, Matthew Gentzkow, Daron Acemoglu, Josh Lerner, Glenn Ellison, Nicholas Bloom, Heidi Williams, Jacques Lawarrée.*

When the Toulouse Network for Information Technology (TNIT) was created in 2005, few imagined that it would last 15 years. The reason for its longevity has been the high quality and engagement of its members. They were very involved and willing to adapt their research topics as the tech industry evolved.

The impact of the network has been important among academic economists, especially those who became exposed to very high-level research on new topics in competition policy, intellectual property policy, cybersecurity and more recently on the impact of artificial intelligence. The quality of the members signaled to the profession that the digital economy had become a core research topic in economics.

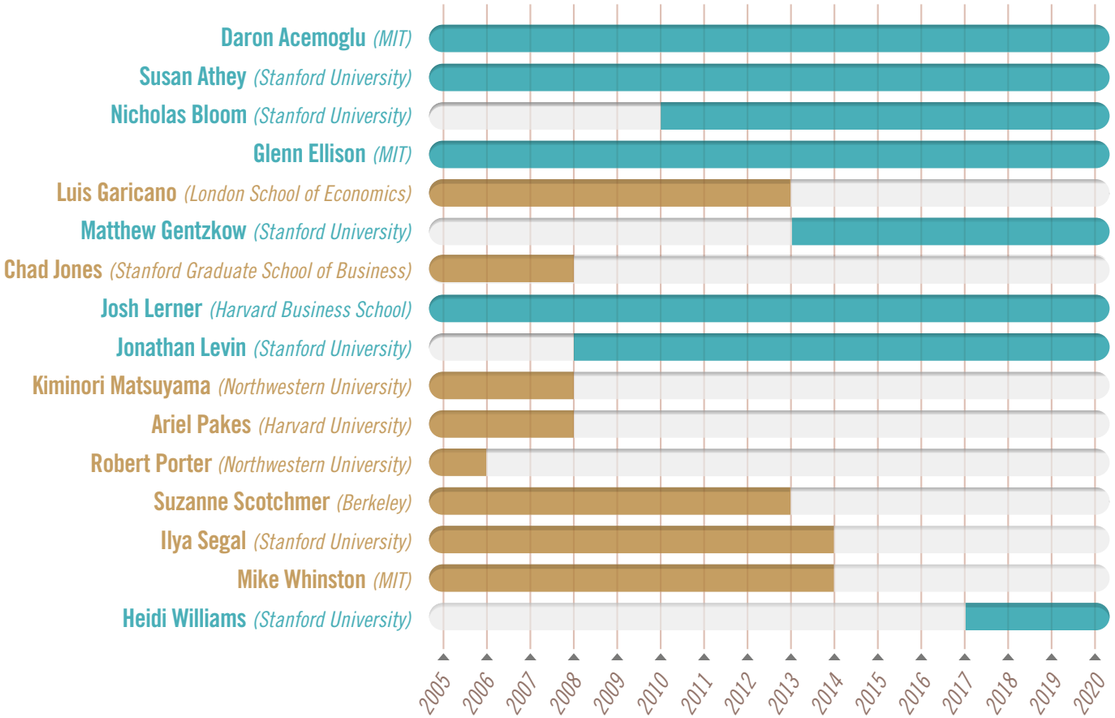
The tech industry also took notice. When the network was created, only Google, among tech firms, had a chief economist (Hal Varian). Microsoft's first chief economist was Susan Athey, a TNIT member. Today, all tech firms, including Microsoft, have a large staff of economists with the biggest one at Amazon, led by Pat Bajari.

The support of Microsoft has been essential over the years. Brad Smith, current Microsoft president, was a great supporter from day one. I also want to thank Kathryn Neal and Sue Glueck for their support over the years. Although the TNIT has disbanded, Microsoft, like other tech firms, still works with economists.

What made the TNIT special was the guarantee of academic independence. TNIT members were free to write and publish any papers on the topics of the network. This independence was guaranteed by the involvement of Toulouse School of Economics and particularly of Jean Tirole and Jacques Crémer. My friendship with them and the other TNIT members is what I cherish the most. As an academic economist, I feel privileged and humbled to have worked with such a group of brilliant and incredibly nice people.

Jacques Lawarrée, *TNIT Coordinator*

TNIT members



Suzanne Scotchmer was a TNIT member between 2005 and 2013. She passed away a year later, in 2014, at the age of 64. Suzanne was a great scholar, probably the foremost expert of her generation on the economics of intellectual property. She was also a fantastic and lively colleague, whose presence made TNIT meetings much more fun and interesting.

Suzanne was born and raised in Pelican, Alaska, and loved to speak about her childhood there. She obtained her undergraduate degree in economics at the University of Washington, taught at Harvard for five years or so at the beginning of the 1980s and returned to Berkeley where she was a professor of Public Policy, Economics and Law. She had the rare ability to combine elegant theory with a great sense of its "real world" implications and was extremely influential both in academic and policy circles.

She was a great friend of Toulouse, and spent a sabbatical at IDEI, before the existence of TSE. The yearly Economics of Digital Industries conference, held every January, remembers her, thanks to the Suzanne Scotchmer lecture. We miss her.

Key figures

14 annual meetings

125 white papers

16 members

2 coordinators

25 newsletters

15 successful years

Toulouse Network for Information Technology was launched in 2005. It was a joint initiative of Microsoft and the Institut d'Economie Industrielle (IDEI), the forerunner of Toulouse School of Economics. At that point, there was relatively little research on the digital economy – from the economics of software and the internet to electronic commerce – especially research at the highest level of the profession. This was clearly a problem for public policy and, more fundamentally, for our understanding of the ways in which these new technologies would transform the world. It was a problem for Microsoft (and, of course, the other firms in the industry) in that the tools to explain their business models to regulators did not exist. TNIT was created to answer these challenges. We are certainly biased, but we believe it was a huge success. Over 15 years, it benefited Microsoft, economic science, and public policy.

At the time of the creation of TNIT, Jacques Lawarrée was academic relations manager at Microsoft, on leave from the University of Washington. He conceived the idea of recruiting a group of very high-level academics (more on this later) who would write one paper every year on topics important to the digital economy. To make sure that the research was relevant and tackled pertinent issues, a yearly meeting brought the researchers together to discuss their research with each other and to facilitate dialogue with Microsoft's executives and engineers. Microsoft approached IDEI, which was at that time directed by Jacques Crémer, and asked whether it would be willing to manage the network. IDEI provided administrative support and, more importantly, guaranteed that members could conduct their research with full independence.

> **"The success of the network was due mostly to the amazing quality of the researchers involved**

The first director of TNIT was Gilles Saint-Paul and the first group of researchers included Daron Acemoglu*, Susan Athey*, Glen Ellison*, Luis Garicano, Chad Jones, Josh Lerner*, Kiminori Matsuyama, Ariel Pakes, Robert Porter, Suzanne Scotchmer, Ilya Segal and Michael Whinston *(an asterisk denotes those who were members for the whole 15 years)*.

In 2007, Jacques Crémer became TNIT director. Along with Jacques Lawarrée, he co-managed the network up to 2020, the last year in which it was active. By that point, the group had been strengthened by Nicholas Bloom, Matthew Gentzkow, Jonathan Levin and Heidi Williams.

The success of the network was due mostly to the amazing quality of the researchers involved. Four of them have won the John Bates Clark Medal of the American Economic Association, probably the most prestigious award in economics short of the Nobel Prize. And Luis Garicano has become an important member of the European Parliament.

Managing the network required from us a non-negligible amount of work whose main reward was participation in the annual meeting. We remember the pleasure of discussions between these fantastic economists, their enormous grasp of a very varied literature, their voracious curiosity and, more than anything, their commitment to understanding the world and the generosity of their comments on each other's work. We were always impressed by how eager they were to participate, despite busy schedules and, for some, heavy family responsibilities.

The range of topics which the research covered was immense: e-commerce, the consequences of robotics for the labor market, innovation and patent policy, the organization of public services, etc. It would be impossible to do justice to all of it, and the rest of this TNIT Newsletter showcases some of the most recent work, but let us mention a few contributions, chosen mostly because of our own interests, but also to highlight the breadth of the topics.

The pandemic has put Working From Home (WFH) at the forefront of the news. Years before, TNIT supported part of Nick Bloom's research on the topic: with his co-authors he conducted the first careful experimental study of the consequences of WFH for productivity and the welfare of workers, concluding that the effects were overall positive. Luis Garicano, with Paul Heaton, had much earlier published a remarkable study of the consequences of the introduction of digital technology for the productivity of US police departments. They showed that it increased productivity only when accompanied by organizational reforms. The consequences of digitalization for labor were studied by Daron Acemoglu and his co-authors, while the consequences for political discourse were studied by Matt Gentzkow. A stellar group – Suzanne Scotchmer, Josh Lerner and Heidi Williams – studied innovation in that space. Susan Athey, Glenn Ellison, Ariel Pakes, Rob Porter, Ilya Segal and Michael Whinston studied the competition policy aspects of the digital economy. Chad Jones and Kiminori Matsuyama focused on trade issues. And so on, and so on.

> **"The range of topics which the research covered was immense: e-commerce, the consequences of robotics for the labor market, innovation and patent policy, the organization of public services, etc**

We are extremely thankful to Microsoft and Toulouse School of Economics but mostly to the brilliant members of TNIT. Thanks to them, participation in the TNIT has been one of the pleasurable highlights of our professional careers. Not only have we learned lots of economics; our admiration for the leadership of our profession has been comforted.

Jacques Crémer & Jacques Lawarrée, *TNIT Coordinators*

TNIT meeting in 2014. *From top left to top right: Jacques Crémer, Yassine Lefouili, Jacques Lawarrée, Chris Nelson, Daron Acemoglu, Sue Glueck, Kiminori Matsuyama, Glenn Ellison, Susan Athey, Josh Lerner, Michael Whinston, John Levin, Glen Weyl, Nick Bloom.*

Where are the fintech innovators?

Josh Lerner
(Harvard)

Amit Seru
(Stanford)

Who are the innovators behind the fintech boom? Despite the intense interest in financial innovations and their consequences, we know remarkably little about how and where these new products and services are developed. Our recent work with Nick Short and Yuan Sun seeks to address this gap using a newly constructed dataset of more than 24,000 financial US patent applications between 2000 and 2018.

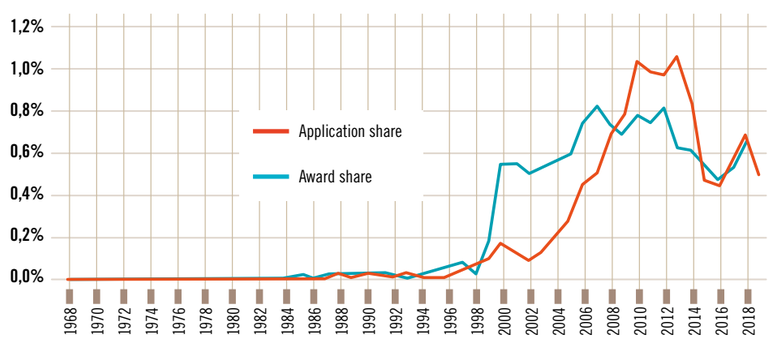
For most of the 20th century, patents provided only a limited guide to innovative activity in finance. Between 1971 and 2000, the US patent office issued just 445 financial patents, less than 0.02% of all awards. Firms were reluctant to incur the time and expense to file for patents, allowing new product ideas to diffuse rapidly across competitors. This is partly because, in contrast to other sectors, there has long been ambiguity about financial innovators' ability to appropriate their discoveries. Following a 1908 US court decision that established a "business methods exception", many judges and lawyers presumed that business methods were not patentable. It has also been very difficult for firms to detect infringement of patents related to valuation and trading.

Attitudes changed with the July 1998 decision in State Street Bank and Trust v. Signature Financial Group. State Street Bank challenged the validity of Signature's patent on a software program used to determine the value of mutual funds, claiming it covered a business method. The Court of Appeals for the Federal Circuit affirmed the patentability of the software since it produced a "useful, concrete, and tangible result". Numerous trade press articles interpreted the case as unambiguously establishing that business methods are just as patentable as more traditional technologies. Conversations with patent practitioners suggest that the historical differences between patenting in finance and in other technological domains have narrowed considerably in recent decades. Similar changing attitudes have been seen in Japan and other nations.

Dramatic rise of financial patents

Identifying finance-related patent filings remains a challenge. We first identify a set of patents that are assigned to financial patent classes, then use the patent text and inventors' names to train a natural-language processing model to recognize similar financial innovations that might be assigned elsewhere. This allows us to analyze financial patents in a wide range of patent classes.

Fig.1 - Financial patents as a share of all utility patents



The number of financial patent applications was 35 in 1994, 1,125 in 2004, and 1,607 in 2014. Utility patents include new or improved ideas, processes, machines, and manufacturers.
Source: Researchers' calculations using data from IFI CLAIMS, PatentsView, Derwent, and Capital IQ.

Figure 1 illustrates the dramatic boost in financial patent applications and awards over this period, from a nearly infinitesimal share to between 0.4% and 1.1% of all grants. Financial patents are also disproportionately important, according to commonly used measures of patent value. The patenting patterns closely reflect those seen when we use another measure for innovative expenditures (corporate venture capital investments) and do not appear to be driven by shifts in reliance on trade secrets.

We also show that an increasing fraction of patented financial innovations focus on consumer rather than business applications. In addition, the surge in financial patenting is driven by US information technology (IT) firms and in sectors other than finance. Banks and other financial institutions represent a modest share of the awards, which are dominated by IT companies. Banks and payments firms increasingly focus on their core areas, while IT firms and other financial firms have continued to patent widely in finance. IT, payments, and other firms are more likely to be issued process patents, as well as consumer finance ones.

The share of US awardees relative to foreign firms is growing. Within the US, we see the rise of innovation in the greater San Francisco region (and the Pacific more generally) and the decline of the New York area.

> **"An increasing fraction of patented financial innovations focus on consumer rather than business applications. In addition, the surge in financial patenting is driven by US information technology firms and in sectors other than finance**

Relocation to escape regulation

Financial regulatory actions seem to have adversely affected innovation by financial firms. In the years after the global financial crisis (GFC),

> **After the 2008 crisis, financial innovation by banks shifted to locations with looser financial regulation… By contrast, regions with the highest technological opportunities attracted innovation by payments, IT, and other non-financial firms**

financial innovation by banks shifted to locations with looser financial regulation. More speculatively, these results suggest that the seeming failure of banks and other financial institutions to expand their innovative scope may have (at least partially) been due to pressures from financial regulators. As well as pushing financial incumbents to relocate innovative activities, regulation may have depressed their focus on innovation more generally.

By contrast, regions with the highest technological opportunities in general attracted financial innovation by payments, IT, and other non-financial firms. Overall, the evidence is consistent with two sets of explanations for relocated innovation: the push of regulatory pressures and the pull of technological opportunity.

Where do the ideas come from?

To examine the source of the ideas behind finance patents, we explore the relationship between financial innovations and the academic knowledge base. Over the sample period, academic citations (references) in finance patents were associated with more impactful patents. This effect also held for citations to articles in business, economics, and finance journals specifically. Over time, the relationship between academic citations and patent value grew stronger (particularly from 2015 to 2018). However, the number of academic citations in finance patents fell. This decline was most dramatic for banks, and for citations to business, economics, and finance journals. Citations have been to increasingly older academic articles.

Three explanations can be offered for the patterns of fewer but more valuable academic references. First, as the focus of financial patents shifted from business to consumer applications, there may have been less relevant academic work. Second, commercially relevant academic discoveries in finance may be harder to come by. Finally, financial organizations, especially banks, may struggle to absorb insights associated with consumer-oriented patents.

Implications for policymakers and business leaders

The failure of traditional financial institutions to maintain pace in consumer-focused innovation is puzzling. The results hint at factors that may have exacerbated the declining share of financial innovation by banks: the seeming decrease in relevant contemporaneous academic discoveries (or the ability to identify and absorb them), as well as regulatory pressures after the GFC.

If financial and consumer-oriented innovation is seen as desirable, it should be protected and encouraged. When tightening financial regulation, government leaders must therefore factor in the unintended effects on innovation. This recommendation is challenging to implement given that the nature and consequences of a financial innovation — unlike, say, a new semiconductor or cancer therapy — can be difficult to anticipate. Moreover, regulation is often arranged by institution and, as we have shown, financial innovations often arrive from outside the finance industry.

Our findings also suggest the need for financial incumbents to intensively explore alternative ways to access knowledge about innovations emerging from the IT sector. Among the important avenues are alliances, corporate venture capital, and acquisitions. Making sure these efforts are appropriately structured will be critical.

KEY TAKEAWAYS

- Offering a window on the fintech boom, financial patents have risen dramatically since 1998.
- The surge in financial innovation is driven by IT firms in the US, focused on consumer rather than business applications. Banks and traditional financial institutions have been left behind.
- Academic citations in finance patents have been falling in number, but growing in value.
- Policymakers should note that financial innovation has shifted to locations with looser regulation and higher technological opportunities.

Racial diversity and private capital

Josh Lerner
(Harvard)

What explains the lack of racial diversity in the asset management industry? In a new working paper with Johan Cassel and Emmanuel Yimfor, we examine the underlying causes of the industry's low levels of minority ownership in the United States, focusing on venture capital, buyout, and growth investment groups.

The predominance of white owners in the asset management industry likely exacerbates America's well-documented disparities of wealth by race. According to the Knight Foundation, groups owned by minorities managed less than 1.6% of assets in 2018, even though minorities represent 40% of the US population. This imbalance is troubling given that the ownership of private capital groups and other financial institutions has been an important driver of wealth creation.

The problem is compounded by the tendency for private investors, particularly venture capitalists, to fund people who share their own characteristics. Racial disparities in the ownership of venture capital groups may thus have substantial effects on what types of entrepreneurs get funded, raising barriers to other critical avenues of wealth and job creation.

Demand for minority-owned funds

Despite differing in their coverage and performance measures, our Burgiss and PitchBook databases paint a consistent picture of racial disparity. Black- and Hispanic-owned funds represent a very modest share of the capital raised by private capital funds, relative to plausible benchmarks. In keeping with this observation, we show that it is more difficult for minorities to enter the market. Using Form D filings, which provide a broad depiction of attempted US private equity and VC fundraising, we show that Black and Hispanic-owned groups (a) are less likely to meet their fundraising goals, (b) raise smaller funds, and (c) have fewer investors participating in their funds. We also show that minority- and majority-owned funds are indistinguishable in terms of their ultimate performance, using various measures constructed with Burgiss and PitchBook data.

Do minority-owned funds suffer from lower demand? To limit the impact of unobserved heterogeneity in manager quality, we focus only on the ability of established groups to raise follow-on funds. In a world of persistent performance, as has characterized private capital historically, past performance should proxy for expected returns. The inflow-performance relationship has been extensively scrutinized in a variety of asset classes, from mutual funds to private equity.

> **Black and Hispanic-owned groups are less likely to meet fundraising goals, raise smaller funds, and have fewer investors. We also show that minority- and majority-owned funds are indistinguishable in terms of ultimate performance**

In our analyses, we find a striking result. The ability of Black- and Hispanic-owned funds to raise follow-on funds is far less sensitive to past performance than those of other funds. This is true whether performance is measured using cash flow data (to compute the public market equivalent, or PME, and other measures) or the success of relatively recent deals (those going public or being acquired). For instance, using Burgiss data, an increase in PME of one standard deviation point is associated with a 24.1% larger follow-on fund for non-minority owned groups, but an insignificant change close to zero for minority-owned groups (-5.5%).

What happens when racial attitudes change?

Do changes in racial awareness affect the sensitivity of inflows to performance? We seek to identify an exogenous shift: an event that may change the attitude of limited partners to diversely owned funds, while not affecting the prospects of the funds in the long term. It might be thought that the best approach is to use events that heightened racial awareness at the national level, such as the riots in 1992 that followed the beating of Rodney King or the presidential election of 2008. Casual observation suggests that in the aftermath of the George Floyd killing, many investors increased their commitments to minority-owned funds. But it is difficult to disentangle such shifts from the national nature of the discussions, as well as the influence of confounding events. For example, the election of Barack Obama coincided with the Global Financial Crisis, while the death of George Floyd occurred during the Covid-19 crisis.

Instead, we follow the recent sociology literature and use data on fatal encounters between unarmed citizens and the police as an exogenous variable. As a measure of racial sensitivity, we calculate the news-weighted ratio of fatal encounters between minorities and police in each state and year. During periods of high racial awareness, we find that the sensitivity of fundraising to performance is substantially greater for diversely owned funds.

Why do minorities struggle to raise capital?

These patterns are consistent with the suggestion that the demand of asset owners differs for funds with managers of different ethnicities. Asset owners may limit the amount of capital they invest in diversely owned funds, regardless of performance, effectively eliminating the ability of many high performers to substantially increase the size of their next funds.

> **The under-representation of Black- and Hispanic-owned groups can at least partially be explained by demand. The lack of a strong relationship between fund inflows and performance suggests a problematic dynamic**

We highlight how minority groups are often funded through pension funds' emerging manager programs, in which a small amount of capital is earmarked for such groups. It may be difficult for managers to "graduate" from these programs and raise significantly more capital from the pensions. Meanwhile, for the far more numerous majority-owned funds, demand for funds may follow the traditional downward-sloping shape.

The weak relationship between fundraising and investment success for diversely owned funds may have a more benign explanation. Given that minority entrepreneurs find it more challenging to raise external debt and equity, the maturation of their firms may be slower. If such firms are more common in the portfolios of diversely owned funds, measures such as PMEs and exits may be less reliable guides to such funds' expected future performance. For these funds, the estimates of fundraising may be biased towards zero.

But the results showing that inflow-performance sensitivity increases during periods of high racial awareness seem inconsistent with the notion that the lower sensitivity for minority funds is simply due to less informative performance numbers. If that were the case, we would anticipate that even if inflows to minority funds increase during periods of greater awareness, the sensitivity of inflows to performance would not change.

Summing up

Together, these results support the suggestion that the under-representation of Black - and Hispanic - owned groups can at least partially be explained by demand. During "normal" times, the lack of a strong relationship between fund inflows and performance suggests a problematic dynamic. While a "set-aside" approach may assure the presence of minority managers in portfolios, it appears likely that high-performing minority groups struggle for recognition and capital. It is only during periods of sharp attention to racial issues that the dynamics appear to change. The analysis leaves many open questions for further study, including better understanding the criteria that asset owners use to select and renew managers.

KEY TAKEAWAYS

- Despite the fact that their performance is indistinguishable from other funds, minority-owned funds control a very modest share of private capital.
- The ability of minority-owned funds to raise follow-on funds is far less sensitive to past performance than that of other funds, increasing only during periods of high racial awareness.
- Setting aside capital for pro-diversity programs may boost the number of minority managers, but it will remain difficult for even high-performing minority groups to access further capital.
- The lack of racial diversity in private capital stems at least partially from the nature of investor demand, rather than the supply of available fund managers.

Automation and inequality

Daron Acemoglu
MIT

Pascual Restrepo
Boston University

Why have the US and many industrialized countries seen rising wage inequality go hand in hand with modest productivity gains? In this article, we consider why economists have often failed to offer compelling answers to this conundrum. In contrast, our recent research offers robust empirical evidence that automation has been the key driver of change in the US wage structure since 1980.

Labor market inequality has risen significantly in many industrialized economies over the past four decades. This trend is particularly clear in the US, where the rise in real wages of workers with a postgraduate degree has been accompanied by a significant decline in the real wages of low-education workers. The real earnings of men without a high-school degree are now 15% lower than in 1980. Simultaneously, many of these economies have experienced a decline in the labor share in national income.

Despite a voluminous literature on both topics, these trends remain imperfectly understood. Leading explanations relate to the changing nature of technological progress. For example, computers are argued to be skill-biased technologies that have raised the productivity of skilled workers, especially those with college or postgraduate degrees, more than those of less skilled workers.

Why do economists struggle to explain rising wage inequality?

In the most canonical approach, technological progress increases productivity capital and labor inputs, which are combined to produce output in the economy. Skill-biased technical change (SBTC) in this framework corresponds to new technologies directly augmenting and increasing the productivity of skilled workers, which then increases inequality because it increases skilled wages more than those of lower-skill workers. Likewise, in this framework, improvements and machinery can also increase the productivity of capital inputs. In both cases, however, technologies tend to increase wages for all worker types, because they are either increasing worker productivity or the productivity of the equipment that is complementary to workers.

These popular and influential frameworks are problematic, however. First, they lack descriptive realism and clear empirical support. Most technologies improve the productivity of a factor in some tasks (for example, a better paintbrush makes a worker better at painting, but not necessarily other tasks), improve the productivity of some industries, reallocate some tasks from one factor to another (as with the spinning and weaving technologies that started the British Industrial Revolution in the 18th century), create new tasks, invent new goods, or introduce new ways of combining existing tasks or intermediates. None of these easily fit into the factor-augmenting framework.

Second, and perhaps more importantly, these frameworks make a range of counterfactual predictions. For example, skill-biased technical change can benefit college graduates more than high school graduates, but should never reduce the real wages of high school graduates. But declining real wages of low-education men has been a persistent trend in the US labor market over the past four decades. Similarly, with just factor-augmenting technological changes, it is difficult to have instances in which new technologies reduce labor demand, employment and wages. Yet again, we have plenty of examples of new technologies, especially automation technologies such as industrial robots, that have been associated with lower wages and employment.

> “Much of the change in US wage structure is driven by the automation of tasks performed by certain types of workers in some industries, such as those in manufacturing replaced by industrial robots

Third, and relatedly, a framework based on factor-augmenting technologies does not generate meaningful changes in the labor share. For realistic values of the elasticity of substitution between factors, generating the changes in labor share experienced in US manufacturing would require huge changes in technology, which should be associated with very large increases in productivity. We do not observe these increases in the data. Likewise, to match the observed changes in the skill premium, the standard SBTC model would need unrealistically large changes in productivity.

Task displacement and falling wages

In recent work, we propose an alternative approach to wage inequality. We argue that much of the change in US wage structure is driven by the automation of tasks previously performed by certain types of workers in some industries, such as the blue-collar workers in manufacturing replaced by numerically controlled machinery or industrial robots. Workers who have not been displaced from the tasks in which they have a comparative advantage, such as those with a postgraduate degree or women with a college degree, enjoyed real wage gains; low-education men, and those who used to specialize in tasks and industries undergoing rapid automation, have experienced stagnant or even declining real wages.

The striking empirical finding of our work is that a simple measure of task displacement explains much of the recent changes in the US wage structure. Specifically, for 500 worker types (distinguished by gender, age, education, race and native/immigrant status), we construct measures of their specialization in different occupations and industries in 1980, emphasizing routine tasks that can be automated. We then construct a measure which captures whether workers specialized in routine tasks in industries

> **Our model can explain a sizable fraction of the real wage declines observed in the data. It also explains how automation can transform the wage structure while having a tiny impact on productivity growth**

that experienced subsequent labor share declines — a telltale sign of automation — saw their relative wages fall between 1980 and 2016. This task displacement measure explains 70% of changes in wage structure. Put simply, rising inequality in the labor market is largely accounted for by declining relative wages for routine tasks at industries susceptible to automation.

The main fact we document is very robust. In particular, the link between our measure of task displacement and real wages is unaffected when we control for changes in industry markups, deunionization, import competition from China, and other non-automation technological developments (and these competing variables do not appear to be important for explaining changes in the US wage structure). Moreover, when we control for various forms of SBTC (for example, allowing productivity to change over time according to workers' educational levels), our measure of task displacement still explains 50%-70% of observed changes in wage structure, while traditional SBTC proxies account for about 8%.

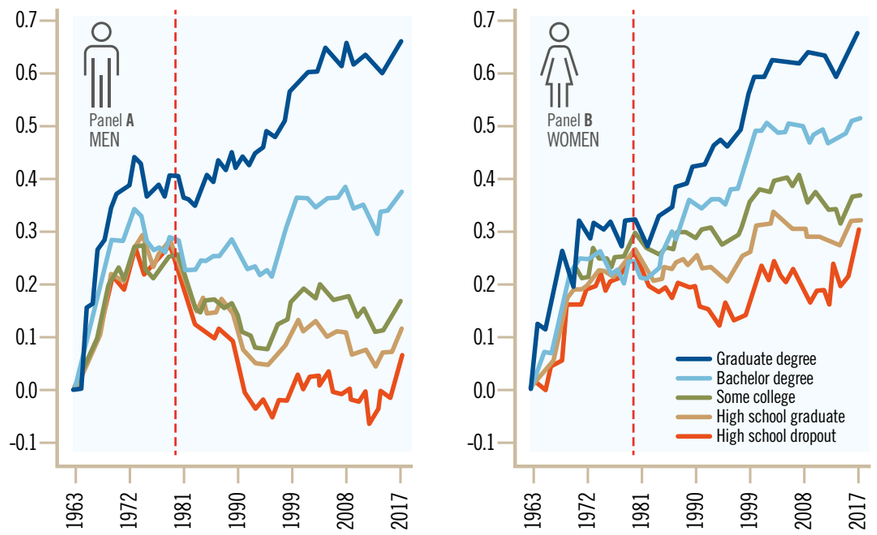
Why do some workers suffer, while others benefit?

To explain why workers specialized in automated tasks suffer wage declines, we start with a model in which each industry performs a range of tasks, some of which are "routine" and susceptible to automation. There are several groups of workers, each with a different comparative advantage across tasks and industries. While we allow technology to directly complement/augment different types of workers, the innovation of our model is to allow for automation technologies that increase the productivity of capital in certain routine tasks that used to be performed by workers.

This setting delivers three key results. First, by allowing technological change to reduce the wages of displaced workers, our framework can explain the puzzles of other SBTC models such as the association of rapid automation with slow productivity growth. Second, we derive a simple equation linking the wage changes of a demographic group to the task displacement it experiences. Third, task displacement can be measured by the group's employment share in routine tasks at industries undergoing automation. In turn, industry-level automation is tightly connected to changes in labor share in that industry.

Although our analysis provides evidence of a strong negative relationship between task displacement and relative wage changes across worker groups, it misses three indirect effects affecting real wages. First, our results are not informative about real wage level changes. Second, our evidence does not account for ripple effects, which result from displaced workers competing against others for some of their tasks and bidding down their wages. Third, because automation and task displacement are concentrated in a handful of industries, they can change the sectoral composition of the economy, shifting the demand for different types of workers.

Fig.1 - Evolution of US wage inequality



To account for these issues, we explore the implications of task displacement for the wage structure, real wage levels, productivity, output, and sectoral composition of the economy. Our conceptual framework provides explicit formulas to calculate the impact of all these effects in combination with our measure of task displacement, as well as cost-saving gains from automation, product demand elasticities, and the ripple effects between different groups of workers.

We find that task displacement accounts for about 68% of the observed change in relative wages during this period and explains 85% of the observed increase in the college premium. Finally, task displacement alone closes the gender gap by about 12%. Importantly, these sizable distributional effects are accompanied by modest increases in the average wage level, GDP and productivity (which increased by a mere 2% from 1980 to 2016). As a result, our model is capable of explaining a sizable fraction of the real wage declines observed in the data and displayed in Figure 1. In doing so, our model also explains how automation can transform the wage structure while having a tiny impact on productivity growth.

KEY TAKEAWAYS

- Up to 70% of changes in the US wage structure since 1980 are accounted for by the relative wage declines of workers specialized in routine tasks in industries experiencing rapid automation.
- We find robust evidence of a simple relationship between the wage changes of a demographic group and the task displacement it experiences.
- Our task displacement measure captures the effects of automation rather than rising market power, markups, deunionization, or import competition, which themselves do not appear to play a major new role in US wage inequality.
- Our evaluation of the full effects of task displacement explains how major changes in wage inequality can go hand-in-hand with modest productivity gains.

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How should Europe tax labor and capital?

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Should capital be taxed at a lower rate than labor? Is a capital tax even necessary? Here, we sketch the main theoretical arguments about the relative importance of these two taxes in an ideal tax system. Note that capital taxation concerns corporate income, self-employment and capital income; labor taxation comprises personal income taxes and payroll taxes.

Labor taxes provide the largest share of revenues in the EU27, followed by consumption taxes, then capital taxes. From 2005 to 2018, labor taxes increased from 50.4% to 51.7% of total tax revenues, while capital taxes decreased from 21.4% to 20.4%. Consumption taxes were quite stable at around 28%. The structure of taxation differs markedly across member states: In particular, capital taxes range from around one third of total tax revenue in Luxembourg to less than 10% in Estonia and Latvia. Yet, the labor tax rate typically exceeds that of capital tax. Nordic countries have been using the "dual income tax", which combines progressive taxation of labor income with (separate) proportional taxation of capital income[1].

Finding the ideal balance

In the public finance literature, there are two polar views concerning these two taxes. The Haig-Simons comprehensive tax applies the same marginal tax rates on all sources of income; including, for instance, both components of the US tax base. However, optimal tax theory shows that taxes on labor and capital have different implications in terms of efficiency and equity and that there is no reason for using identical rates. This critique is now widely accepted. Instead, the question is how different those rates should be and if capital should be taxed at all.

The second view, supported by conservative groups, holds that the capital tax rate should be zero. Initially, this claim rests on the idea that wealth largely results from saving, which has already been taxed as a component of income. More formally, Chamley (1986) and Judd (1985) use a dynamic model to show that capital tax should eventually vanish, as the tax elasticity of capital income tends to infinity. However, this proposition rests on a number of assumptions and Chamley (2001) himself shows that his result does not hold with uncertainty. In any event, since it applies only in the long run, it is of little practical relevance for policy design.

> "Taxation of capital income should be positive, under realistic conditions, but there is no reason why the tax rate should be equal to that of labor income

A more relevant challenge appears to come from Atkinson and Stiglitz (1976) who suggest that a capital income tax is unnecessary as all redistribution can be efficiently achieved via income tax. Their original result states that commodities should not be taxed at different rates, implying that consumption at different periods should not be taxed at different rates. Roughly speaking, the interest rate determines the relative price of current and future consumption. While their assumption that preferences are separable between goods and labor supply is debatable, there is no clear evidence against it. However, another significant assumption is that individuals differ only in their productivity[2]. But if individuals differ also in inherited wealth, a capital tax achieves redistribution that is beyond the scope of a labor income tax. This is quite intuitive: in reality, differences in wealth are to a significant degree explained by inheritances[3]. The result also breaks down when individuals differ in preferences (leading to different saving behavior) or if there is uncertainty.

The art of the possible

To sum up, taxation of capital income should be positive, under realistic conditions, but there is no reason why the tax rate should be equal to that of labor income. In the choice of this tax, policymakers cannot avoid the reality of tax avoidance and tax arbitrage. With capital mobility in the European Union, tax competition may lead to a race to the bottom. Recent information exchange agreements among member states have mitigated this problem, at least for individual capital income. Nevertheless, a linear tax will be easier to enforce in a context of capital mobility.

We therefore recommend a Nordic dual income tax system, which taxes labor income according to a nonlinear progressive tax schedule and capital income at a proportional rate. This system is being adopted by an increasing number of countries and appears to strike a balance between an optimal and administratively feasible tax system. The overall progressivity of the tax system can be adjusted by combining the dual income tax with taxes on wealth or inheritance.

1 - For a good survey of these issues, see Banks and Diamond (2010) and Bastani and Waldenström (2020).
2 - Cremer et al. (2003).
3 - Alvaredo et al. (2017).

> **Nordic dual income tax appears to strike a balance between an optimal and administratively feasible tax system. Overall progressivity can be adjusted by combining it with taxes on wealth or inheritance**

Income shifting is another issue that arises when tax rates on labor and capital income differ significantly. For instance, the self-employed can "transform" their labor income into capital income by incorporating their business so that part of their income is paid out as dividends.

Empirical studies tend to find that capital income is more responsive to taxation than labor income, which suggests that capital income should be taxed less than labor income on efficiency grounds. Equity considerations, on the other hand, call for taxing capital income at a higher rate than labor income. More research is needed to quantitatively assess the welfare gains of taxing labor and capital income in different ways; for example, by comparing comprehensive and dual income tax systems.

KEY TAKEAWAYS

- Under realistic conditions, capital income should be taxed, but there is no reason why the tax rate should be equal to that of labor income.
- A Nordic "dual income tax" system, which taxes labor income according to a nonlinear progressive tax schedule and capital income at a proportional rate, appears to strike a balance between an optimal and administratively feasible tax system.
- The overall progressivity of the tax system can be adjusted by combining the dual income tax with taxes on wealth or inheritance.

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Daron Acemoglu

Congratulations to the TNIT on fifteen wonderful years of research and progress

Chad Jones

TNIT has been fantastic working with such good friends over the years, and incredibly helpful for my research on working from home and management practices. I will always treasure those TNIT meetings for the feedback, discussion and collaboration that has been to impactful

Nicholas Bloom

I will really miss TNIT. Some e-commerce projects from the early days are among my favorites, and it was so valuable to be spurred to think broadly about where IT mattered and to interact with an amazing group

Glenn Ellison

During the years I was affiliated with TNIT, the network was a wonderful source of positive externalities — both academic and personal. It gave me the opportunity to discuss and get comments on my work on how Information Technology affected inequality (with Esteban Rossi-Hansberg), its impact on police effectiveness (with Paul Heaton), on inequality and organization in law firms, on how it changed management practices and hierarchical structure (with Nick Bloom, Raffaela Sadun and John Van Reenen), or organizational codes in firms (with Andrea Prat and Jacques Cremer) etc Personally, the network gave me the opportunity to interact and get to know a wonderful group of people that were leading the profession´s evolving thinking on issues that have become, over the last 15 years, the central issues affecting our economies: inequality, superstar workers and firms, increasingly concentrated markets, etc.

Luis Garicano

The TNIT was a unique gathering of researchers with a common interest in digitization and its profound economic impact. It proved to be a tremendous environment for exploring new ideas as the industry evolved, enriched by the perspective of Microsoft executives

Josh Lerner

The Toulouse Network was ahead of its time in recognizing the potential for modern communications, data, and computing to transform industries, organizations, and people's lives. I'm grateful to have had the opportunity to learn from the TNIT economists

John Levin

TNIT helped my field, empirical Industrial Organization, adjust to the policy issues of the day, for which we are all grateful. It was particularly helpful in bringing applied theory and empirical work together, a combination needed for useful analysis of those issues. For me personally it helped cement a relationship with the Toulousse School of Economics, which has continued until this day. Many thanks to the organizers

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