Winter 2017

Special edition on invention and innovation

MIT SLOAN

FINTECH COMES HOME

Creating new solutions
at the intersection of finance and technology


INVENTORS WELCOME
COURAGE
+ CURIOSITY

INSIDE

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MIT MANAGEMENT
SLOAN SCHOOL

MIT SLOAN

Special edition on invention and innovation
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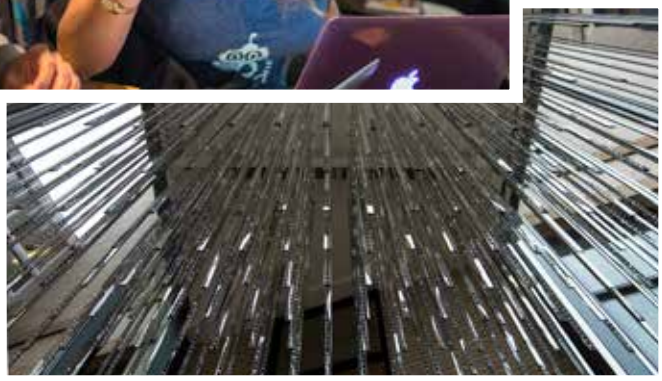


DEAR FRIENDS,

Invention and innovation. In 2013, we brought you the first issue of the *MIT Sloan* Alumni Magazine, which was devoted to the idea that invention and innovation are more than a set of buzzwords. They are the results of the uncommon work done every day by our faculty and students, brought to the world through their initiatives. At MIT Sloan, we are unwavering in our commitment to fostering ideas made to matter, and our community is grounded in the conviction that we can change the world for the better.

In this, our fifth "Invention and Innovation" issue, I invite you to see how that conviction is alive and thriving at the school. On pages 4–6 you will learn how we are securing resources, updating facilities, and supporting our diverse MIT Sloan community to ensure that today's students and tomorrow's leaders have the resources they need to continue our important work.

In our feature story, "Fintech Comes Home," we celebrate that we are smarter together. Collaborating at the intersection of technology and finance, faculty members Bill Aulet and Antoinette Schoar designed a course devoted to teaching entrepreneurship in the financial sector. We meet emerging challenges like cybersecurity through tested management practice combined with inventive approaches laid out by Stuart Madnick in one of our research snapshots. Our commitment to harnessing data for the greater good can be seen in the work of Dimitris Bertsimas's algorithm for the treatment of Type 2 diabetes, which promises to improve the delivery of healthcare for countless individuals. These are just a few of the individuals who recognize that a better world is ours to make.

As a member of our alumni community, you are an integral part of this better world. I hope that you will take part in one of our upcoming MIT Campaign for a Better World events in San Francisco on March 29, New York City on April 13, or Boston on April 24. I look forward to celebrating MIT Sloan's exceptional spirit as an inventive and innovative community, and I hope that you will join us by registering at mitsloan.mit.edu/campaign/events.

Sincerely,

David Schmittlein
John C Head III Dean

MAKING

MIT Sloan students aren't the only ones hard at work in Cambridge. Every day, the MIT Sloan community defies convention, ensuring that impact in the world is our bottom line.

We are pleased to share the state of the school progress report for Fiscal Year 2016 (July 1, 2015–June 30, 2016).

FINANCIALS *as of June 30, 2016*

MIT SLOAN REVENUE

- **Net Tuition and Non-Degree Fees** $126.9M 61%
- **Endowment Income** $27.9M 14%
- **Expendable Gifts*** $23.7M 12%
- **Sponsored Revenue** $9.2M 4%
- **Other Revenue** $18.2M 9%

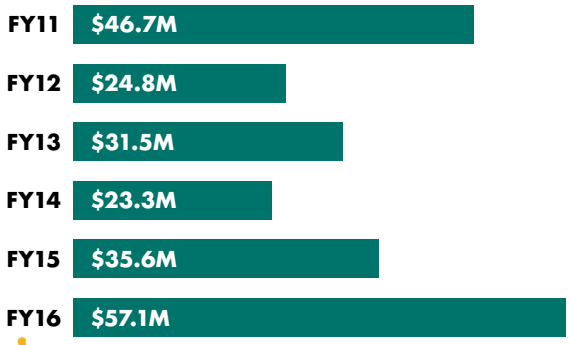
*FY16 pledges not included in expendable gifts totals

MIT SLOAN ENDOWMENT MARKET VALUE

$820M

FUNDRAISING

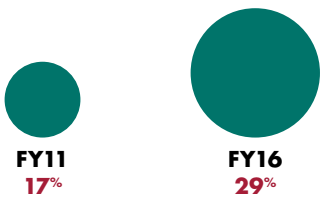
MIT Sloan New Gifts and Pledges



FY16 New Gifts and Pledges Totals

MIT Sloan Annual Fund:	$5,400,000
Major Gifts:	$51,700,000
TOTAL:	$57,100,000

Alumni Participation



THE GRADE

CAMPAIGN

Launched in May of 2015, the MIT Campaign for a Better World is the Institute's most comprehensive capital campaign to date. For more information on the campaign, visit mitsloan.mit.edu/campaign.

$194M
raised

PRIORITY AREAS

- Teaching, Learning & Living
- Inquiry & Discovery
- Innovation & Entrepreneurship
- Health of the Planet
- Human Health
- MIT Sloan Core

Campaign Priority Spotlight: MIT Sloan Core

Fellowships for masters-level students are a key priority for MIT Sloan, helping the school attract the best students who embody the school's mission and vision.

$33,000,000
raised toward
$100M campaign fellowship goal

THE CASE FOR FELLOWSHIP SUPPORT

While MIT Sloan has increased fellowship support to $2.7M, it still falls short of peer schools that offer, on average, $4.0M to the same applicants.

MIT SLOAN	$2.7M
PEER SCHOOLS	$4.0M

STUDENT BODY

MBA & LGO APPLICATIONS

4,254
Last year

5,707
This year

PROGRAM ENROLLMENT

MBA/LGO	409	Sloan Fellows	110
Master of Finance	114	Executive MBA	126
PhD	95	Master of Business Analytics*	16
System Design & Management	63	Undergraduates	32

*Created to prepare students for careers that apply modern data science to solve critical business challenges, the first class was accepted in fall 2016.

DEMOGRAPHICS

		Female	International
MBA/LGO		40%	39%
MIT Sloan Executives	Sloan Fellows	30%	85%
	EMBA	32%	10%
MFin		40%	88%

FACULTY

STUART MADNICK

Madnick's research shows that too many companies turn to software and hardware patches to prevent critical data breaches. The best way to prevent hacking? Changing corporate culture and incentives to increase the focus on cybersecurity internally.

ZEYNEP TON

Ton's research, outlined in *The Good Jobs Strategy*, presents a compelling case that viewing employees as operating costs instead of strategic investments is a choice, not a business necessity. Arguing that investing in workers is good for business and society, her work spurred real change in companies nationwide.

RETSEF LEVI

Engaged by the FDA, Levi led a multidisciplinary team of faculty members from MIT Sloan in collaboration with the MIT Center for Biomedical Innovation in a systematic study of how food is grown, processed, and shipped to the United States. The study has provided the FDA with tools and models to evaluate risk to food safety, and Levi's team is launching a new study of supply chains in China, the world's third-largest food exporter.

FACILITIES UPDATE

On March 3, 2016, E52 was reopened after a two-and-a-half-year renovation and renamed the Morris and Sophie Chang Building, providing new space for students and administrative offices and expanded event space through the addition of the Samberg Conference Center.

RESEARCH SNAPSHOTS

Positive impact. It is the result of the purpose-driven work of our faculty, grounded in the belief in MIT Sloan's mission. In the following pages, you will hear from just five of our faculty members aiming to improve the world through their research. From lean manufacturing applied to Nike's supply chains to redefining the 2008 housing crisis to delivering better personalized medicine through new algorithms, MIT Sloan faculty members demonstrate that impact is our bottom line.

GREG DISTELHORST:

NOT JUST THE BOTTOM LINE: LEAN MANUFACTURING MAY HELP WORKERS, TOO

New research links management practices to compliance with labor standards in Nike supply chain.

By Brian Eastwood

Businesses tend to adopt lean manufacturing in order to streamline production and improve efficiency, but recent research from a new MIT Sloan professor suggests that lean principles can help alleviate poor conditions for factory workers, as well.

A study of the adoption of lean manufacturing by factories within Nike Inc.'s supply chain found that lean adoption was linked to a 15 percent reduction in noncompliance with labor standards such as wages, benefits, and time off.

"The assumption people have is that good business and treating workers well are in fundamental conflict," says study co-author Greg Distelhorst, who joined MIT Sloan last fall as the Mitsubishi Career Development Professor in International Management and an assistant professor of global economics and management. "The pretty significant positive impact [of lean manufacturing] we saw in our research was a pleasant surprise. It suggests a way to align business interests in the supply chain with worker well-being."

ENGAGING WORKERS: A BIG COMMITMENT

Amid concerns about delivery time, product quality, and working conditions, Nike began securing commitments from long-time suppliers to implement lean manufacturing in 2002. While mass manufacturing focuses workers on a single task, the lean manufacturing principles popularized by Toyota teach line workers to complete several different tasks. In an apparel factory, this could mean having the skills to sew an entire shirt instead of a single seam, Distelhorst says. Lean manufacturing also encourages workers to take responsibility for quality control and find ways to improve overall production. In turn, this makes workers more valuable and more important for the factory to retain.

Some prior research connected lean manufacturing to a more engaged and satisfied workforce, but those papers had only focused on a handful of factories. Distelhorst and his co-authors examined audits of more than 300 factories in Nike's supply chain in 11 countries. About one-third of the factories were in Southeast Asia; another half were in China.

Lean manufacturing was a big commitment for the factories. They needed to appoint managers responsible for lean transformation and send them to Nike's training facility in Sri Lanka. In some cases, the physical layout of the factory had to change—moving the sewing line and the pressing line onto the same production floor, for example.

This was a major investment by Nike, as well, involving a dedicated training facility and years of engagement from its in-house lean staff. "Just going

"Just going up to the factory door, yelling 'Lean management,' and walking away isn't going to produce the change that you want," Distelhorst says.

up to the factory door, yelling 'Lean management,' and walking away isn't going to produce the change that you want," Distelhorst says.

Two years after certifying their first lean manufacturing line, factories on average scored more than half a letter grade higher on their audits than those that had yet to adopt a lean line. This amounted to the 15 percent reduction in labor noncompliance.

The impact was not universal, though. While conditions improved in most countries—namely India, Malaysia, Thailand, and Vietnam—they did not improve in China. The lack of improvement in China is consistent with previous research, also co-authored by Distelhorst, which examined compliance in Hewlett-Packard's electronics supply chain.

It is not yet understood why Chinese lean-adopters failed to improve, but Distelhorst noted that China's high rate of worker turnover may reduce the benefit of investing in training, while the country's dominance of the global clothing industry may make factories in smaller countries more willing to commit to new ideas. Sri Lanka also showed little improvement in Distelhorst's analysis, but that's because factories there were already largely compliant with Nike labor standards.

IMPACTING WORKERS WORLDWIDE

Distelhorst joined MIT Sloan from the Saïd Business School at the University of Oxford, United Kingdom, where he was an associate professor of international business. He holds a bachelor's degree in cognitive science from Yale University and a PhD in political science from MIT, with a concentration in Chinese politics. His management research explores business models that are simultaneously profitable and have a positive impact on labor and environmental conditions where trade unions are weak and environmental regulations are lax.

He is particularly committed to China, where he lived and worked for more than five years. "When we find ideas that work, I want them to work in China," he says. ● ● ●

CATHERINE TURCO: A LOOK INSIDE A "CONVERSATIONAL FIRM"

Is there room for more open corporate communication than ever before? Will the old guard let it happen? Should it?

By Kara Baskin

In her new book, *The Conversational Firm: Rethinking Bureaucracy in the Age of Social Media*, Catherine Turco explores how one software firm upended traditional bureaucratic hierarchy by giving all employees a voice.

Turco, the Theodore T. Miller Career Development Professor and an associate professor of work and organization studies at MIT Sloan, spent 10 months inside "TechCo"—the actual company name is kept anonymous—documenting daily activity, shadowing workers, sitting in on hundreds of meetings, and conducting interviews with 76 employees. What she found is a new way of communicating across old management structures, something she calls a "conversational firm." And it may guide other companies through the shift in workplace culture as millennials grow in the workforce. In this interview, she explains her findings.

What new approach to communication did you find inside TechCo?

What most excited me was the realization that there is a new organizational model that companies can shoot for today. I believe this model has become possible—and perhaps even necessary—on account of the communication technologies now available and the habits and expectations that today's employees bring into the workplace. I call the model the "conversational firm," and it's the idea that organizations can have far more open dialogue across the corporate hierarchy than we ever before thought possible.

The key insight underlying this idea is that hierarchy can be deconstructed in ways we haven't previously seen or thought about. In the past, it was generally assumed that a firm's formal communication and decision-making structures were tightly linked. Just think about how an organizational chart is taken to be a visual mapping of the formal lines of communication and decision-making authority.

However, I found something quite different when I looked carefully inside TechCo. There, I saw a firm that was leveraging a wide range of social media tools and platforms and that was responding to its millennial workforce's expectations for voice rights by opening up the company's communication environment quite dramatically. And yet it was doing so without destabilizing or disrupting a conventional decision-making hierarchy.

When it came to communication, executives shared with the entire workforce detailed business information that other executives might pore over in senior leadership meetings but not distribute. The company's executives also extended voice rights to everyone in the company by encouraging employees to speak up and weigh in on major business issues, not just those that concerned an individual's specific job.

Meanwhile, the company still retained a fairly conventional hierarchy when it came to decision-making authority. It was as if voice rights and decision rights had been pulled apart from one another. Voice rights were delegated broadly, while decision rights were organized in a more conventional, hierarchical fashion. In fact, in a few cases when executives tried to delegate certain decision rights more broadly, employees used the voice rights they'd been given to speak up and note the problems this might cause. I was fascinated by what I was seeing, and I was also influenced by some brilliant work on the nature of hierarchy that my colleague Ezra Zuckerman has done.

Most interesting to me was the fact that this company, which was so vocal about rejecting conventional bureaucracy, ended up adopting some bureaucratic practices over time—but this happened precisely because employees used their voices to speak

up and say when certain conventional practices that had been rejected would not be useful. It struck me that a whole new model was emerging, one in which cross-hierarchical conversation was a central mechanism for confronting business challenges.

How can an organization become a conversational firm?

For starters, it requires leveraging today's communication technologies. TechCo had a very active corporate wiki on which executives and employees constantly communicated. It also had an enterprise chat system, and it was constantly adopting new tools to foster even more dialogue. Moreover, it had created a physically open communication environment to complement its digitally open one. People worked in wide-open workrooms with no offices or cubicle walls to separate them. Executives didn't have offices, either; they sat with everyone else. Employees told me that this was especially important to them because it symbolized the sort of access and free-flowing communication they valued.

That said, building a conversational firm involves a lot more than just adopting a corporate wiki and taking down some cubicle walls; and it's not easy to do. You need corporate leaders who really mean it when they say that they're delegating voice rights and want to hear employees' opinions. You need leaders who appreciate that the whole point of having a conversation is to surface a range of opinions. It won't work if you tell people that you want their thoughts and then punish them when they speak up. Also, with open dialogue comes a lot of noise that many corporate executives might prefer to do without. But for executives who want more engaged employees and who want to be able to tap into the organization's collective wisdom to confront business challenges when they arise, I think it's well worth it.

How did this work at TechCo?

I think it's easiest to explain by way of example. At one point, the company experienced a spike in its customer churn. The executives could have hunkered down and tried to solve the problem in closed-door meetings among just themselves. But they didn't. At the same time as they were thinking through the issue as a senior leadership team, they used the wiki to share over 100 pages of data on the issue with the workforce, and they encouraged employees to speak up and weigh in with questions, comments, and ideas. Then they took the conversation offline and held a "hack night," where employees were invited to come and share their thoughts and work in small groups to "hack away" at the problem. Those groups continued to work together in the weeks that followed, using the wiki to update the rest of the organization on their progress and collect ongoing feedback. By promoting dialogue in digitally and physically open spaces like this, the company was able to turn the problem around quickly. In my opinion, that sort of rapid learning and adaptation is a unique strength of this conversational model.

What is the work relationship between millennials who came of age with social media and older generations of workers who did not?

From my conversations with millennial workers, I came to see that what they wanted most were voice and access. In reality, I think that's what almost all of us want. Millennials are just particularly useful for revealing this desire because they display an extreme version of it in some sense. They were raised on social media tools and platforms that gave them more voice and access to information than prior generations had, and as a result they have come to expect those things.

Describe "openness" in the workplace. Should we aspire to it?

Openness is a slippery concept because it's so multi-faceted. It can mean participatory democracy. It can mean free-flowing communication. It can mean an organization without clear boundaries between itself and the external world. It can even mean surveillance.

Even though TechCo's executives talked in terms of openness, I quickly realized that the word wasn't the central metaphor for what I saw as truly unique about their evolving project. "Conversation" was more apt. Just like bureaucracy, openness solves some problems but creates others. At different stages of an organization's life, different combinations of formal bureaucratic practices and more informal open ones might be necessary. The key is to have an open enough communication environment so that the organization can collectively surface the needs of the current moment and thoughtfully approach the next. ● ● ●

STUART MADNICK: TAKING A MANAGEMENT APPROACH TO FIGHTING CYBERCRIME

Preventing a hack takes more than a software patch.

By Meghan Laska

Have you ever had the nightmare where you log in to your bank account and discover that the bank has been hacked and it looks like your money is gone? At the recent Cambridge Cybersecurity Summit, hosted by MIT in conjunction with CNBC, the question for panelists was: Could this really happen? Stuart Madnick, the John Norris Maguire (1960) Professor of Information Technology, answered, "Not only could this happen, it is inevitable." He says, "If you haven't been hacked yet, it's only a matter of time." Madnick has been studying cybersecurity issues since the late 1970s and coauthored one of the first textbooks on the topic, *Computer Security*.

When it comes to cybersecurity, Madnick's key message to businesses is that this is a management issue, not just a software or hardware issue. He explains, "As recently as five years ago, cybersecurity largely involved a junior assistant walking from desk to desk with the latest security patches from Microsoft. This issue is starting to get more attention, but management still has a lot of work to do."

According to several studies, attackers can operate inside an organization's computers for an average of 243 days before they are detected. In the Asia-Pacific region, that number jumps to more than 500 days. Also concerning is the statistic that up to 80 percent of breaches are aided or abetted by insiders, often unintentionally from an employee who opened an attachment in an email.

"You may be under attack now and just not know it. It is important to address the managerial and strategic aspects of cybersecurity, and we are uniquely positioned to do that at MIT Sloan," says Madnick, who is the academic director of MIT Sloan's Interdisciplinary Consortium for Improving Critical Infrastructure Cybersecurity, also known as (IC)^3. "Our goal at (IC)^3 is to raise awareness and build a safer world."

POOR INCENTIVES

At (IC)^3, a major focus is on the incentives and disincentives for organizations when it comes to the cybersecurity of infrastructure. Within that umbrella, an important question involves partnering and data sharing.

"If a cyberattack knocked out power to your business, what is your reporting obligation? Who would you contact? There are many business reasons you may not want to report the hack: to protect your reputation, fear of encouraging copy cats, and fear of legal liability. Decisions about who to call, what to say, and what information to share are management issues. It comes down to understanding incentive systems and goals," explains Madnick.

In a recent paper on this topic, Madnick and fellow researchers identified about 120 organizations around the world focused on data sharing. "We found a cobweb of organizations that is dusty, messy, and not well organized. There is a lot of information sharing happening, but it's not effective."

For example, he points to the creation of Financial Services Information Sharing and Analysis Centers (FS-ISACs) set up for specific industries like financial services. If a major bank is attacked, the bank should contact the FS-ISAC. Yet when the SWIFT funds transfer network was attacked, SWIFT created its own information sharing initiative, separate from ISAC.

Several of the top banks, says Madnick, also meet privately to share information with one another—not the entire banking community.

"This is a trust issue, and it shows there is a fundamental problem with the incentive system. We know what isn't working, so we are looking at what can be changed to make the information sharing process work better," he says.

PUTTING SAFETY FIRST

Another $(IC)^3$ project involves changing corporate culture—and incentives—to increase cybersecurity internally. "We want to take research on how industrial organizations have improved safety over the past decade to see how we can apply those lessons to improving cybersafety in companies," notes Madnick.

He points to ExxonMobil as an example of how this can work. "If you walk down the stairs at Exxon's headquarters, someone will ask you to hold the handrail. The idea is that if you focus on doing certain tasks more safely, you will take a safer approach in all your actions. It's a safety-first corporate culture."

In the realm of cybersecurity, this safety-first mindset could be very helpful, especially when it comes to suspicious emails. A financial services firm, notes Madnick, conducted a test to see how many employees clicked on phishing emails. Even when the email clearly stated that it was a phishing email and opening it would cause harm, at least one executive clicked the link, "just to see what would happen."

He says, "There is a different mindset when it comes to cybersecurity at companies that needs to be changed. We're trying to understand what works and what doesn't when it comes to changing the corporate culture around cybersecurity."

CROWDSOURCING SECURITY

A different mindset is also needed when it comes to detecting and defending against threats. Too many companies are focused on the latest attack, preparing for it to happen again instead of thinking about what is to come, explains Madnick.

"We need better ways to optimize the workforce to ensure employees' skills can match the threats that are forthcoming," he says, noting that some strategies are common sense, but are nonetheless resisted by managers.

Bug bounty programs are a good example. These originated at software companies and use crowdsourcing to find bugs for rewards. Madnick says even an organization like the U.S. Pentagon benefited from a bug bounty program. After spending $5 million for a consulting firm to identify bugs—and discovering only 10 flaws in three years—the Pentagon invited 1,400 white hats—ethical computer hackers—to do the same thing. Within six months, they found more than 120 bugs at a cost of $150,000.

"Organizations need to consider using these types of programs because we're anticipating a shortfall of 2 million cybersecurity specialists in the next five years," says Madnick. "We need to be creative in how we leverage the cybersecurity workforce. A bug bounty program is one way to do that. Our research attempts to understand how companies can most effectively address their workforce needs."

AN INTERDISCIPLINARY APPROACH

Throughout all the projects at $(IC)^3$, Madnick is taking a collaborative approach by working with faculty across MIT's campus and with academic and industry partners. He is looking at conventional information systems, as well as the cyber-physical infrastructure and Internet of Things—the computer-controlled facilities, such as electric power, manufactured goods, financial services, telecommunications, healthcare, autonomous vehicles, etc., that form the infrastructure of a safe and secure world. His team seeks to produce metrics and models that organizations can use to measure all facets of cybersecurity and to make the best possible decisions about allocating resources to protect themselves.

"Together, we can identify and develop the strategies, models, and processes that will improve cybersecurity and protect our critical infrastructure," he says. ● ● ●

DIMITRIS BERTSIMAS:

HOW A NOVEL ALGORITHM CAN IMPROVE THE PROGNOSIS FOR TYPE 2 DIABETES

Transforming patient care, one algorithm at a time.

By Alix Stuart

Dimitris Bertsimas was a young boy in Athens, Greece, when his mother was diagnosed with Type 2 diabetes. He was already familiar with the disease—a chronic, hereditary condition that causes blood glucose (sugar) levels to rise higher than normal—because his grandfather had died of complications related to it. His mother's sister, who lived only a few streets away, also suffered from the illness.

Even as a child, Bertsimas recalls being puzzled by the fact that his mother and aunt received such very different treatment from their respective physicians. His mother never took insulin, a hormone that regulates blood sugar levels; instead, she ate a restricted diet and took other oral drugs. His aunt, meanwhile, took several injections of insulin each day and dealt with many more serious side effects.

"Back then, there was no way to provide targeted treatments, no data to show which treatment was best, and no understanding that patients of similar age, heritage, and genetics might respond to certain drugs in the same way," he says. "These two sisters had the same disease but very different medical trajectories."

In the dawning era of personalized medicine, times are different. The availability of genomic information and the increasing use of electronic medical records (EMRs), combined with new methods of machine learning that allow researchers to process large amounts of data, are speeding efforts to understand genetic differences within diseases—including diabetes—and to develop treatments for them.

Bertsimas, who is the Boeing Leaders for Global Operations Professor of Management, a professor of operations research, and the co-director of the Operations Research Center, a major analytics center at MIT, is helping to lead the way. He and his colleagues have developed a data-driven algorithm for personalized diabetes management that has the potential to improve the health of the more than 29 million Americans living with the illness. The algorithm is applicable to other diseases, including cancer, Alzheimer's, and cardiovascular disease. The paper describing the work was accepted for publication in the journal *Diabetes Care*.

"Essentially, the algorithm mines patient and drug data, finds what's most relevant to an individual patient based on his or her history and genes, and then provides a recommendation on whether a different treatment or drug would be more effective," he says. "Our algorithm is a vivid illustration of how personalized medicine has the potential to transform patient care."

The role of doctors is not to be overlooked, however. "The data sets and the genomic sequencing are critical to the future of precision medicine, but human expertise provides an important third element," he says. "For it is the doctors—who have the education, skills, and relationships with patients—who will make informed judgments about the potential courses of treatment. Even with the best data in the world, we need highly trained doctors to make smart medical decisions."

Bertsimas's mother died in 2009 at the age of 75 and his aunt died the same year at the age of 78. But he sees a brighter future ahead for the patients of tomorrow. "I have a scientific motivation to work on this problem and, because of my family history, I have a human motivation, as well."

Through a partnership with Boston Medical Center (BMC), the largest safety-net hospital in New England—providing care for low-income, uninsured, and vulnerable populations—Bertsimas and his team obtained the EMRs for over 1.1 million patients from the years 1999 to 2014. Within this dataset, about 11,000 patients were included in the study. These patients had three or more glucose-level tests on record; they had a prescription for at least one blood glucose regulation drug—including insulin, metformin, or sulfonylureas; and they did not have a recorded diagnosis of Type 1 diabetes. The researchers also had access to each patient's demographic data—including information on each individual's age, sex, and race, as well as all BMC EMR data, including every patient's height, weight, body mass index, and prescription drug history. (All patient information was anonymous.)

Bertsimas and his colleagues divided each patient's medical history into distinct lines of therapy, each characterized by a particular drug regimen. Within each line of therapy, the team looked at patient visits occurring every 100 days, corresponding to the life cycle of a red blood cell. These visits provided the basis for how the team deemed whether or not a certain drug regimen was effective at managing blood sugar levels for particular patients.

Next, the team developed an algorithm to define precisely when each line of therapy ended and the next one began according to when the combination of drugs prescribed to the patient changed in the EMR data. All told, the algorithm considered 13 possible drug regimens, including single prescriptions of blood glucose regulation agents, as well as combinations of different drugs.

Then the algorithm went to work. For each patient, the algorithm processed the menu of available treatment options, including the patient's current treatment, as well as the treatment of his or her 30 "nearest neighbors" in terms of genomic and demographic similarity to predict potential effects.

The algorithm assumed that the patient would inherit the average outcome of his or her nearest neighbors.

"This is the ideal task for a computer," says Bertsimas. "It would be impossible for a doctor to look at medical data from millions of people to learn which drugs have the best possible shot at working for a patient. But this is what computers are built to do."

If the algorithm spotted potential for improvement, it proposed a change in treatment; if not, the algorithm suggested the patient remain on his or her existing regimen. In two-thirds of the patient samples, the algorithm did not propose a change.

The patients who received proposed new treatments saw dramatic results. Using historical data from the database, the algorithm resulted in an average beneficial change in the hemoglobin of 0.44 percent at each doctor's visit for which the system's recommendation differed from the standard of care. This is a meaningful, medically material improvement.

Based on the success of the initial study, Bertsimas and his team are organizing a clinical trial with Massachusetts General Hospital.

"By tailoring specific treatments to specific patients, we're giving everyone the best possible opportunity for a healthier life," says Bertsimas. "Medicine will no longer be a shot in the dark or a one-size-fits-all approach. I dedicate this effort to the memory of my mother." ● ● ●

Personalized Diabetes Management Using Electronic Medical Records: Dimitris Bertsimas, Nathan Kallus, Alex Weinstein, Daisy Zhuo, Operations Research Center, MIT

ANTOINETTE SCHOAR:

RETHINKING HOW THE HOUSING CRISIS HAPPENED

New research casts into doubt the central storyline of 2008—that this was ever a subprime crisis to begin with.

By Zach Church

"In 2006, Robert and Julia Tanner borrowed $30,000 to put an enclosed patio on their home that they had somehow managed to live without for 25 years. Why don't you ask them about that when they're spitting in your face while you walk them to the curb? Why don't you ask the bank what the hell they were thinking by giving these people an adjustable-rate mortgage? And then you can go to the government and ask them why they listed every other regulation … . You, Tanners, the banks, Washington, every other homeowner and investor from here to China turned my life into evictions."

So Florida businessman Rick Carver lectures a young protégé in *99 Homes*, a 2014 film that casts the late-2000s housing collapse as a morality play. Carver, loaded with unforgiving moral certitude by the actor Michael Shannon, orders the Tanners' eviction while standing in an empty McMansion. He's living there part time after evicting the tenants when their mortgage went underwater.

99 Homes is littered with ruin. Nobody—the poor, the Tanners, the McMansion dwellers—escapes, or escapes blame for, the crisis. Now research from MIT Sloan finance professor Antoinette Schoar finds this picture truer than is commonly accepted. In fact, Schoar argues, it was middle-class borrowers with good credit who drove the largest number of dollars in default.

"A lot of the narrative of the financial crisis has been that this [loan] origination process was broken and therefore a lot of marginal and unsustainable borrowers got access to funding," Schoar says in September at the MIT Golub Center for Finance and Policy's annual conference. "In our opinion, the facts don't line up with this narrative … . Calling this crisis a subprime crisis is a misnomer. In fact, it was a prime crisis."

That's important to know, Schoar says, because a new narrative of the crisis could inform public policy decisions and help prevent a repeat event, or at least soften the blow.

"For this, better screening at origination alone doesn't do the trick," she says. "We need macroprudential tools to actually protect ourselves against these types of dynamics in the housing market."

In a paper forthcoming in *The Review of Financial Studies* titled "Loan Originations and Defaults in the Mortgage Crisis: The Role of the Middle Class," Schoar and her co-authors (MIT Sloan PhD graduates Manuel Adelino and Felipe Severino, now professors at Duke University and Dartmouth College, respectively) show that in the run-up to the housing collapse, both credit and defaults expanded proportionally across borrowers of every income level and every credit rating.

And yet when the bottom fell out, the researchers found, there was a sharp increase in delinquencies for middle-class borrowers and borrowers with "prime"—or high—credit ratings.

While all types of people participated in the crisis, borrowers defaulting on bigger mortgages were responsible for a greater dollar amount in defaults. The researchers found that the top quintile of borrowers by income were responsible for 13 percent of delinquent mortgage debt in 2003. That share increased to 23 percent by 2006. Meanwhile, the bottom quintile of borrowers saw their share of delinquent mortgaged debt drop from 22 percent in 2003 to 11 percent in

"It points to the fact that this was a house price bubble that you could say most people in the economy seem to have bought into." —*Schoar*

2006. The shift in the middle was less pronounced, but tells the same story. And the researchers found a similar shift in the share of delinquent mortgage dollars when segmenting borrowers by credit score.

EVERYONE BOUGHT IN

So what really happened? Schoar and her co-authors believe there was an increase in leverage among borrowers of all income levels. Homeowners and investors bought and sold homes at an increasing speed between 2000 and 2006. House flipping was especially pronounced in areas of the country that saw high housing price growth between 2002 and 2006. This is when the Tanners put in their enclosed patio.

"Given that it's such a systemic event across income groups and especially in the middle class, it points to the fact that households, as well as banks, really believed in this house price appreciation and thought that it was sustainable," Schoar says. "And they acted on this feeling that they were richer because their home was worth more. Once the economy slows down, then it becomes tougher for people to pay their mortgages, but also they have less incentive to pay them if the house is underwater. It points to the fact that this was a house price bubble that you could say most people in the economy seem to have bought into."

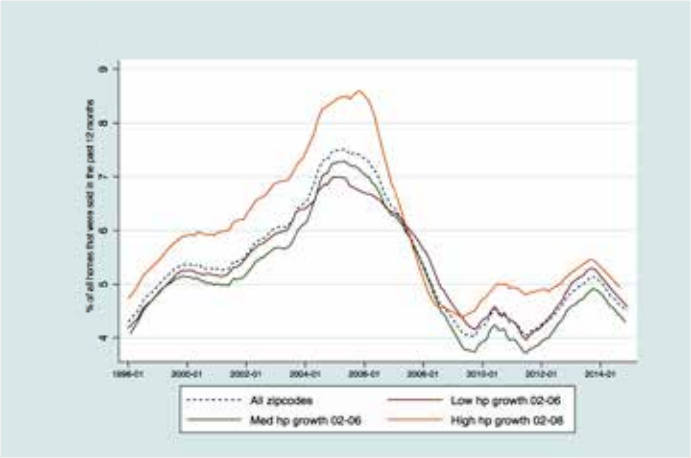
When the economy slowed, defaults went up across income spectrums. But while the chance of a low-income borrower defaulting increased from 6 percent post-crisis to 12 percent post-crisis, the chance of a high-income borrower defaulting went from almost zero to around 5 or 6 percent. And the latter group was defaulting on bigger loans.

PREVENTION, PLANNING, AND REGULATION

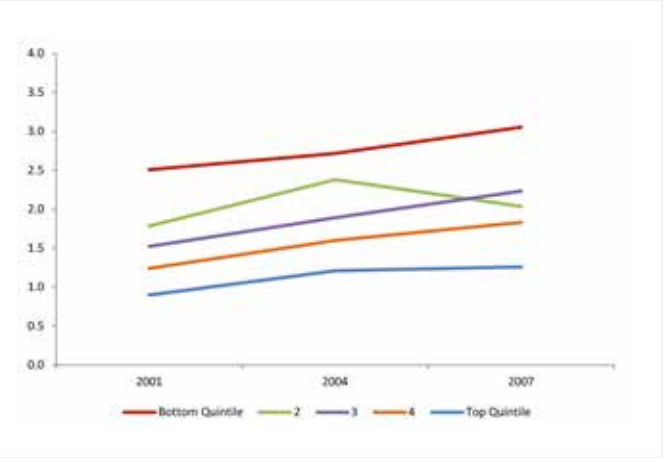
The first version of Schoar's paper was released in 2015, when conventional wisdom among economists and in the popular press said the housing crisis was caused by a shift in debt to low-income households through subprime mortgages.

"She and her co-authors really opened this up. Once you saw what she had shown, then it raised all kinds of other questions that went much deeper into what had happened," says Paul Willen, a senior economist and policy advisor in the research department at the Federal Reserve Bank of Boston. Schoar's paper has launched a reassessment of the housing crisis among economists and researchers,

HOW DID HOUSEHOLD LEVERAGE BUILD UP? INCREASED SPEED OF HOME SALES



EFFECT ON THE STOCK OF HOUSEHOLD MORTGAGE DEBT (SCF)



Willen said. In research presented last summer at the National Bureau of Economic Research, Willen shows that the share of debt remained stable between high-income and low-income borrowers leading up to, during, and after the housing crisis.

"I think everybody is now going back and revisiting all these questions. There are new facts that any theory of the financial crisis has to match," Willen says.

Both Schoar and Willen said preventing another housing bubble could be futile (a 2015 book chapter by Willen states bluntly that "... economists should acknowledge the limits of their understanding ...") and that instead policymakers should focus on ensuring that a decline in house prices will not shatter the banking industry as it did in 2008.

"From a policy perspective, what that means is that we need to understand and be prepared to absorb these types of losses when they happen or if they happen," Schoar says. "And the question is how to absorb them. Because one way to absorb them is by saying, 'Even before prices become very high, can we dynamically regulate banks so that loan-to-value ratios have to be lower when prices are high. So there's more buffer in the loans of each individual person."

A bank collapse could also be prevented by increasing the burden on creditors in the event of failure, Schoar said. One example, she said, might be providing safeguards such as contingent convertible bonds (known as CoCos) that would convert to equity in the event of impending bank failure, stabilizing a bank before bankruptcy can occur. CoCos are undergoing a test in the European markets, where volatility among banks is causing investor concern.

While working on their paper, the researchers spoke with experts and leaders in the financial industry who, Schoar said, were skeptical of the most prominent, and more narrow, narrative of the housing crisis—that low-income, low-credit-score borrowers had been given bad loans they couldn't afford.

"A lot of them told us they very much agreed with us, and they were quite frustrated that the story hadn't been captured," Schoar says. "Maybe people who were very well-meaning wanted to point out the plight of subprime borrowers, which is definitely a big problem. It's one of the many of the groups that were affected, but it became the only narrative." ● ● ●

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FINTECH COMES HOME

By Alix Stuart

When most people think about fintech, or financial technology, a plethora of catch phrases comes to mind: big data, bitcoin, blockchain, crowdfunding, peer to peer, and robo-advisors, to name a few.

When Bill Aulet, managing director of the Martin Trust Center for MIT Entrepreneurship, and Antoinette Schoar, a professor of finance and Michael M. Koerner (1949) Professor of Entrepreneurship, began thinking about fintech, just one word came to mind: perfect.

"At the intersection of finance and technology, fintech was almost made for MIT," said Schoar. MIT Sloan is commonly considered the birthplace of modern finance, having housed Nobel Laureates such as Paul A. Samuelson, Robert C. Merton, Myron S. Scholes, and Franco Modigliani at critical junctures in their careers.

Fintech is also an area where innovative startups can make a big difference, providing rich fodder for the highly respected entrepreneurship program that Aulet leads. "Fintech is about how you create new solutions in an industry that is changing, but faces significant regulatory dimensions," Aulet says. "That's a complicated problem, so it fits our DNA well."

Together, Aulet and Schoar spearheaded the FinTech Ventures program at MIT Sloan in 2014, starting with a club to gauge student interest and then a half-semester class, a student-run conference, and a business plan competition in 2015. In the fall of 2016, MIT Sloan offered its first full semester course in FinTech Ventures in collaboration with MIT's Department of Electrical Engineering and Computer Science and Harvard Law School. Aulet and Schoar consider it the first graduate-level course devoted to entrepreneurship in the financial sector in the country.

FINTECH FRENZY

By almost any measure, fintech is a hot sector. Global investment in the space began spiking in 2014, hitting $19 billion in 2015 and nearly $18 billion in the first three quarters of 2016, according to research by KPMG and CB Insights. Traditional venture investors are crowding the space; but increasingly, established financial companies are joining them, with corporate venture arms participating in better than 25 percent of venture capital deals each year.

"It's a very competitive field right now," says Matthew Rhodes-Kropf, visiting professor of finance, who teaches the FinTech Ventures course. "It's as if everyone suddenly woke up to the idea that things are not being done very well."

Yet fintech is also a broad category, covering everything from online banking services to digital currencies and payment systems. For example, "thanks to mobile apps and internet platforms, you no longer need to think of a bank in a physical way," said Schoar. "Now you can access your bank account or robo-advisor at 10:30 at night, when your kids are finally in bed." Peer-to-peer payments, consumer loans, and even business loans are also becoming much easier to transact, thanks to distributed ledger systems such as blockchain and digital currencies such as bitcoin. And with greater volumes of digital transactions come greater volumes of usable data, giving rise to increasingly powerful analytic models about how people behave with money and how they are likely to behave in the future.

A number of MIT Sloan professors are doing research that is foundational for many fintech applications, including big data and modeling of household financial decisions (see pages 23, 25, and 26). Simon Johnson, Ronald A. Kurtz (1954) Professor of Entrepreneurship, has led weekly campus discussions on bitcoin, and is currently exploring the very open question of how central banks will and should engage with it. Last summer, the Bank of England issued its own digital currency; in contrast, the European Central Bank has issued a paper urging members to curb the use of digital currencies.

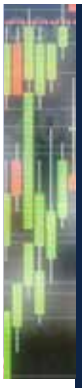
Schoar, meanwhile, has looked at how better data and analytics change how financial companies customize products. "They can use the information to provide better products, but it also comes with risks," she said. She found evidence that credit card issuers tend to offer less-educated consumers cards with hard-to-understand fees that rise steeply over time, for example, while they offer travel rewards to more sophisticated consumers.

TEACHING FINTECH

While fintech is driving faculty research interests, Aulet and Schoar say it was student demand that ultimately convinced them to launch the FinTech Ventures program on campus. One of those students was Carlos Sánchez Altable, MBA '16, a banking consultant with McKinsey & Company, who came to campus wanting to understand more about how the industry was evolving. Thanks to an anonymous donation, Aulet was able to hire Altable to coordinate a multipart effort to launch the program as a sector practice leader.

continued on page 24

Bill Aulet



"Fintech is about how you create new solutions in an industry that is changing, but faces significant regulatory dimensions."

Bill Aulet, Managing Director, Martin Trust Center for MIT Entrepreneurship

Antoinette Schoar

Many MIT Sloan professors are launching new research efforts on the implications of using financial technology. Here, we highlight a few of the most prominent ones featured at MIT Sloan's Fintech and the Disruption of Finance Conference held in New York last September.

Simon Johnson

RONALD A. KURTZ (1954) PROFESSOR OF ENTREPRENEURSHIP
PROFESSOR OF GLOBAL ECONOMICS AND MANAGEMENT

New digital currencies like bitcoin have the potential to disrupt the flow of money all over the world, threatening the banking intermediaries that people have relied on for decades. How should central banks like the Federal Reserve and European Central Bank respond? That's the question Simon Johnson, former International Monetary Fund chief economist, is exploring in his current research and weekly on-campus discussion group.

Bitcoin won't likely displace the U.S. dollar, "but it's absolutely a new currency for making payments and recording transactions," Johnson said at the conference. Central banks "have the responsibility to not try to shut it down or prevent it from developing."

In recent publications, Johnson predicts that central banks will ultimately issue their own digital currencies and aim to exert some control over the underlying blockchain technology that records the transactions.

While blockchain is inherently a decentralized ledger, existing simultaneously in multiple places and negating the need for a centralized authority, central banks can still provide much-needed stability, Johnson says.

"Over time, all financial systems will likely converge on a more decentralized global structure," he wrote in an article published in the journal *Democracy* (Spring 2016). "If policymakers coordinate, there is a better chance that some central bank-controlled form of money can anchor this system."

"Carlos built the blueprint for how we were going to go about this," developing contacts in New York and London and attending industry conferences to create "a best-of-breed fintech ecosystem," said Aulet. For his efforts, Altable won the Patrick J. McGovern, Jr. '59 Award, which recognizes individuals who have made a significant impact on the quality and overall spirit of entrepreneurship at MIT.

Forming a FinTech Club was stage one, and more than 200 students attended one of the 10 events the club organized during the spring of 2015, its first semester in existence. Stage two, a daylong MIT FinTech Conference on campus in May 2015, drew some 300 people. Stage three was a half-semester course in fall 2015, taught by Schoar, and stage four was a business plan competition the following spring.

And with 55 slots available, last semester's FinTech Ventures course received about 100 applications from students across the school, MIT, and Harvard Law School, Schoar said.

working on a new, income-based approach to education financing to make repayment more flexible and less onerous to recent graduates.

To help students better understand the industry landscape, the course often includes guest speakers from established financial institutions. An executive from Citigroup spoke about the firm's internal fintech venture capital arm and what it looks for in investment candidates, said Schoar, while a BlackRock executive spoke about the firm's experience of integrating robo-advisor capabilities into its investment platform.

Leading fintech startup founders and investors are featured in the guest speaker rotation, as well, with Lara Hodgson, founder and CEO of NOW Corp; Inaki Berenguer, founder and CEO of CoverWallet; and Trinity Ventures investment firm partner

The MIT Sloan Fintech Conference was held in New York City on September 16, 2016.

In FinTech Ventures, students work in groups to formulate business ideas that they could feasibly launch by graduation. This past semester, projects included a blockchain solution to replace paper invoices that Mexican farmers use to obtain bank loans, a lending system that uses utility bill payments as the basis for credit decisions and repayment for consumers with no credit history, and an app that uses behavioral incentives to encourage millennials to repay student loans.

A hallmark of the program is its collaboration across campus and across institutions. Notably, Harvard Law School professor Howell E. Jackson, who is also a visiting scholar at the Consumer Financial Protection Bureau, is a frequent visitor to the class to help students understand how regulations governing payment processors, banks, or lenders might apply to their business plans. Harvard Law School students are part of the mix. "To be in a room where business and technical people can interact with those who know so much about the challenges you have on the legal side is fantastic, and has proven critical in this industry," said Pepijn van Kesteren, MBA '16, who took the course in 2015 and is currently

Schwark Satyavolu (who is also a founder of several technology firms) among those joining the class last semester. These speakers are integrated and utilized to reinforce the fundamental principles and frameworks of the course.

Such close access to successful entrepreneurs is a big part of what attracted Sheinal Bhuralal, SF '17, to the course. "People are very open in this context about what they did right and what they did wrong," said Bhuralal. He is working with fellow MIT Sloan Fellows Nick DeLeonardis and Alin Dragos, as well as students from Boston University, the John F. Kennedy School of Government at Harvard University, and Harvard Law School, to help companies finance their wage cycles and address employee wellness issues. Bhuralal has found the speakers to be open to follow-up calls saying, "they've helped connect us to others, as well."

In the fast-moving industry, it's no surprise that the interest goes both ways, with outsiders eager to hear about the students' progress on various ideas. "One thing a group of MIT students can do better than an insurance company or any established institution is build something clever quick," said Rhodes-Kropf.

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Roberto Rigobon, PhD '97

SOCIETY OF SLOAN FELLOWS PROFESSOR OF MANAGEMENT
PROFESSOR OF APPLIED ECONOMICS

Roberto Rigobon and his colleague Alberto Cavallo, Douglas Drane Career Development Professor in Information Technology and Management and an associate professor of Applied Economics at MIT Sloan, are working on two projects that use ecommerce pricing data to construct new macroeconomic benchmarks. The Billion Prices project collects data on a standard basket of online goods every day from more than 70 different countries in order to build new measures of inflation. Compared to the offline data that government agencies such as the U.S. Bureau of Labor Statistics track, they find that the core inflation rate suggested by online activity is far smaller than the one implied by offline data, even though headline inflation rates are generally similar.

Rigobon's other research effort, dubbed the Thousand Big Macs project, tracks identical items sold online by multinational retailers (such as Apple phones) to create an implied exchange rate. Though similar to the World Bank's purchasing power parity measure, this benchmark gauges the relative supply and demand for exactly the same basket of goods in different countries, rather than the basket of dissimilar products considered in the World Bank's measure.

This "organic" data that is a byproduct of other activities online "opens the possibility for alternative measures," Rigobon said at the conference. "And with better data, I am confident we can make better decisions."

Andrew W. Lo

CHARLES E. AND SUSAN T. HARRIS PROFESSOR
DIRECTOR, LABORATORY FOR FINANCIAL ENGINEERING
PROFESSOR OF FINANCE

Trading algorithms, or robo-advisors, can create highly customized portfolios, perfectly matched to a person's age, income, and lifestyle. What they can't do is counteract the ingrained behaviors that compel people to, say, sell when the market is down by double digits. That inescapable behavioral conundrum is the core of Andrew Lo's research, which explores how financial technology can be designed to adapt to and even counteract human impulses.

"Let's agree that we all freak out from time to time," said Professor Lo. "What we're trying to do is deal with that reaction in a realistic way. The idea is to take the emotional response into account," rather than ignoring it.

One part of his investor behavior project involves analyzing years of anonymized data from over 750,000 investors supplied by a major U.S brokerage firm. By looking at how and when those investors decided to trade, he and his team are trying to uncover what conditions are most likely to prompt different investors to cash out or stay the course. Among the preliminary findings: investors are more likely to close out a position when they've either won or lost big over the last month, but are twice as likely to cash out if they've already made at least one trade during that time. Using simple patterns like these can help financial advisors identify which of their clients are most likely in need of more personal attention.

NEW CHALLENGE, PROVEN MODEL

The FinTech Ventures program follows a model Aulet first developed a decade ago to help students start firms in the energy industry. Energy was also a tough industry to crack, in large part because of the heavy regulation involved, so "we set up a whole ecosystem around it," with a club, a class, a conference, and a business plan competition to foster student interest at all levels, said Aulet.

That model is also a perfect extension of how the school views finance, said Schoar. "As Nobel-worthy as the research is, MIT Sloan has a unique perspective to see it as just the first step to a real-world application, to affect how real markets work, or how real companies do capital allocation and budgeting," she noted.

Aulet is well known for putting methods around what some would call the madness of entrepreneurship. He wrote *Disciplined Entrepreneurship: 24 Steps to a Successful Startup* (John Wiley & Sons, 2013) after a career as a serial entrepreneur, running three MIT spinouts after graduating as an MIT Sloan Fellow. Since 2009, he's been managing director of the Martin Trust Center for MIT Entrepreneurship, which oversees entrepreneurship across all five MIT schools and encourages the growth of student clubs, conferences, competitions, networking events, awards, hackathons, student trips, and accelerators outside the classroom.

By 2014, the energy program was thriving, with over 300 entrepreneurs and more than two dozen new companies coming from the course, and Aulet had expanded the same template to the healthcare industry. With an anonymous donation to fund student sector practice leaders for industry verticals starting in 2014, Aulet saw fintech as a perfect candidate to further expand the initiative. Ultimately, he'd like to add venture programs in education, as well as food and agriculture.

"There's definitely value and the opportunity for more specialization in the Entrepreneurship track," which typically draws one-quarter to one-third of each MIT Sloan class, said Aulet. "Once they do all the introductory coursework, we give them options to focus with like-minded people."

SIGNS OF SUCCESS

Though the FinTech Ventures program is young, it is already bearing fruit on campus and beyond. Ten fintech business plans reached the semifinals of the MIT $100K Entrepreneurship Competition in spring 2015, and two made it to the final: CurrencyDoc, a multi-currency prepaid card for travelers, and InvoPlace, an online marketplace for small enterprise financing in Latin America.

Alfie, the income-based alternative to student loans, won the first fintech business plan competition in spring 2016. Its co-founders participated in the MIT delta v accelerator program in 2016, and hope to get their first pilot off the ground in 2017, said van Kesteren, who is CEO of the startup.

Ten fintech business plans reached the semifinals of the MIT $100K Entrepreneurship Competition in spring 2015, and two made it to the final.

Meanwhile, Altable is back at McKinsey bringing a new perspective to his banking clients. "I can help clients make [industry] connections in New York and Boston, so they can talk to people and see how their business might be disrupted," he said. "I couldn't have done that before, because I didn't have that network."

Plans are already in place for this year's business plan competition. And Aulet and Schoar expect to continue offering the FinTech Ventures class—but never exactly the same way twice. The course, said Schoar, "will evolve over the next five years to reflect the changing face of fintech and new trends in the industry." ● ● ●

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